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Review Article

Enhanced Cell Mitochondrial Activity using Electrospun Nanofibers

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Abstract: Research in tissue engineering related to the improved processes using nanofiber scaffolds has seen considerable progress in the last decade in the regeneration and construction of a number of artificial tissue types. These designs are generally viewed from the perspective of possible sources for clinical implant and transplant materials. Nowadays, advancement in engineering of tissues often referred to as three-dimensional (3D) cell culture provides enhanced activities owing to the 3D systems that readily imitate the *in vivo* setting for differentiated organs, than a typical 2D cell culture. Electrospinning has been useful in producing nanofibrous scaffolds with large surface area and high pore volume that has the potential to mimic the morphology of a tissue extracellular matrix and hence promoting cell attachment, proliferation and differentiation. This review reports improved processes of tissue revitalization utilizing electrospun nanofibrous scaffolds. Different tissue engineering approaches including their advantages have been discussed. Also, various biomaterials from both synthetic and natural origin have been elaborated.

Keywords: Cell activity; Electrospinning; Biomaterials; Tissue Engineering

Abbreviations: **PCL:** polycaprolactone; **PLA:** polylactic acid; **PHB:** polyhydroxybutyrate; **ECM**: extracellular matrix

Introduction:

It is becoming apparent that biomaterials have a critical role to play in the development and evolution of regenerative medicine. Tissue engineering is one interdisciplinary area that combines the principles of engineering and life sciences to advance biological substances that restore, maintain and revitalize the damaged tissues and organs [1-3]. To replace diseased, defected, or lost cartilage tissue and to restore natural tissue functions during regeneration process, biomaterial and biomechanical considerations should be incorporated into a designed [4]. In the past, a large focus was on the development of biomaterials scaffolds for permanent tissue replacement. Among the few types of polyester onto which human cells can either differentiate, divide or both, biocompatible and biodegradable PCL, PLA and PHB have been successfully electrospun into nanofiber scaffolds [1]. However, electrospun nanofibrous scaffolds are of great interest in tissue engineering due to their interconnected pores, their high surface area to volume ratio and architectural similarity to the native ECM [4]. These properties enable electrospun scaffolds to stimulate cell mitochondrial activities including cell adhesion, proliferation and differentiation but also improve spatial organization on the mesoscopic scale [1, 5-9].

Tissue Engineering Approaches

Generally, engineered tissue is normally composed of primary or immortalized cells that are organized and cultured on the surface or inside a three-dimensional (3D) scaffold composed of either extracellular matrix proteins or analogous biomaterials [10]. However, utilizing regenerated tissue in biomedical research is to bridge the gap between traditional two-dimensional (2D) cell culture and the *in vivo* setting, thus, creating an environment that more closely represents the complex 3D structure of intrinsic tissue. In this tactic, the *in vitro* phenotype of cells in a 3D model, surrounded by extracellular matrix and other cells offers the ability to measure phenotypes that cannot be measured in 2D cell cultures and therefore in some cases will be more relevant to the *in vivo* situation [11, 12]. Another powerful advantage of 3D systems is to apply a high-throughput method to perform phenotypic measurement of traits typically limited to organ systems in analogous to 2D culture models. Furthermore, electrospinning has proven to be one of the significant methods for fiber-based 3D scaffold production [13].

Electrospun Nanofibrous Scaffolds

Polymeric biomaterials and their blends have been widely utilized in biomaterials research due to their biodegradability. PCL, a hydrophobic polymer, is a well-known biocompatible polymer that has been successfully fabricated via electrospinning technology [14-16]. Electrospun PCL blends include natural biopolymers such as gelatin, chitosan and lecithin. However, PCL-gelatin blend can improve cell and neurite growth whereas PCL-chitosan blend promotes cell growth and expansion [17].

Discussion and Conclusions

The presence of high porous networks and large surface area in the morphology of electrospun nanofibrous scaffolds can promote cell regeneration, proliferation and differentiation. Various approaches for tissue regeneration using a 3D *in vitro* model surrounded by extracellular matrix offers the ability to measure phenotypes that cannot be measured in 2D cell cultures.

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