Team 14: Electrical Stimulation Plate for Neuronal Tissue Regeneration

Sponsored by: Dr. Kumbar Laboratory, UCHC
Sponsor Advisor: Sangamesh G. Kumbar, Ph.D.

Front left: Rita Matta, Justin Letendre, Paige Collins

UCONN HEALTH

BIOMEDICAL ENGINEERING

Twenty million Americans suffer from peripheral nerve injury constituting ~150 billion health-care dollars annually. Axonal regeneration is extremely slow process that occurs at a rate of ~1mm/day, requiring at least 12-18 months for muscle reinnervation and functional recovery. Current procedures involving biological and synthetic grafts focus on defect repair, however, the clinical outcomes in terms of functional recovery, time, and quality of regenerated tissue are suboptimal. Tissue engineering approaches involving growth factors and cells have shown benefits in preclinical settings, but face significant challenges for clinical translation, with no currently marketed products.

Electrical stimulation (ES) of injured peripheral nerves has been shown to accelerate axonal regeneration and functional recovery in laboratory animals and human clinical trials. Electrically-conducting, non-degrading polymers and their composites enable ES, presenting an appropriate scaffold for housing cells and directing regeneration. However, these materials face significant challenges in terms of degradation, biocompatibility, and reliable electrical conductivity in vivo. Popularly used polymers PANI and PPY are brittle, non-degradable or slow-eroding, and tend to exhibit deterioration of electrical conductivity under physiological conditions due to oxidation-reductions (redox) reactions. Therefore, development of alternative approaches for enhancing peripheral nerve regeneration that achieve and surpass the performance of the current gold standard autograft is currently an unmet need.

The goal of this project is to create a reusable cell plate which will enable application of uniform and reproducible ES to scaffold materials in vitro and optimize ES parameters, promoting cell differentiation. Dr. Kumbar's laboratory has synthesized novel ionically conductive (IC) materials that address redox instability and provide very stable electrical conductance in physiological environment will serve as the matrix. Human mesenchymal stem cells (hMSCs) will be seeded on IC materials placed in the designed plate to apply ES and study changes in cell morphology and neuronal phenotype expression using various analytical techniques. Studies are designed to identify optimal ES parameters that lead to higher neural phenotype expression, including *β-III tubulin* and *microtubule-associated protein-2*, by hMSCs. The novel device configuration focuses on relatively easy use to provide uniform stimulus while striving to mitigate current density loss due to media interaction. Electrode dimension can be changed to fit variable graft sizes. Additionally, we have designed circuits to percutaneously apply ES to tissue and evaluate permeation of stimulation through tissue.