A Biomaterials Approach to Schwann cell Development in Neural Tissue Engineering

Article *in* Journal of Biomedical Materials Research Part A · September 2019

DOI: 10.1002/jbm.a.36749

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Received: 26 November 2018 | Revised: 8 February 2019 | Accepted: 7 May 2019

DOI: 10.1002/jbm.a.36749

REVIEW ARTICLE

A biomaterials approach to Schwann cell development in neural tissue engineering

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Abstract

Schwann cells, in addition to forming myelin sheaths, have pivotal roles in regeneration of injured axons in the peripheral nervous system such as producing a natural permissive conduit between distal and proximal stumps and secreting nerve growth factors. Due to the atrophy and senescence of Schwann cells in long nerve gap, and the need to ensure the presence of nerve growth factors and basal lamina tubes for axon regeneration in a critical time, injection of Schwann cells with the aid of an engineered conduit seems to be an effective approach to induce axon regrowth. Stem cells with high differentiation and proliferation capability can provide an adequate number of Schwann cells in healthy state for regeneration purposes. Guidance of stem cells differentiation into desired lineages, control of implanted Schwann cells fate, maintenance of nerve growth factors expression, and guidance of axon regrowth are possible with the aid of biomaterials with appropriate chemical, physical, and mechanical properties. Biomaterials' surface chemistry and biomolecules interacting with cells' receptors initiate specific intracellular signaling cascades and direct cells fate. In addition, biomaterials' surface topography in association with cells contact area, focal adhesion, and cytoskeletal remodeling by mechanotransduction process influences cells behavior and induces specific differentiation. The main objective of this review is to investigate the chemical, topographical, and mechanical properties of biomaterials which influence the fate of Schwann cells and the nerve regeneration process.

KEYWORDS

biomaterials, biomolecules, peripheral nerve regeneration, Schwann cells, stem cells, surface properties

1 | INTRODUCTION

The nervous system is composed of the central nervous system (CNS, brain and the spinal cord) and the peripheral nervous system (PNS, nerves throughout the body). Nervous system cells are divided into neurons, glial cells, and immune and connective cells (Painter, 2017). The neuron structure is composed of dendrites, cell body, axon, and telodendria (presynaptic terminals). Neurons are divided into three

Abbreviations: BDNF, brain-derived neurotrophic growth factor; CNTF, ciliary neurotrophic factor; ERK, extracellular signal-regulated kinase; FGFs, fibroblast growth factors; GDNF, glial cell line-derived neurotrophic factor; HBMSCs, human bone marrow stem cells; NICD, notch intracellular domain; NT-3, neurotrophin 3; OSM, oncostatin M; PDGF-AA, platelet-derived growth factor-AA; PDMS, poly-di-methyl-siloxane; PLGA, polylactic-co-glycolic acid; PPy, polypyrrole.

