Organ printing: A revolutionary advancement in the medical domain

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***Abstract*: Modern life style has also brought new challenges in human life and has made our life very robotic. This unnecessary hectic life style has been costing heavy on the health of every individual. Organ failure is one such challenging area which is responsible of number of deaths every year globally. The recent advancement in science especially bio printing has infused a new ray of hope. Though this field is in its infancy stages in present time but definitely it has a lot of potential for growth in near future. Hopefully with passage of time the initial hiccups will be over powered thereby saving hundreds and thousands of precious lives worldwide from premature deaths.**

***Keywords*: 3D printing, bio printing, donors, bio-ink, organ transplant etc.**

Science is growing at much faster rate than expected. What seems to be fiction a few decades is now a hard reality. Thanks to the out of box thinking of our great scientists. Bio printing is one such new emerging area of great significance for humanity as a whole. Since, hundreds and thousands of people have been dying every year worldwide for want of organs as everyone is not so lucky to get the organs for transplantation in the time of need. The misfortune people who die each day waiting for an organ transplant because of the simple reasons that we do not have sufficient donors. So much so that sometime even the family members feel hesitation while donating organs for a moment. One of the emerging solutions to this major issue could be use of 3D bio printing technology to make viable organs that could help keep seriously suffering people alive and lead a happy and healthy life. “3D Bio-printing” or simply “bio-printing” is a cousins of 3D printing that uses living cells and biomaterials instead of plastic and metals to create 3D structures. The biomaterials used to construct bio structures are called “Bio-inks” and they copy the composition of our cells, tissues and organs. Bio-printing can be applied to a variety of areas and is not limited to few selected fields only. In simple words we can say “bio printing” as customized printing of living cells, tissues and organs.

The history of bio-printing dates back to the year1986 when Charles Hull invented the first 3D printer allowing 3D objects to be created from digital data (Murphy & Atala, 2014). In the following year1996 individual cellular aggregates to form new combination of structures was achieved. Thereafter in the year 1998 biologist James Thompson developed the first human stem cell lines. Also, in 1999 first lab-grown organ was implanted a remarkable achievement indeed. In the year 2000 medical field started using 3D printing. 3D printing empowers to design, visualize, hold and test ideas in real space (Gonzalez-Gomez et al., 2012). In 2003 Thomas Boland created the first bio printer and same year saw the completion of computer mapping of the human genome. In 2006 Dr. Shinya Yamanaka made the Nobel Prize winning discovery that cellular differentiation could also be reversed. The same year was remarkable in a sense that lab-grown human bladder was implanted. Further in 2009 first blood vessels were constructed using 3D bio-printer. The cartilage scaffolds was constructed by extruding alginate hydrogel onto PCL (Kundu et al. 2015). Since 2015 till date additional advancements in 3D printing technology has been enabling production of number of structures such as tissue, bones, ears, windpipes, blood vessels, vascular networks, exoskeletons and even simple organs thereby giving a new rays of life to sufferer human beings and big relief to the traumatised families.

The procedure for bio-printing involves three important steps:

1. **Pre-bio-printing:** creating a digital file.
2. **Bio-printing:** loading bio-ink into a cartridge and choosing appropriate print heads.
3, **Post bio-printing:** Process involving for creating a stable structure.

Clinical images of the damaged area can be obtained by techniques like PET, magnetic resonance imaging (MRI) and Computer Tomography (CT) etc. These images can then be used as input to design anatomically accurate models of the functional tissue in the form of STL files using CAD/CAM graphic interphase (Catros et al., 2015). After creating the model, it is translated into a standard 3D printer file known as “STL”. The STL describes the outer surface of the modelled object as adjacent triangles and is difficult to print directly. The printer should aware what is to be printed inside the surface. To attain this one need a computer program that slices the printable object into 2-dimensional planes along with to open the STL file with one of these slicing programs and save the file as a GCODE file. Thereafter 3D printer can print from the GCODE file.

Bio-inks on the other hand and the components added to it are a challenging area to master (Groll et al., 2018). The biomaterial should include properties like mechanical strength, biodegradability, cyto compatibility and printability etc. Both natural (Collagen, Gelatin, Silk Fibroin, Alginate, Fibrin, HA, d ECM and Agarose) and synthetic (PEG, PEGDMA, PDMS, PCL and PLGA) polymers can be used in bio-inks. However natural materials are preferred over the other due to their better biological properties despite having insufficient mechanical strength. The most preferred material used is alginate followed by gelatin, hyaluronic acid and polyethylene glycol (PEG). The hydrogels can easily imitate the soft body tissues. However the toughest tissues require materials like thermoplastic polymers filled with hydrogels. It is easier to control different parameters in synthetic than the natural hydrogels which provides a better mechanical strength of the printed tissues. Though natural hydrogels are tough to manipulate but they makes it easier to copy the original cell environment. They are naturally bioactive and hence create a rich environment for integration of cell and tissue. Many bio inks lack the ability to carry their own weight to achieve structural and shape stability or their printability is low due to too high or too low viscosity. What is more, their biocompatibility is not good and the viability of the cells suffers as the bio ink's stiffness or cross linking increases. Printable bio inks have several requirements for their printability, which makes it possible for the bio printer to succeed in its printing job. The materials must be:

- Pseudo plastic or shear-thinning
- Form a continuous long filament
- Hold their original shape
- Mimic the intended design at an acceptable level

Future bio inks will perform significantly better with regard to both printability and biocompatibility. This will be achieved through modifying the bio ink's physical, chemical, and biological properties. The field of bio ink development is one of the hottest research areas in recent time. Cryo bio printing works much the same way except that the bio ink is printed onto a cold plate at -20 degrees Celsius. There exists significant real challenge of developing ideal bio inks (Skardal, 2018).

Last but not the least step is the post bio printing process which is utmost necessary to create a stable structure from the biological material. Post-processing refers to the maturation of the fabricated construct in a bio reaction and its structural and functional characterization (Papaioannou et al., 2019). This process has to be well-maintained otherwise the mechanical integrity and function of the 3D printed object will be at risk. To maintain the object both mechanical and chemical stimulations are needed. These stimulations send signals to the cells to control the re-modelling and growth of tissues. In addition in recent development, bioreactor technologies have allowed the rapid maturation and vascularisation of tissues along with the ability to survive transplants. Bioreactors work in providing convective nutrient transport along with creating microgravity environment and hence specific bioreactor are needed for different types of tissue.

The major advantages of bio printing can be summarised as follows:

1. It can replace organ donors.
2. It can prevent cell rejection.
3. It can replace animals in testing labs.
4. It can replace volunteers in drug testing labs.

Future of 3D bio printing: As the science of bio printing is still in its budding phases and researchers have to go a long way in perfecting this technology. No doubt it is a revolutionary innovation but requires a very detailed cell composition to make the organ or tissue function well inside the human body. Scientists need to take into account number of factors such as space distribution, growth factors, cell concentration, drop volume etc. This task becomes even more herculean to solve with multi-layer tissues and organs. The possibilities of bio printing is much more complicated in tissues such as eye and will require some more time to wait. It is expected that in the future 3D Bio printers can be much cheaper and could be within reach of common man (Agarwal et. Al., 2020).

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