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Commentary

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An Overview on Tissue Engineering and the Significance of 3D and 4D Printing

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DESCRIPTION

Tissues are complex structures made up of several cell types, an Extracellular Matrix (ECM), and a range of signalling chemicals. The Extracellular Matrix (ECM) is an important component of the cellular microenvironment, forming a complex three-dimensional network. ECM is a complex 3D network composed mostly of collagen and elastic fibres, as well as proteoglycans, multiadhesive proteins (e.g., fibronectin, laminin), and glycosaminoglycans, with varying architectural shapes and compositions in different tissues (e.g., hyaluronan). ECM structurally supports and aids in the spatial structure of tissues, as well as acting as a location for cell anchoring. Furthermore, ECM is a dynamic system that carries biochemical and mechanical signals from the surroundings into cells, influencing cell behaviour. In tissue engineering applications, the generation of tissue-specific scaffolds with the complicated hierarchy of real tissues is still lacking. Three-dimensional printing (additive manufacturing) is an efficient technique in the production of biomimetic scaffolds with desired features and well-controlled spatial chemistry and architecture.

Three-dimensional printing is mostly conducted through the use of 3D software to create a model, which is then loaded into slicing software and printed using a 3D printer. A computer-controlled layer-by-layer method may be used to create these 3D creations with microporous features. Lyophilization, salt leaching, wet spinning, and electro spinning are the traditional methods for producing sponge or mesh scaffolds. However, utilising these strategies, it is difficult to generate pre-determined, well-defined structures in a regulated manner. Furthermore, cells are implanted onto these scaffolds after manufacturing and may not penetrate the depths of the structure; as a result, cells may not be dispersed uniformly throughout the scaffold. The constraints of traditional scaffold construction processes are solved by three-dimensional printing technology. The major benefit of 3D printing is the ability to create patient-specific scaffolds. Four-dimensional printing is a new discipline in tissue engineering in which scaffolds are made from smart materials that can replicate the dynamic nature of tissues to a significant extent. Four-dimensional printing is a less intrusive and more reliable approach that allows users to create simple forms that can be transformed into complicated patterns over time *via* a programming step that is unique from 3D printing. The smart materials used to create the 4D scaffolds respond to a variety of stimuli and adapt to their surroundings by altering conformation or other features.

Three-dimensional (3D) printing, also known as additive manufacturing or fast prototyping, is used extensively in tissue engineering applications to create scaffolds to heal or replace damaged tissues and organs. Bottom-up printing is used in three-dimensional printing. A computer model guides production, which employs cross-sectional data collected by slicing a Magnetic Resonance (MR) or digital picture of the defect region. Thus, employing this technology, layer-by-layer fabrication with great structural complexity is achievable, particularly for patient-specific implants. Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), and stereolithography are the three primary 3D printing categories that utilise solid polymers for product production. Another category is bio printing, which employs polymeric hydrogels filled with cells.

Scott Crump invented and patented Fused Deposition Modelling (FDM) in the late 1980s, and it is now one of the most widely utilised fast prototyping processes. This technology has been employed in a variety of industries, including automotive, aerospace, model creation for visualisation, design verification, and biomedicine. FDM is based on heating a thermoplastic polymer delivered to the device (in the form of a filament or powder) to a molten state in the heating chamber, which is then extruded *via* a nozzle onto the platform and deposited layer by layer to create a 3D shape. During the manufacturing process, a computer programme controls the location of the nozzle, which travels in the x-y plane to form the desired pattern. When a layer is finished, the nozzle travels up a predetermined distance along the z-axis to print the following layer.