

Editorial

# Unraveling the Critical Mechanisms and Functions of Neuroglia in Spinal Cord Injuries

Chih-Wei Zeng <sup>1,2</sup> 

<sup>1</sup> Department of Molecular Biology, University of Texas Southwestern Medical Center, Dallas, TX 75390, USA; chih-wei.zeng@utsouthwestern.edu

<sup>2</sup> Hamon Center for Regenerative Science and Medicine, University of Texas Southwestern Medical Center, Dallas, TX 75390, USA

In the dynamic landscape of neuroscience and regenerative medicine, the pivotal role of neuroglia, or glial cells, is increasingly being recognized. These cells, historically deemed auxiliary to neurons, are now the subject of intense investigation due to their potential insights with respect to understanding and mitigating the impacts of spinal cord injuries [1]. Neuroglia play multifaceted roles in maintaining the functionality of the central nervous system, and their dysfunction can lead to profound neurological damage, as evidenced in spinal cord injuries. These injuries instigate intricate cellular and molecular responses within the neuroglia, exacerbating damage and impeding recovery. Thus, a comprehensive understanding of neuroglial response post-injury is of utmost importance [2].

Glia, derived from the Greek word for “glue”, form a complex network of cells, including astrocytes, oligodendrocytes, and microglia. These cells provide structural, nutritional, and functional support within the central nervous system [2]. They are crucial in maintaining homeostasis, modulating neuronal communication, and coordinating responses to neural damage [3]. Following a spinal cord injury (SCI), glial cells rapidly undergo morphological and functional changes to protect the surrounding tissue. For instance, astrocytes proliferate and become hypertrophic, creating a physical and chemical barrier—known as a glial scar—around the lesion site [4]. While this scar serves to limit the spread of inflammation and damage, it also forms a significant barrier against axonal regeneration, thereby contributing to the permanency of spinal cord injuries [5]. Oligodendrocytes, the myelin-producing glia within the central nervous system, are often severely affected by SCIs, resulting in demyelination and the subsequent impairment of nerve signal transmission [6]. Simultaneously, microglia, the primary immune cells of the nervous system, react by releasing pro-inflammatory cytokines, thereby contributing to secondary injury while facilitating debris clearance and tissue repair [7].

This Special Issue highlights the potential of neuroglia to serve as therapeutic targets following an SCI. The dual nature of glial responses—simultaneously protective and deleterious—suggests that sophisticated strategies for enhancing the beneficial aspects of glial activation while curbing their detrimental effects could pave the way for promising recovery avenues. Molecular pathways potentially exploitable to this end are beginning to emerge from cutting-edge research. For example, one strategy involves promoting the survival and proliferation of oligodendrocyte precursor cells via the activation of signaling pathways such as the PI3K/Akt pathway [8]. Another aims to reduce astrocytic scar formation, which is primarily mediated by the STAT3 and NF-κB pathways [9]. Inhibiting these pathways could mitigate scar formation and thereby enhance the regenerative capacity of injured neurons. Controlling the activation of microglial cells, the resident immune cells within the nervous system, is another potential strategy. By blocking the NF-κB pathway or stimulating anti-inflammatory pathways such as the Nrf2 pathway, it might be possible to control microglial activation, reduce inflammation, and promote tissue repair [10].

The Special Issue further explores the therapeutic potential of stem cell technologies in the realm of regenerative medicine, specifically focusing on neural stem cells (NSCs)



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and induced pluripotent stem cells (iPSCs) [11]. The capacity of NSCs to self-renew and differentiate into neurons, astrocytes, and oligodendrocytes renders them attractive candidates for restorative interventions [12]. The transplantation of NSCs into the injured spinal cord has demonstrated an enhancement of axonal growth, remyelination, and functional recovery in various experimental models [13]. Concurrently, the advent of iPSCs, which can be reprogrammed to transform from somatic cells into pluripotent stem cells, offers vast opportunities for patient-specific cell therapy [14]. The ability of iPSCs to differentiate into neuroglia and neurons, combined with their potential to circumnavigate the ethical concerns associated with embryonic stem cells, holds immense promise for revolutionizing regenerative medicine [15]. Beyond iPSCs and NSCs, other types of stem cells also show potential in the context of SCIs. For example, mesenchymal stem cells (MSCs) can differentiate into a variety of cell types and have been found to secrete various neurotrophic factors that promote neural regeneration and remyelination, modulate inflammatory responses, and improve functional recovery after an SCI [16]. Moreover, this Special Issue examines the application of innovative techniques like gene therapy and nanotechnology to modifying neuroglial responses to injury. Gene therapy allows for the manipulation of key genes involved in neuroglial responses and regeneration, offering a refined level of control over cellular responses. Coupled with the precision delivery afforded by nanotechnology, this creates an unprecedented potential to fine-tune neuroglial responses to injury [15].

In conclusion, this Special Issue highlights the crucial role of neuroglia in the underlying pathophysiology of spinal cord injuries and underscores their immense therapeutic potential. We hope that by expanding our understanding of the sophisticated mechanisms and dynamic interactions associated with neuroglia, we can significantly contribute to the development of innovative regenerative therapies for spinal cord injuries [12]. We trust that this issue will trigger further exploration and foster dialogue, thereby accelerating our progress toward efficacious regenerative therapies for SCIs.

**Conflicts of Interest:** The author declares no conflict of interest.

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