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Understanding Neuronal and Glial Cell Behaviour in Multi-Layer Nanofibre Systems to Support the Development of an in vitro Model of Spinal Cord Injury and Personalised Prostheses for Repair

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Abstract : Aligned electrospun nanofibres act as effective neuronal and glial cell scaffolds that can be layered to contain multiple sheets harboring different cell populations. This allows personalised biofunctional prostheses to be manufactured with both acellular and cellularised layers for the treatment of spinal cord injury. Additionally, the manufacturing route may be configured to produce in-vitro 3D cell based model of spinal cord injury to aid drug development and enhance prosthesis performance. The goal of this investigation was to optimise the multi-layer scaffold design parameters for prosthesis manufacture, to enable the development of multi-layer patient specific implant therapies. The work has also focused on the fabricating aligned nanofibre scaffolds that promote in-vitro neuronal and glial cell population growth, cell-to-cell interaction and long-term survival following trauma to mimic an in-vivo spinal cord lesion. The approach has established reproducible lesions and has identified markers of trauma and regeneration marked by effective neuronal migration across the lesion with glial support. The investigation has advanced the development of an in-vitro model of traumatic spinal cord injury and has identified a route to manufacture prostheses which target the repair spinal cord injury. Evidence collated to investigate the multi-layer concept suggests that physical cues provided by nanofibres provide both a natural extra-cellular matrix (ECM) like environment and controls cell proliferation and migration. Specifically, aligned nanofibre layers act as a guidance system for migrating and elongating neurons. On a larger scale, material type in multi-layer systems also has an influence in inter-layer migration as cell types favour different material types. Results have shown that layering nanofibre membranes create a multi-level scaffold system which can enhance or prohibit cell migration between layers. It is hypothesised that modifying nanofibre layer material permits control over neuronal/glial cell migration. Using this concept, layering of neuronal and glial cells has become possible, in the context of tissue engineering and also modelling in-vitro induced lesions.

Keywords : electrospinning, layering, lesion, modeling, nanofibre
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