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Changing Lives and Empowering Humanities

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Changing Life and Empowering Humanity:

The next level of treating **Spinal Cord Injuries** from clinical perspectives

Assoc. Prof. Dr Mohd Muzamir Mahat
Faculty of Applied Sciences,
UiTM Shah Alam

Nurhidayah Shahemi
Faculty of Applied Sciences,
UiTM Shah Alam

Spinal cord injuries (SCI) devastate over 15.4 million lives worldwide, and despite decades of research, there has been no significant improvement in recovery outcomes or life expectancy for these patients since the 1980s. Current treatment options—anti-inflammatory drugs, decompression surgery, and physical rehabilitation—offer limited relief but fail to address the broader spectrum of regenerative processes. Managing SCI complications like respiratory issues, bowel dysfunction, and urinary tract infections further detracts from efforts to promote regeneration. Regenerating the central nervous system (CNS), which includes the brain and spinal cord, remains one of the most challenging areas in regenerative medicine, as these tissues have minimal capacity to repair themselves. Even if some axons regenerate, improper reconnections within the brain's sensory and motor cortex can lead to abnormal sensations and movement, complicating recovery efforts.

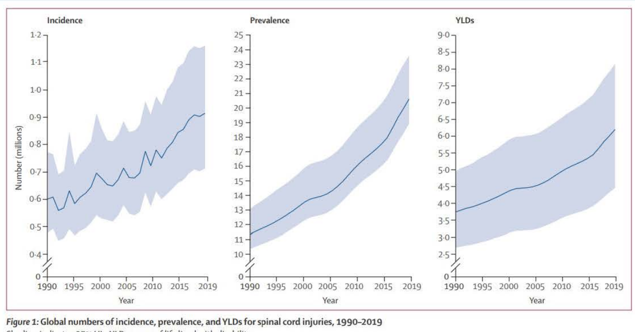


Figure 1: **Global numbers of incidence, prevalence, and YLDs for spinal cord injuries, 1990–2019**
Shading indicates 95% UIs. YLDs=years of life lived with disability.

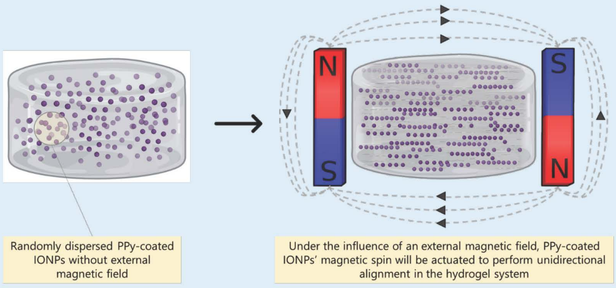
Three pioneering approaches are currently pushing the boundaries of SCI treatment, each led by distinguished experts. At the Mayo Clinic, neurosurgeon Prof. Dr. Mohamad Bydon has developed a stem-cell therapy that uses fat-derived stem cells harvested from patients. After expanding these cells in the lab, they are injected into the injured spinal cord to promote regeneration at a cellular level. Through extensive monitoring over two years, the therapy has shown potential to aid healing, particularly when integrated with other treatment strategies.

In Switzerland, Prof. Dr. Grégoire Courtine of Lausanne University Hospital (CHUV) is leading groundbreaking research on epidural electrical stimulation (EES). His studies show that EES can reactivate suppressed neural pathways in the spinal cord, enabling remarkable restoration of movement when combined with motor training. This approach highlights the role of activity-dependent mechanisms in fostering neural plasticity, paving the way for more effective rehabilitative interventions.

On the cutting edge of regenerative nanomedicine, Prof. Dr. Samuel Stoop from Northwestern University has introduced a revolutionary innovation with his "Dancing molecules." These nanostructures, embedded in an injectable hydrogel, dynamically engage with cellular receptors, significantly enhancing the chances of spinal cord healing. This unprecedented approach holds great promise for improving recovery in SCI patients by utilizing supramolecular chemistry to promote cellular regeneration.

Assoc. Prof. Dr. Mohd Muzamir Mahat and his team at Universiti Teknologi MARA are leading a transformative project in Malaysia, aiming to reverse spinal cord injuries with an injectable conductive hydrogel. This cutting-edge therapy combines several advanced technologies: an injectable scaffold to deliver targeted treatment, conductive materials to restore electrical communication between damaged neurons, and stem cells to regenerate spinal tissue. Additionally, nanoparticles are used to guide the growth of axons, preventing abnormal reconnections that could impair movement or sensation. If successful, this therapy could revolutionize SCI treatment in Asia, offering new hope to millions. Despite the promise of this novel therapy, the team faces challenges, including limited resources, funding, and

ALIGNMENT FOR CELL GROW TO ENHANCE HEALING EFFICACY BY INCORPORATING IRON OXIDE NANOPARTICLES



The orientation of PPy-coated IONPs is impacted by an external magnetic field, a vital factor in directing neural cell growth, particularly in the regeneration of injured spinal cords. While PPy has promising properties for electromagnetic interference (EMI) shielding, further research is needed to determine its impact on IONPs' magnetic stability when exposed to physiological environments.

KEY PRELIMINARY SCIENTIFIC FINDINGS

A. RAPID GELATION TIME, POROUS STRUCTURE FORMATION, STABILITY

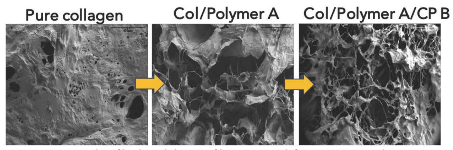
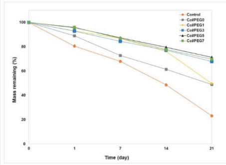


Fig 6: Micrographs of hydrogel showing fibrous network from semi IPN with enhancing porous volume, pore size (30-45 µm), and interconnected 3D pores.



The combined effects of the semi IPN crosslinking network and controlled pore distribution in hydrogels lead to **increased swelling capacity, stability, uniform expansion,** and improved biocompatibility, making them versatile for applications in tissue engineering

B. ELECTRICAL AND CONDUCTIVITY BEHAVIOR

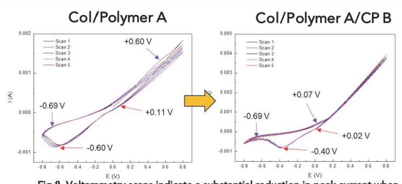
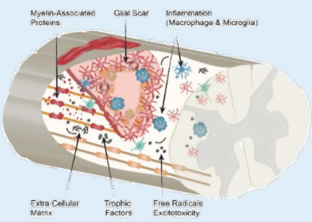


Fig 8. Voltammetry scans indicate a substantial reduction in peak current when CP B is incorporated into the semi-IPN conductive hydrogel. This observation suggests weak electrochemical activity and implies that the electrical properties of the hydrogel remain stable when exposed to physiological conditions.

The high conductivity hydrogel with weak electrochemical activity is potentially due to the **stability of CP B as charge carriers without being easily oxidized or reduced.** Plus, the **semi-IPN crosslinking network traps the charge carriers** and prevents them from diffusing away.

RESEARCH PRODUCT COMPOSITION & HOW IT WORKS



Cystic cavity and glial scars formation retard the neural pathway connection

Fig 2. Scar formation on the injury site cutting all the communication of the spinal cord

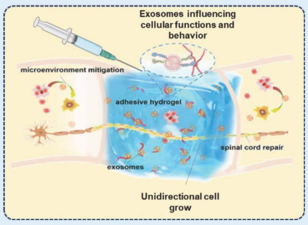


Fig 3. The injected hydrogel solidifies, becoming a conductive medium that affects cellular behavior. It also provides inherent cues for directing cell growth. Cell-material interactions within the microenvironment strongly influence exosome release, with potential implications for tissue regeneration.

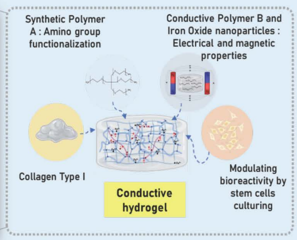


Fig 4. The injectable hydrogel is functionalized with amino group as reactive site for biomolecules, conductive polymer and iron oxide nanoparticles for intrinsic unidirectional guidance, and cell seeding on the later stage of the product development for bioreactivity enhancement.

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Department of Research & Innovation,
Level 5, Bangunan Canseleri Tuanku Syed Sirajuddin,
Universiti Teknologi MARA, 40450 Shah Alam, Selangor

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