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3D PRINTED TISSUE ENGINEERING IN MAXILLOFACIAL PROSTHODONTICS: A REVIEW OF THE PROCESS

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ABSTRACT

The ability to regenerate what has been lost due to trauma or disease is a dream for mankind. Maxillofacial prosthodontics recreates the lost maxillofacial structure to the best of their capability with the use of artificial materials. The doors to an entire new world of possibilities opens with tissue engineering and its amalgamation with 3D printing can change the world of dentistry in general and maxillofacial prosthodontics particularly.

KEYWORDS: tissue engineering, scaffolds, maxillofacial prosthodontics.

I. INTRODUCTION

The development of implantable tissues has radically changed the treatment protocols; however the issues of regeneration failure, limited supply of donors and need of immune suppressants are the on-going problems. Tissue engineering offers a silver lining to these problems by recreating autologous organs and 3Dprinting holds remarkable promise for tissue engineering; as it can potentially provide a rapid and robust approach to assemble functional tissue in vitro.[1,2] (Fig 1) The advent of 3D printing allows researchers to fabricate specific shapes that can ideally be patient-specific through medical imaging data and CAD models .[3]

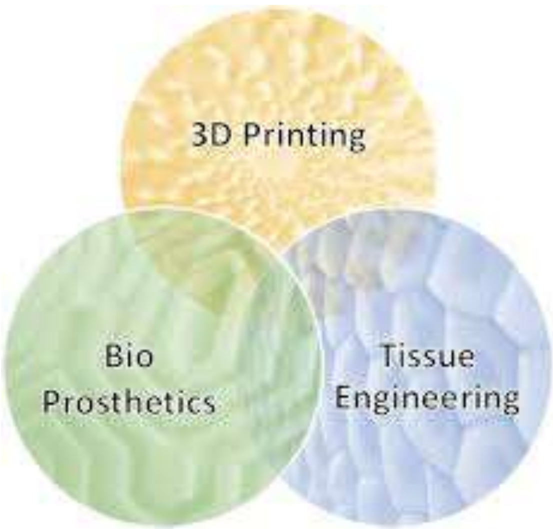

Fig-1: Inter-relation between tissue engineering, prosthetics and 3D printing.

A functional macro-tissue requires a specific set of microarchitecture that provides the structural and mechanical support, sufficient nutrient supply, the necessary cell types, and the ability to actively remodel once implanted.[3,4,5] 3D printing proposes an effective means to assemble all of these necessary components through the use of biomaterials, printing techniques, and cell delivery methods. For tissue engineering, the ideal 3D-printed construct would be a growth-directing structure on which cells could migrate and proliferate to form a functional tissue. The process of 3D printed tissue engineering is depicted in the flow chart below (Fig 2); it is followed by overview of the components of the process.

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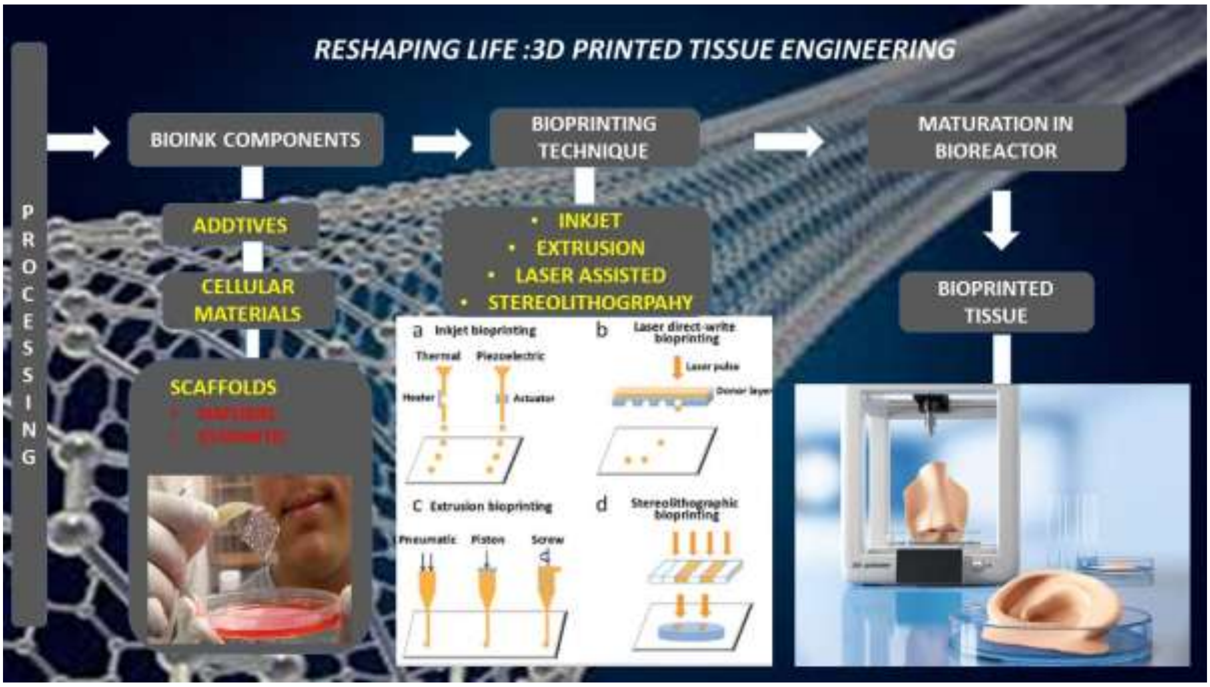

Fig-2: Process of 3D printed tissue engineering at a glance

A. BIOINK:

Bio-inks are substances made of living cells that can be used for 3D printing of complex tissue models. These materials mimic an extra cellular matrix environment to support the adhesion, proliferation and differentiation of living cells. The various bioinks that may be used are:

- Agarose based
- Alginate based
- Collagen based
- Hyaluronic acid based
- Fibrin
- Cellulose
- Silk
- ECM derived cell aggregates
- Cell spheroids

A few components required for success of bio-printing are:

a. Additives which include growth factors, chemicals, micro carriers, cytokines, morphogenic proteins, hormones.
b. Cellular material: Stem cells which include mesenchymal stem cells, induced pluripotent stem cells, embryonic stem cells.
c. Scaffolds: These are natural or synthetic highly porous biomaterials which act as templates for tissue regeneration. 3D printing plays an important role in this phase of processing as highly complex structures can be 3D printed to act as scaffolds which cannot be made manually.
Material selection plays a decisive role in the performance of 3D-printed tissue engineering constructs, including cellular integration, maturation, and proliferation. Natural polymers (e.g., collagen) contain cell-interactive properties that can induce differentiation or enhance cellular motility, while synthetic polymers can be precisely modified to fit a specific tissue engineering application. Inorganic scaffolds require balance of mechanical support and cellular integration.[6]

B. METHODS FOR BIOPRINTING OF MATERIALS ON THE SCAFFOLDS:

a. Inkjet method: It accurately positions drops which may contain cells in suspension. Drops are generated either by vaporising the ink so that a bubble forces out a liquid drop or by mechanical actuation.

b. Extrusion: Micro extrusion or filament plotting deposits a continuous thread of material to build up layer.

c. Laser assisted tissue engineering: With laser forward transfer, material is initially deposited on a transparent ribbon in gel form. A pulsed laser beam vaporises a small quantity of material and is ejected; the remainder of the material illuminates which transfers to substrate across a small air gap.

d. Stereolithiography: Focused light beams allow for precise photo-polymerisation of layers of light sensitive polymer to apply any desired pattern to bioink.

C. BIOREACTORS:

It is a system in which conditions are closely controlled to permit or induce certain behaviour in living cells or tissues. Eg: Spinner flask bioreactor, Perfused bioreactor. Once maturation cycle is completed in the bioreactor the tissue is ready to be implanted at the desired site to be used to rehabilitate the lost structure and reshaping the life of the individual by restoring aesthetics as much as possible and mainly restoring the confidence and self esteem.

D. BIOPRINTED TISSUE:

The final tissue obtained after maturation in bioreactor can be transferred to the defect site and implanted there and as a result we will have the part replaced by regeneration of ones own tissue.

Tissues related to eyes (mainly orbit), ears and nose if successfully developed will change the field of maxillofacial prosthodontics forever and in the most satisfying way.

II. SCOPE IN THE FIELD

Future research is aimed towards the development of a grafts (skin, bone, cartilage, and muscle) with associated nerve and blood vessels, which are a product of tissue engineering of the host stem cells. With further research and development of technologies the entire lost part may also be developed using this approach. It will be a blessing as defects of eye, nose, ears and intra oral components could be upto a great extent treated with 3D printed tissue engineering.

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