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3D Bioprinting Technology: Present and Future Applications in Biomedical

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Abstract
Additive manufacturing technology is one of the fast growing manufacturing/fabrication process in all sectors. 3DP techniques are most widely used in biomedical or tissue-engineering applications is last decade. On the principle of 3DP technology, 3D bioprinting technology have been developed that are designed biological materials (Gelatin, CS, Collagen, PLA, PCL, Starch and etc.) and most widely used. Biological materials such as; blood vessels, organs, tissues and cells are most widely fabricated by using 3D bioprinting techniques for tissue and organ transplantations. Apart from organ and tissue printing 3D bioprinting are also used for *in-vivo/in-vitro* modelling, drug screening and drug delivery system. However, there are many limitations on the use of this technology. In this review paper, classification, advantages, materials used, limitations, and process of 3D bioprinting with applications of 3D bioprinting technology has been reviewed and discussed.

Keywords: Three-dimensional printing, three-dimensional bioprinting, biomedical, tissue, biopolymers.

Abbreviations

3DP	Three-dimensional printing
PLA	Polylactic acid
CS	Chitosan
AM	Additive manufacturing
FDM	Fused Deposition Modeling

INTRODUCTION

Along with research and development, industries and every sectors are growing rapidly. 3DP or AM technology has improved our role in many areas (such as; biomedical sector, fabrication or manufacturing sector, construction sector, automotive sector and aviation sector)[1]. As per previous research study, 3DP technology is a process of fabrication of a 3D objects layer-by –layer[2]Several types of 3D printing technology are shown in Fig. 1.

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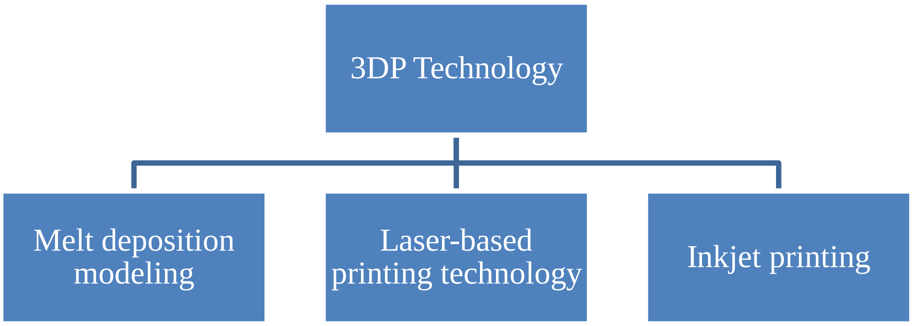

Fig. 1 Different types of three-dimensional printing technology

3D bioprinting innovation that works fundamentally with 3D printing standards gives the chance to get biocompatible and biomimetic biomaterials with the printing of natural materials, for example; cells, tissues and organs not at all like 3D printing[3], [4]. It has different sorts that are shown in Fig. 2, for example, ink-jet bio printing, expulsion/extrusion based bioprinting; laser based and laser upheld bioprinting[5], [6].

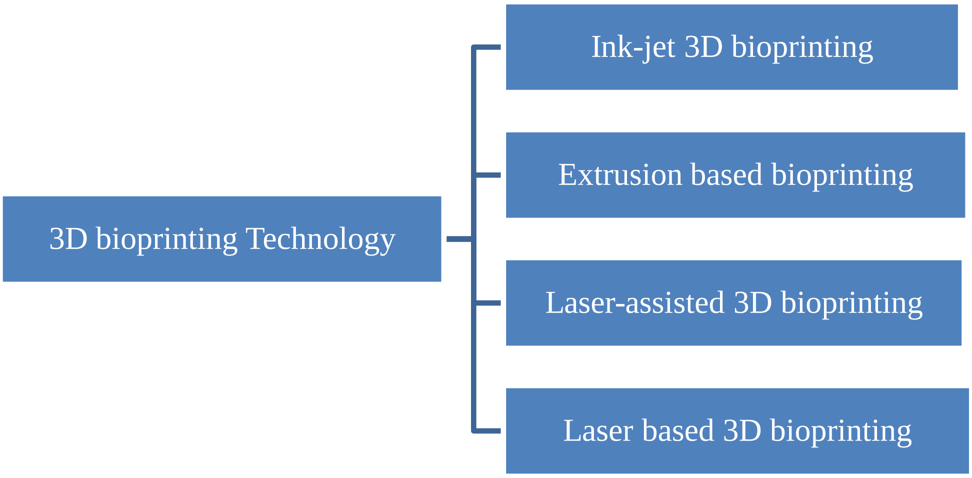

Fig. 2Different types of 3D bioprinting technology

The utilization of 3D bioprinting innovation stands out particularly in the field of medical or health system, biomedical fields and drug store[7]. This technology gives expanded bioavailability and patient consistence by empowering the creation of medication transporter implants/scaffolds, organs, tissues, and drug based carrier system for persistent life structures and patient-particularity and discretionary and moment creation[8], [9]. Hence, cost and time saving can be accomplished by forestalling pointless costs in the field of medical and health. In this survey, 3DP and 3D bioprinting innovation and their applications in the biomedical field for health application, drug store and biomedical fields will be examined [14]. In this review paper, different types of 3D bioprinting techniques are to be disused with their advantages, applications in different field, materials used and their limitations[10].

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3D Printing Technology

3DP technique are normally the process of fabrication or manufacturing of easy or

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complicated structure layer-by-layer with the help of computererd-controlled design (using 3D design software)[11]. 3DP technology has been developing very rapidly in last one decade for different applications in different sectors such as; biomedical, food packaging, aviation, construction, automobile, etc. [9]. By the use of 3DP most of the industries are minimize their errors and waste materials in their production system. On the basic principle of 3DP techniques 3D bioprinting process are to be started and sussecfully invented and implemented[2]. Basic working process/methodology of 3DP process are shown in Fig. 3.

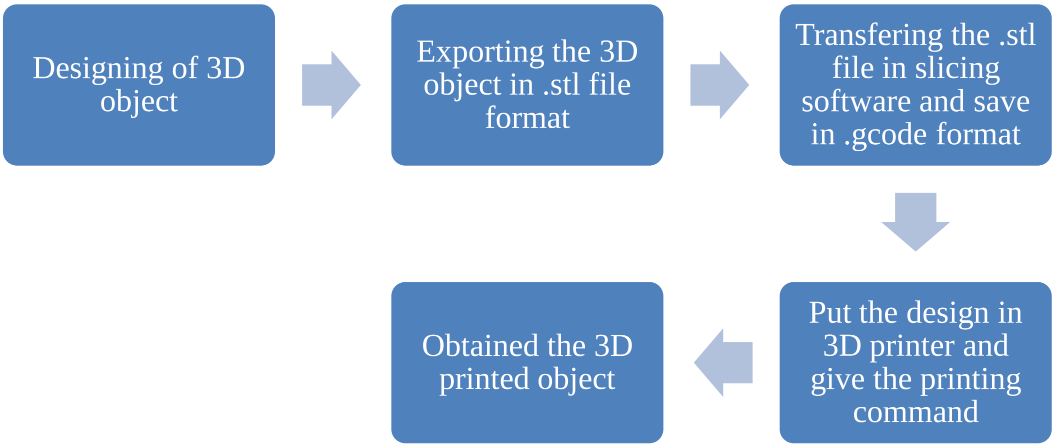

Fig. 3 The basic working process of 3D printing technology

3D Bioprinting Technology

In the field of biomedical applications after a very extensive research and development in the field of tissue and organ transplantation fabrication process are to be developed and that is called as 3D bioprinting techniques[7]. This techniques organ easily does regeneration, organ transplantation, tissue regeneration and transplantation as compared to previous techniques. 3D bioprinting process is most widely used in TE because of this process previous research work shows that effects of cell propagations and implants/scaffolds fabrication[12]. Scaffolds are mainly used for interaction of cells in biomedical and that cause new tissue has been developed at the place of damaged tissue. Scaffolds main advantage is the tissue regeneration or regrowth process is complete in very controlled manner. The help of 3D bioprinting very easily manufactures porous scaffolds that is most useful for tissue regeneration[6]. Bioprinting are mainly defined as organ and tissue printing and its main uses in TE field. Bioprinting has lots of other applications in biomedical field such as; tumor models, drug toxicity screening, cell-based sensors and tissue models. Fig. 4 shows the different 3D bioprinting techniques.

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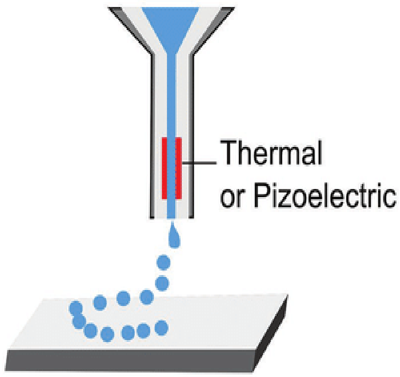

Fig. 4a. Ink-jet 3D bioprinting

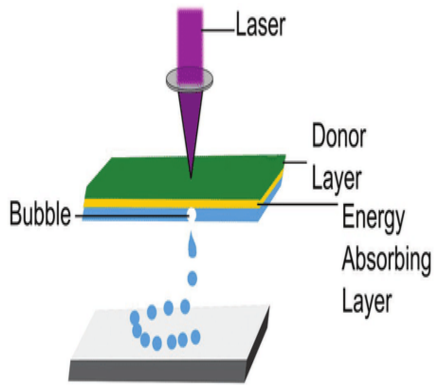

Fig. 4b. Laser based 3D bioprinting

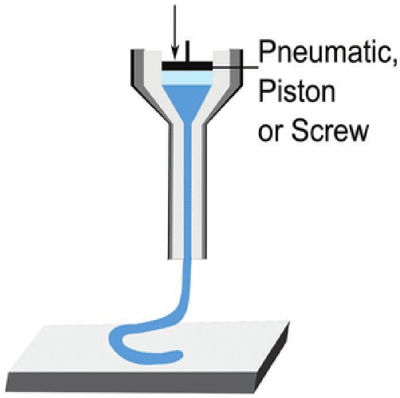

Fig. 4c. Extrusion based 3D bioprinting

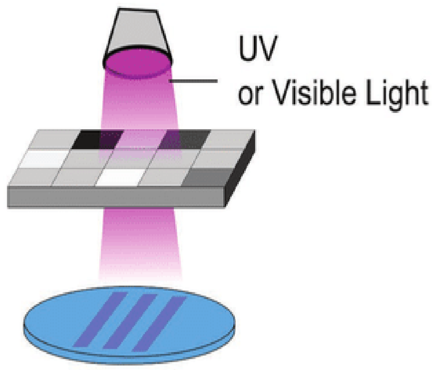

Fig. 4d. Stereolithographic 3D bioprinting

Fig. 4 Different 3D bioprinting techniques working setup and their procedure

The bioprinting process are mainly done in three steps as in 3DP technology. The processing steps are similar as 3DP process; the main differences are only in terms of obtained product and materials used in 3D bioprinting[13]. The first stage is as similar to the design stage of the material[14]–[16]that has been planned to be printed on bioprinter. At the design stage, imaging is done by using methods such as computerızed tomography (CT), MRI to determine the internal and external structure or shape of the material to be printed and after that transform it into the design[17]. The scanned data/object is changed into designs as per suitable shape and size with the help of software programs such as CATIA, SOLIDWORKS and AutoCAD used for this purpose[18].

In the subsequent stage, the bioprinting of the material planned with the bioprinting gadget is made with the assistance of these designs. The decision of technique and material influence the bioprinted material, so the determination of the most appropriate strategies and materials is significant for bioprinting. The last stage incorporates all the means that ought to be taken before the bioprinted material is prepared for use in vivo. This third stage normally happens in a bioreactor. Despite the fact that bioreactors assume a significant job in bioprinting, bioreactor innovation needs further turn of events. There might be issues, for example, loss of cell suitability in the got material due to bioreactor lack.

CONCLUSIONS

There are conclusions that have drawn from this study of 3D Bioprinting Technology: present and future applications in biomedical area: -

- Biological materials such as; blood vessels, organs, tissues and cells are most widely fabricated by using 3D bioprinting techniques for tissue and organ transplantations. Apart from organ and tissue printing 3D bioprinting are also used for *in-vivo/in-vitro* modelling, drug screening and drug delivery system.
- By the use of 3DP most of the industries are minimize their errors and waste materials in their production system. On the basic principle of 3DP techniques 3D bioprinting process are to be started and sussecfully invented and implemented.
- 3D bioprinting process is most widely used in TE because of this process previous research work shows that effects of cell propagations and implants/scaffolds fabrication.

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