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Overview of Tissue Engineering

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Abstract

Tissue engineering is an emerging field, which aims to create artificial tissue from biomaterials, specific cells and growth factors. These engineered tissue constructs have far-reaching benefits, with possibilities for organ replacement and tissue repair.

This video introduces the field of tissue engineering and examines the components of engineered tissue. This video also outlines some prominent methods used to create the tissue scaffold, introduce a cell population and encourage growth and proliferation. Finally, some key challenges and important applications of the technology are demonstrated.

Transcript

Tissue Engineering is a field of regenerative medicine that uses cells, biomaterials, and biologically active molecules to create, repair, or replace tissue. Natural tissue consists of a structural component, the extracellular matrix, or ECM, and the tissue-specific cells that inhabit it. Engineered tissue aims to resemble natural tissue as closely as possible, using natural or engineered structural components and tissue-specific cells. This video will introduce the field of tissue-engineering, demonstrate some common techniques and challenges in the field, and introduce some applications of this technology.

First, let's take a look at the typical components of engineered tissue. The tissue is formed by first creating a scaffold using a biomaterial. The tissue scaffold is intended to provide structure and mimic the natural ECM. The tissue scaffold can take many different morphologies, such as a fiber mat, or a hydrogel, depending on the desired type of tissue. In any case, the biomaterial used must promote cell adhesion and desirable cell interaction. Alternatively, a decellularized scaffold from a donor organ can also be used to provide structure to the new tissue. The next component is the cells. All tissues utilize living cells, which define the tissue type. For example, fibroblasts are used to make skin, and chondrocytes are used to make cartilage. The cells used in engineered tissue can come from several sources. Primary cells are extracted from native tissue, which requires that the native tissue is minced and digested with an enzyme to release the cells. Alternatively, secondary cells, which are available from a cell bank, can be used. However, these cells are not patient-specific and can cause rejection. Finally, stem cells can also be used, which are undifferentiated cells that are able to give rise to different forms of specialized cells, or replicate themselves. To create the tissue, the selected cells are seeded on the tissue scaffold, along with necessary growth factors to encourage tissue formation. The seeded scaffolds are then allowed to grow in a static culture. Alternatively, specialized tissue culture reactors can be used to seed and grow the engineered tissue.

Now that the components of engineered tissue have been introduced, let's take a look at some common methods used in the field. Fabrication of the tissue scaffold can be the most critical factor in determining the tissue's mechanical properties. A popular scaffold morphology is the electrospun scaffold, which is mat of micro-scale fibers. Electrospinning is done by applying a voltage between a collection plate and the tip of a syringe containing the biomaterial. This creates microfibers, which are allowed to collect until the mat reaches the necessary requirements for the scaffold. It must have interconnected micropores to allow for cells and nutrients to migrate in; adequate surface area to promote cell adhesion; and mechanical properties that match native tissue. Next, a key technique used to grow tissue is a tissue culture reactor. Tissue scaffolds are often seeded with cells through droplet or submersion techniques, and allowed to grow in stagnant culture. However, natural tissue, such as blood vessels, grow under mechanical stimulation. Tissue culture reactors aim to mimic physiological conditions, such as the pulsatile flow in arteries, in order to influence the behavior and growth of endothelial and muscle cells in the artery.

There are many challenges faced in this field, however. The main limitation of in-vitro engineered tissue is the lack of blood-vessel systems. Natural tissues possess vascularization, which provides nutrients and removes waste. However, engineered tissue relies heavily on diffusion, which limits nutrients supply and tissue size. One strategy for vascularization is focused on the use of synthetic scaffolds with built-in vasculature, which could aid in delivering nutrients to the tissue. Though the benefits of engineered tissue are far-reaching, it is difficult to produce tissue on a large enough scale for clinical use. For implantation, cells must first be harvested from the patient and then expanded and cultured on a scaffold. This would require separate cell culture systems for each patient. In addition to the significant amount of time required for these steps, the regulatory challenges and high costs make this difficult to implement broadly at this point.

Now that you've seen some of the current methods and challenges of tissue engineering, let's take a look at some applications of the technology. Tissue engineering can be used in chronic wound or burn healing. One method is to use a tissue scaffold containing growth factors but no cells. The decellularized matrix promotes the migration of cells and encourages tissue growth. Alternatively, for deep wounds, a matrix containing cells can be used, which integrates into the host's tissue. Eventually, researchers aim to be able to fully replace damaged organs. Currently, this is approached using organ culture. First, the donor organ, such as a lung in this case, is decellularized and its native structure maintained, then the lung is recellularized with cells from the patient. This would limit rejection and the need for a donor match.

You've just watched Jove's Overview of Tissue Engineering. You should now be familiar with some basic concepts and methods in the field, as well as some key challenges and applications. Thanks for watching.