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BIOMEDICAL APPLICATIONS OF ADDITIVE MANUFACTURING

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Abstract— Additive manufacturing a virtue of future is now rapidly implemented in almost all areas of medical professions. 3D printing covers all range sectors that is from surgical operators to pharma people and from dental doctors to Biomedical engineers. The modern technology usage is already started to get revenue as helpful and profitable in medical sector like Foot and ankle-foot orthoses, prosthetics, dental and hearing aids. Though the technology advanced the cost is main issue in manufacturing these devices or implants. This paper reviews about the various new biomedical advancements and the 3D printing devices and methods.

Keywords— 3D printing, Implants, Biomedical, AM methods

I. INTRODUCTION

The Bio printed implants or organs or small bio structures, a huge breakthrough in additive manufacturing has the potential to study and observe the motions of a body from outside the body, in three dimensions. 3Dimensional printed structure that is bio organ is likely or accurately resembling the naturally occurring system of biology performed research in two dimensions, and is highly relevant in biological means. This is widely used in the sectors of bioengineering, materials science and tissue engineering. Three dimensional bioprinting is hugely used for various sectors in medical filed that are: dental, pharmaceutical, bone replacements, organ 3d prints, and in all areas of bio related printings. This 3D printing of bio organs is the new future of mankind as it is a huge savior of human life in many ways.

II. 3D BIOPRINTING

Bio-fabrication is defined as "the generation of biologically functional products by automation with structural organization from bioactive molecules living cells, cell aggregates such as microtissues, biomaterials, hybrid cell-material constructs through bio-assembly or bioprinting.

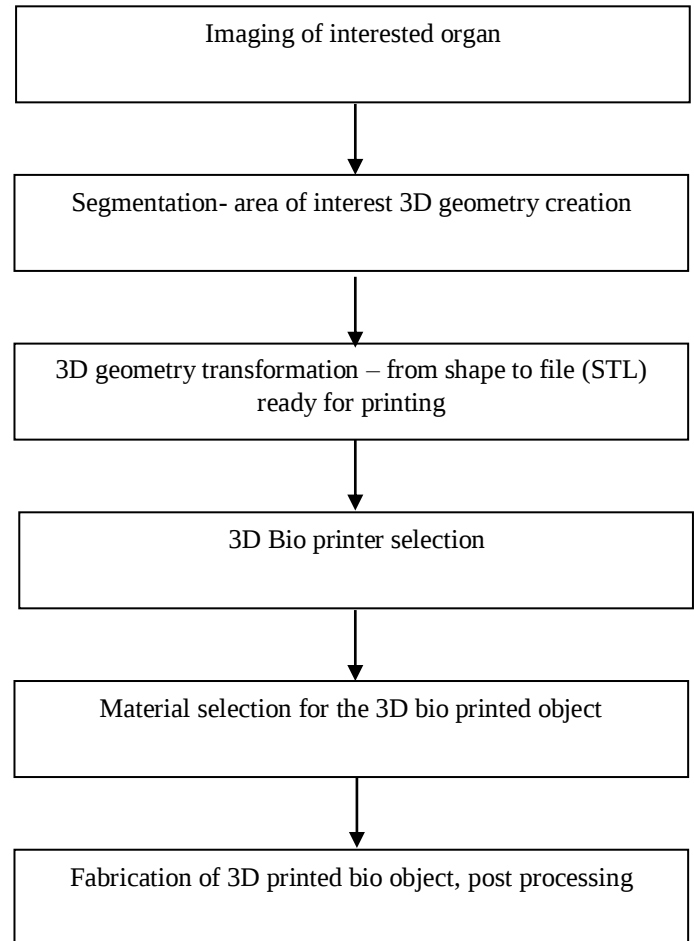


Fig. 1. Process of 3D printing of organs

Basically, three-dimensional printing of bio organs is relied on the layer-after-layer precise placing of biological matters, living cells, by placing the functional constituents. The three-dimensional bioprinting is always relied on the 3 basic things:

- biomimicry,
- self-assembly of autonomous,
- building blocks of amini-tissue.

The vital or important thing in engineering of tissue is called as the scaffold. It is a three dimensional largely porous

substrate. Cells are grown in the culture-medium, which is then applied to the scaffold. Then the tissues are also grown in a growth medium and these tissues are also transferred to the proper medium using the scaffold. Biological properties of the cells are modified and controlled by scaffold composition of material as it as internal structure is changed. A diagrammatic resemblance of 3D bio printing is shown in figure below.

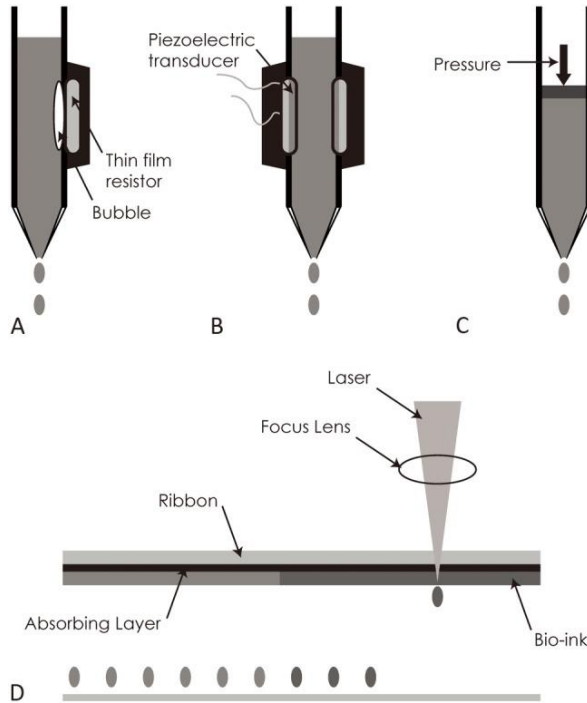


Fig. 2. Bio Printing Process

III. MATERIALS AND PROCESS IN BIOMEDICAL AM

Famously and easily used types of 3D printing techniques used in bio field are:

- Fused deposition modelling,
- Bioprinting based on extrusion,
- Inkjet printing,
- Jet or Polyjet printing.

Biomaterials are defined as synthetic or naturally available substances which are in contact with the biological systems.

These substances help in repair of damaged, replacing of cells. A three-dimensional printing bio-material should have the property of printability with good characteristics and good degradability. Other normal 3D printing materials are listed below in the Table 1.

Material	Applications
Titanium	Bones, stent, valves made artificially
Ti-29Nb	Teeth, dents, implants, valves
P2O5	Bones, Dental implants, orthopedic implants
Pd	Implants of tiny bones, knee joints
Cobalt	Joints of hip, knee, bones
Fe	Implant for spinals
Cp	Screw and abutment

Table. 1. Materials used in FDM bio medical printing.

a) 1.1 Bio-inks for extrusion-based printing:

Creating living tissue structures by process of forming the multi-cellular bioprinting building blocks, Cell-encapsulating hydrogels are used in 3D bioprinting. Cell encapsulation paves way for the precise spatial distribution of the cells, control over cell attachment. The bio-inks plays a vital role in 3D bioprinting as this only the available solution of extrusion-based printing. These bio-inks are made from wide variety of natural or synthetically created materials which has the property of biological as well as printability. The widely used materials for bio-inks, the popularly used materials are:

- Thickest collagen
- GelMA
- Pluronic (Pl)
- Alginate (Ag)
- PEG and
- ECM – (Decellularized extracellular matrix)

Metalysis is newly developed process where metal powders are produced directly from the oxides of their metals in one step. It is done by lowering drastically of its manufacturing environmental impact-ability and other impacts. This process of innovation is cost-effective and also simple. But also, this process produces metal powders of proper uniform size so it can be used in metal 3D printing. The end product will be good enough to withstand all standards which is highly important in implants in medical sector.

S.no	3Dprinting method	Output remark
1	Selective laser sintering	The product finish time is less when compared to others
2	Electron beam melting	Inaccuracy is a major factor
3	Fused deposition modelling	Circular shape fabrication has less accurate shapes
4	Stereo-lithography	Over curing will cause in-accuracy in parts.
5	Inkjet printing	This method has highest build quality
6	Direct metal laser sintering	Scan speed is very good and method is fast
7	Laser metal deposition	Very good surface finish is obtained

Table. 2. Various AM methods and their output remarks

b) Future of 3D printing for Biomedical Applications

The design automation, it is the thing which will be the backbone of the all the fields in world. But here in bio medical AM fields this paves way for the ease of design of very complex parts or implants. For huge scale applications within a filed of dental or clinical and future affordance is a term AM is the bridge connecting it.

Additive manufacturing has been applied in the medical field, including in complex and important surgical procedure design, surgical guide fabrication, surgical simulation, implant design and manufacturing.

The 3D printing is the future gateway for the mankind as it is the easiest and safest technology for the manufacturing of medical implants. This bioprinting is virtue that has the ability to sustain any environment. As the technology develops day-to-day it has a huge impact on humans, since humans are the one who brings new technology.

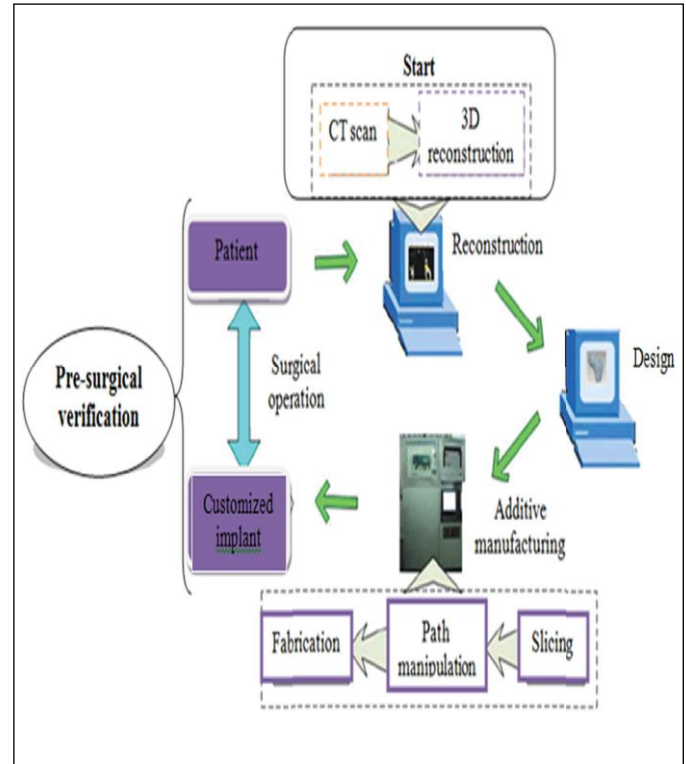


Fig. 3. Automated Biomedical AM

IV. CONCLUSION

The bio-medical applications of additive manufacturing are huge sea, there are lots more to explore in it. As said, it's a sea, new wonders are day-by-day rising up when we are going deep down in research. Although there is not enough research done in this bio-medical field of additive manufacturing.

Biomedical additive manufactured components are required to meet the standards of international governments, as this is new era beginning and still were following old standards for the manufacturing of additive components in bio-medical field.

Thus, we can conclude by saying that additive manufacturing of biological implants is a huge benefit that mankind has got. 3D bioprinting is a sector where every field of medical is concerned and benefited.

Up to date there are still things to discover more in 3D bioprinting. This issue can be solved only when there are more reteach done in this field.

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