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Emerging boundaries in spinal cord injury treatment: a narrative review of neural stem cells, bioscaffold innovations and combinations techniques over traditional treatment approaches: A Narrative Review

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Key Points

Question:
How do bioengineering techniques improve neuroregeneration in SCIs? Can combination therapies enhance sensory and motor recovery beyond traditional treatments?

Findings:
SCIs result in permanent damage with current treatments providing limited recovery. Neural stem cells, bioscaffolds, and 3D bioprinting improve axonal growth and circuit restoration. Combination therapies yield better functional outcomes but face integration challenges.

Meaning:
Bioengineering approaches hold significant potential to transform SCI treatment by addressing limitations of conventional methods. Further research is crucial to optimize recovery and integration.

Abstract

Importance:
Spinal cord injuries (SCIs) lead to sensory, motor, and autonomic dysfunction due to primary axonal damage and secondary inflammatory processes. Current treatments focus on damage control and management, often leaving permanent functional impairments.

Objective:
To explore emerging bioengineering techniques and regenerative medicine principles, including neural stem cells, bioscaffolds, conductive biomaterials, and 3D bioprinting, to improve neuroregeneration and overcome limitations of conventional SCI treatments.
Challenged by the limitation and the incapacity, scientists and researchers have developed a brain–computer interface technology (BCI) that enables direct communication between the brain and external computing devices independently of the peripheral nerves or muscles augmenting human capabilities in interacting with the physical environment.

Evidence Review
A narrative review of advancements in regenerative medicine, focusing on preclinical and clinical studies involving combination therapies. These include innovative materials and approaches that aim to enhance neurogenesis, axonal growth, and neuroelectrical circuit restoration.

Findings
Current treatments like surgical decompression and rehabilitation have limited efficacy in reversing SCIs. Bioengineering techniques such as neural stem cells and bioscaffolds promote neuroregeneration and provide structural support for cell survival and integration. Combination therapies demonstrate improved sensory and motor outcomes compared to standalone interventions, though challenges like limited recovery and functional integration remain.

Conclusions and Relevance:
Regenerative medicine offers promising avenues for SCI treatment by enhancing neuroregeneration and functional restoration. Combination therapies leveraging bioengineering innovations have shown beneficial outcomes, emphasizing the need for further research to overcome existing limitations.

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