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3D Electrospinning Scaffold for Directing Stem Cell Fate

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Abstract

Usage of stem cell fat through 3D electrospinning technique, which can regenerate/repair damaged tissue and other body organs. This particular technique mainly encounters the problem that holds back stem cell induce differentiation of stem cells. Improvement of the scaffold through this particular method will further elaborate its quality and expand research parameters. Moreover, Developed 3D scaffolds will allow the researchers more flexibility with the type and volume of tissues that can be grown. Production in research laboratories and knowledge of stem cell technology will reach on next level. The application of this electrospinning technique is to fabricate biomimetic nanofibers for tuning stem cell fat in the tiny fibrous form which can be used to regenerate and repair damaged tissue and organs.

Keywords: 3D Electrospinning technique; 3D Scaffolds; Stem cells; Biomimetic nanofibers

Introduction

Natural extracellular matrix (ECM) that consist of a couple of Nano fiber materials involving collagen, fibronectin, Laminin plays a pivotal role on controlling tissue repair and regeneration. ECM is a combination of different components that corroborate together and give a physical scaffolding, mechanical support also arranges biochemical elements in a proper alignment for tissue formation and equilibrium. ECM provides a basic cell structure for the instinctual network formation. Electrospinning technique is an effective strategy to gain Nano fiber biomaterial simulating the structure of natural ECM. The advantages of this specific technique include i.e. high surface area with respect to regular fibers, provide higher interconnectivity between fibers, control the composition of Nano fibers to gain required parameters and functions, also offer flexibility in surface functionalities. Stem cells are an ideal seeded cell for tissue engineering due to their high proliferation capacity, multiple differentiation potential and excellent biocompatibility, and have been extensively applied to tissue engineering. Stem cells are attractive for these applications due to their unique ability to self-renew and differentiate into multiple tissue specific cells. Moreover, stem cells secrete various kinds of trophic factors that can regulate immune response or condition the cellular microenvironment for tissue regeneration, giving them distinct advantages over terminally differentiated cell. In this proposal, we attempt to apply the electrospinning technique to fabricate biomimetic nanofibers for tuning stem cell fate in the tiny fibrous form which can be used to regenerate and repair damaged tissue and organs [1-5].

Objectives

The proposal mainly encounters the problem that holds back stem cell research: developing instructive scaffolds that is not only biocompatible but can induce differentiation of stem cells. Improvement of the scaffold through this particular method will further elaborate its quality and expand research parameters. Moreover, the aim of this proposal is to advance the stem cell technology, 3D scaffold and biocompatibility of material. Developed 3D scaffolds will allow the researchers more flexibility with the type and volume of tissues that can be grown. Production in research laboratories and knowledge of stem cell technology will reach on next level [6,7].

Background

Current cutting edge

Nowadays, electrospinning is a strategy to produce fibrous biomaterials with Nano scale or micro scale and has gained focus in research industry and generating eagerness from past decades because “the diameter of electro spun fibers is of similar magnitude to that of fibrils in extracellular matrix (ECM) that mimics the natural tissue environment”. Electrospinning product is characterized by thin mat of fiber with high surface area to its volume ratio, and “the current maximum achievable thickness of the mat is about 2 millimeters” (Arinzeh). Electro spun fibers used in tissue engineering processes for treating and regenerating body parts and gives organ lining if it has been damaged.

Rivalry

Companies like Neotherix have been using this method for "the repair of acute (surgical and traumatic) wounds as well as the repair of chronic wounds. Other clinical targets are likely to be in aesthetic surgery, periodontology, surgery to repair other soft tissue tumors, colorectal surgery and abdominal wall repair" (Neotherix). Two dimensional tissue growth is limited on large scale. Three dimensional growth is only possible on thicker scaffolds. Think scaffolds would be able to remove limitation of flat mat and take world toward new opportunities and will introduce new application of stem cells. Furthermore, companies such as fanavaran Nano meghyas, who manufacture electrospinning machines have limited access in the market only because they avail electrospinning equipment but not the scaffolds, so the small lab who require scaffold but are not able to purchase a whole machine is out the game. Though unlimited scaffoldings can grab both clients attention. It will provide scaffold as well as equipment depending on clients needs [8,9].

Research Methodology

Process called electrospinning through which thin layer of woven and non-woven fibers produced. Desired polymers dissolved in the solvents and get charged and then placed in a syringe. Moreover, the syringe tip referred as needle that would be charged with high voltage generator. Solution gain charge when it will go through the syringe needle that initiate and gravitate it toward collector plate. Charged polymers attracted toward thin collector plate. "During the jet's travel, the solvent gradually evaporates, and a charged polymer fiber is left to accumulate on the grounded target. The charge on the fibers eventually dissipates into the surrounding environment. The resulting product is a non-woven fiber mat that is composed of tiny fibers with diameters between 50 nanometers and 10 microns. This non-woven mat forms the foundation of the scaffold. Previous work has shown that the mechanical properties of the scaffold can be varied by varying the fiber diameter and orientation" (Bowlin) (Figure 1).

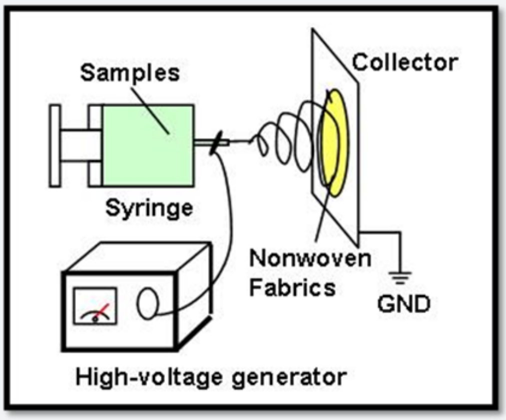

Figure 1: Photo courtesy of Koyama Laboratory, Yamagata University.

Circular motion will be used to eject polymers on collector plate that produce thin mat with small diameter. Polymers won't build up on the other existing mat and the process get terminated if the collector plate already be covered with material. Process occur in seconds and create one millimeter thick mat. "According to Professor Treena Arinzeh, PHD, recent work in NJIT's stem cell lab has resulted in fibers of a 2 millimeter thickness".

These processes are necessary in the formation of scaffolds used in tissue engineering technology. These materials are same as our body tissues i.e. collagen fibers, formed through artificial method and mimic body tissue and facilitate stem cells growth. These are regenerative cells that can be found in someone's bone marrow. If provided required environment, they can initiate division and change their own characteristics and become different cell with unique qualities. Scaffolding provide space for stem cells to grow because it has gap and a matrix structure that provide tissue growth in certain manner.

Research Goals

Reviewing current electrospinning technique

A. Reviewing current research process related to the electrospinning technique

B. Scaffolds measurements produced my current technique

C. Propose a new electrospinning setup

D. Measurements of new scaffold (Sizes)

E. Produce a new scaffold with a desired thickness

F. Testing scaffolds

G. Place stem cells into scaffolds and evaluate their responses to the scaffold materials including cell adhesion, proliferation, migration and differentiation

H. Investigate the effect of the morphology, structure, thickness of scaffold on directing stem cell fate

Conclusion

Regeneration of damaged tissues by using stem cell fats gives us unique advantages over normal cells. Utilizing stem cell fat in the tiny fibrous form will help to fabricate biomimetic nanofibers, it will help us to get more efficient result i.e. high surface area with respect to regular fiber, higher interconnectivity among fibers and flexibility in surface functionalities can be achievable.

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