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Study On Utilization Of Magnetic Levitation In 3D Bio Printing

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Abstract

With the advancement of technology and increasing complexities, one of the most challenging tasks for the mankind is a reliable method to implement the frequent need of dialysis and tissue replacement.

The growth and performance of a living system is hindered as the result of inadequate supply of blood to the cells, causing these cells to die. Replicating these intricate structures and creating artificial blood vessels has proved to be a stumbling block in both the field of research and tissue engineering. However, implementing the technique of 3D bio printing removes this difficulty by emulating the circulatory system of human body and creating the bio-print of affected or damaged tissues and organs. This paper presents some of the recent developments with regard to 3D bio printing and its applications in various related fields. Also, it brings out the implementation of magnetic levitation in aiding the process of 3D bio printing and its advantages over the conventional approach.

Keywords: *Author Guide, Article, Camera-Ready Format, Paper Specifications, Paper Submission.*

1. Introduction

The introduction of various automated technologies in the field of engineering and research has contributed to the growth in fields of medical science and tissue engineering. From 2D to 3D cell culturing, [1] from prosthetic limbs and various surgical devices made with plastics and metals, to using cells to print human organs, experiments in these industries are progressing quickly. One such technology that utilizes biologically compatible particles to print 3D cell cultures or spatially controlled cell patterns is bio printing. In other words, [2] bio printing refers to the technologies whereby living cells are layered by the additive process yielding highly complex three-dimensional human tissues or organs. The process of magnetic levitation, aiding the process of bio printing, [5] involves an object which is suspended with the support of magnetic force to counteract the effect of gravitational field and other accelerations. The following paper highlights the challenges to traditional approaches and simultaneously suggests solutions by mentioning a more advanced approach to the problems.

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2. Challenges to the conventional approach

2.1 Approach 1: Scaffolding Technique

[8]Traditional tissue engineering uses a biocompatible gel scaffold to accommodate the cells to be grown in number which is a slow process and is limited with respect to the shape of tissue that can be engineered. In other words, the scaffolding technique does not have the capacity for accurate cell placements [7]. This limits the volume and complexity of tissue it can produce severely.[4] More complex tissue, found in major organs such as the kidney, or heart, contains various types of cells in specific positions due to which the fabrication of these organs require the capability to accurately place different types of cells.

Another problem with the conventional method is vascularisation. [10] The vascularisation of tissue is challenging, that limits the production of thick tissue or solid organs. The inability of this technique to arrange the multiplied cells within the tissue results in the creation of tissue which is not vascularised. Due to this, the cells will not get enough oxygen and nutrients, ultimately leading them to die.

2.2 Approach 2: 3D Bio printing

[8] In contrast to scaffold-based tissue engineering, bio printing is an automated approach with the potential for mass production of tissues from standardized building blocks. The problem of vascularisation and accurate placement of various types of cells is easily solved using bio printing. It prints the vascular tree along with the printed tissue at the same time.

The three most important characteristics that give bio printing an edge over other approaches are: First, it replaces the traditional scaffolds with biocompatible particles to create 3D cultures

Second, it is an automated process that uses spheroids or cell aggregates having greater cell density. Third, it is much faster as it needs no intermediate steps of creating scaffolds.

3D Bio printing Process Overview

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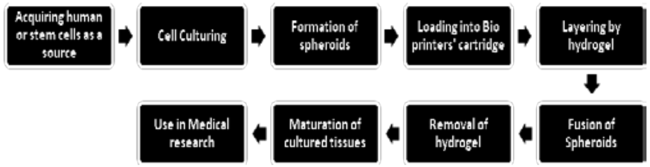

Fig 1: Block diagram for 3D bio printing process

The process of 3D bio-printing can be broadly classified into three steps namely:

1. Collecting the main components - The main components include the cells, hydro-gel and the bio-printer. The cells are taken from the patients' body or as the stem cells from plants in order to grow them in numbers using the bioprinting techniques.
2. Bio-Ink creation- Bio-inks consist of a suspension of cells in a liquid medium, and hydro gels that are used to hold cells in a geometric construct once printed. The creation of bio-ink requires culturing and collecting. Culturing means proliferating or multiplying the number of cells or growing the cells in a huge number so as to aggregate them. Collecting refers to clustering of the cultured cells so as to form spheroids or similar shapes for making the bio-ink.
3. Printing- It is the final process which is done only when cells mature into tissues. This takes over three weeks since the structural growth and chemical reaction is promoted in such an environment that it requires a long time in its formation.

But this approach has certain disadvantages like:
The time taken by the whole process to complete is very large. Moreover, it is difficult to find the cell source which renders this technology cumbersome and tedious to be applied in medicine.
The challenges of the current approach have been resolved in the next approach that uses magnetic levitation.

2.3 Approach 3: Magnetic 3D bio printing

The use of magnetic 3D bio printing over simple 3D printing technique is due to its speed and accuracy in processing and formation of cultured tissue. It takes about 15 minutes to an hour compared to several days before the bio print is generated. Moreover, this approach accounts for rapid printing of models varying simple spheroids to intricate organ-type models. Integrating the two techniques namely, bio printing and magnetic levitation, takes into consideration the lifting force and stability for [5] providing an upward force sufficient to counteract gravity, and for insuring that the system does not spontaneously slide or flip into a configuration where the lift is neutralized, respectively. Another advantage of Magnetic 3D printing is the perfect spatial arrangement that is obtained using it over an irregular, uncontrolled arrangement of cells.
The following paper describes this approach in detail.

3. 3D bio printing using magnetic levitation: An Overview

The methodology adopted in Magnetic 3D Bio printing brought a huge transition from the traditional approach 1 and 2.[3] It does not aim at seeding cells on a biodegradable scaffold but at organizing the elements of the tissue during the fabrication step individually through the process of depositing layers of biologically important components.

3.1 Process

In this technique, cells are printed into 3D structures magnetically. The process completes within 24 hours when the cells interact with each other and are cultured. There is a shrinkage in the formed structure that is observed which differs with the drug concentration.

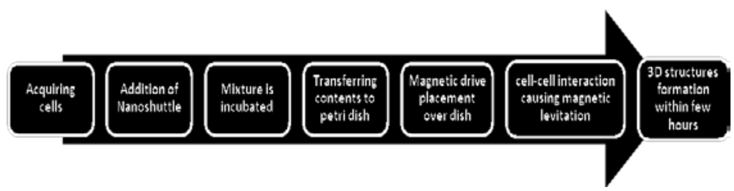

Fig 2: Block diagram for 3D Magnetic bio printing

According to the above block diagram, Nanoshuttle is added to the cells that are acquired. This nanoshuttle is an assembly of magnetic iron oxide nanoparticles with which the cells bind and is rendered magnetic. The cells unite and mature into tissues when they are processed into an incubator, which is the fundamental step in cell culturing. Later, the incubated mixture comprising of Nanoshuttle is transferred to the petri dish after which a magnetic drive is taken and placed over it. This drive works as an external magnetic field which causes the levitation and concentration of cells at the air- liquid interface. This starts the formation of 3D cell structures at the interface and within a few hours, these aggregated structures appear at the surface.
The cultures that are created are dense and are capable of synthesizing extra- cellular matrix.

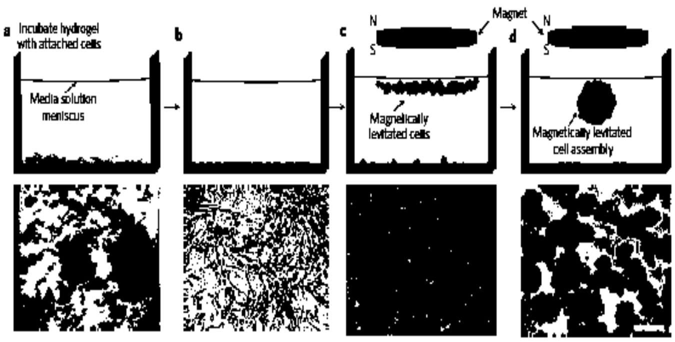

Fig. 1: 3D Cell Culturing by Magnetic Levitation [11]

[9] The advantages of this approach over other 3D bioprinting systems are basically due to its speed (15 min to a few hours to form cultures) and ease of handling (easy to hold down and transfer with magnetic forces) Integration of ease of portability and handling for its usage with mobile device-based imaging has proved to enhance its observed accuracy and throughput.

4 . Conclusion

As presented in the paper, 3D cell culturing by magnetic levitation is the most accurate and efficient method by which 3D bioprinting can take place smoothly. Three approaches have been discussed in relation to tissue culturing. The flaws presented in first and the second approach has been rectified in the third approach. The scaffolding technique and the conventional bio printing are less advanced than magnetic 3D bio printing in terms of the pace at which they produce results. The biggest problem with bio printers is their cost. Since they are highly expensive and require an appropriate environment to work in, the actual results have not been shown in this paper.

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