ABSTRACT

Recent technological developments have allowed for three-dimensional printing to be used within the healthcare system to create scaled prototypes for surgeons to practice operating on in anatomical cases. This is done using silicon printing with the design derived from CT scans and gives doctors a chance to assess the issue and figure out the best means of operating. The current use is now expanding to using three-dimensional printing to allow the printing and replication of biomaterials through stem cell reproduction, such as creating skin grafts and small blood vessels. Due to the great demand for transplant organs in the United States and worldwide as well as the natural obstacles in transplantation of donor matching and rejection, biolabs are now creating model organs to improve their quality of performance. Each surgery that a surgeon performs removes about 1% of the surgeon’s life, and the complexity of printing specified functional cells, and the issue of printing vascular systems to keep the tissue alive throughout the printing process are still up until recently have been unable for surgeons to practice removing it before doing so on the real kidney. The real surgery was a complete success, and the patient received a completely functional and healthy kidney.

ORGAN MODELLING

- Creating an Organ Model via Imaging
  - Organ modeling is the exercise of capturing and processing a 3D graphic image of an organ or bodily system, and then using that computed image to manufacture a perfect replica of that organ system for a healthcare professional to use to their benefit. The driving force of organ modeling technology is the ability to obtain detailed computer-imaged structures within the body. These types of images have been used for decades to help medical professionals develop diagnoses, and only up until recently have they been used to create physical models of the structures they capture.

- Obtaining 3D Representative Images
  - These provide the necessary data required to build a full 3D model in a software, such as AutoCad.

APPLICATIONS OF MODEL ORGANS

- Surgeons facing difficult and complex procedures can make use of model organs to improve their quality of performance. Each surgery that a certain individual requires may be unique in some fashion that complicates the ease of surgical methods. Model organs have begun to be used in practice surgeries to allow medical professionals to attempt difficult procedures. A remarkable use of organ modeling was done at a hospital in Belfast, Ireland, as a team of surgeons were faced with a patient requiring an immediate kidney transplant. The patient’s father was the only acceptable donor available; however, his kidney contained a potentially dangerous cyst. The surgeons turned to axial3D, a 3D printing company, and they created a model of the kidney using CT scans. The model contained a dyed representation of the cyst, and the surgeons were able to practice removing it before doing so on the real kidney. The real surgery was a complete success, and the patient received a completely functional and healthy kidney.

3-DIMENSIONAL BIOPRINTING: A REVOLUTIONIZING APPROACH TO HEALTHCARE

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SYNTHESIS OF MODEL ORGANS

- Laser-based printers have the best resolution.
- Inkjet-based printers are versatile, affordable, and print multiple cell types.
- Extrusion-based printers are better structural integrity, fastest method.
- Laser shock induced cell deformation.

TYPES OF MATERIAL USED IN MODEL

<table>
<thead>
<tr>
<th>TYPE OF MATERIAL</th>
<th>BENEFITS</th>
<th>CONSEQUENCES</th>
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</thead>
<tbody>
<tr>
<td>PLASTIC</td>
<td>Low cost</td>
<td>Poor representation</td>
</tr>
<tr>
<td>ELASTOMER (rubber)</td>
<td>Can be used in practice surgeries</td>
<td>Expensive</td>
</tr>
<tr>
<td>POWDERS (starch, plaster)</td>
<td>Low cost &amp; excellent detail</td>
<td>Inaccurate material properties</td>
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APPLICATIONS OF MODEL ORGANS

- Stem cells are cells that can differentiate into specialized cell types, making them ideal for use in bioprinting. After stem cells are extracted from tissue samples, they are prepared with growth factors and multiplied. Embryonic stem cells (ESCs) are extracted from human embryos created in an in vitro fertilization clinic. In order to control the use of ESCs, the National Institutes of Health created guidelines for stem cell research, stating that they can only be used when the embryo is no longer needed and with informed consent from the donors. Current research has shown that regular adult cells can be reprogrammed as induced pluripotent stem cells (iPSCs), which mimic embryonic stem cells, which would be the best solution because they do not carry with them ethical controversy.

BIOPRINTING CELLS

- 3D bioprinting methods
  - Laser-based printers
  - Inkjet-based printers
  - Extrusion-based printers

- Laser shock induced cell deformation.
- Can cause cell damage due to printing nozzle

BIOPRINTING WITH STEM CELLS

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CURRENT RESEARCH OF SMALL CELL PRINTING

- Results from a study done with extracted porcine tissue decellularized into a bioink suggest that skin-derived bioink contains growth factors that accelerate wound healing. In these studies, researchers have successfully 3D bioprinted vascularized tissues and skin patches that can have revolutionary health applications. This research is vital for engineers to move forward in the toward 3D printed organs.

3D PRINTED KIDNEY MODEL FROM AXIAL3D

These provide the necessary data required to build a full 3D model in a software, such as AutoCad.

CREATE A REAL ORGAN

-六步设计原理
  1. Blueprint the organ
  2. Create a model
  3. Create a plan
  4. Print the organ
  5. Transplant the organ

- Organ modeling requires a printer to lay down the substance, resulting in the printed object's multi-dimensionality. Thesesolidified materials do not occur in the confines of nature, as things grow through the complexity of biological structures, the use of bioprinting becomes a viable method of creating such a structure. It is currently being investigated as to whether this could be a possible means of copying a structure.

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- Cell density and vascularization are also a factor that needs to be modified in order to grow operating organs. Organs consist of differing cell types, which each have differing, and corresponding cell densities. For example, low tissue in an organ means that there is about 1% of the cell type per gram. These densities need to be accounted for when replicating cells as the viscosity of the printing substrate the biolabs. To account for this, viscosity needs to be considered when utilizing the bioinks and designed accordingly.

- Arguably one of the most pressing unanswered questions to naturally complet bioprinted organs, there must be a readily accessible vascular system to supply the organ with blood supply on it is being built. The vascular system provides the cells with nutrients and much needed oxygen to survive.