Additional Table 1 Abstract table of the latest biological therapeutic approaches for spinal cord injury implemented in macaques

Type of injury	Type of intervention	Material	Main functional outcomes	Animal species	References
Spinal cord injury C3/4-Th10 level, complete sub-acute (within 24 days post-injury).	Cell transplant	Neural stem/progenitor cell (NS/PC) human transplantation and galectin-1.	There were notable distinctions in the myelinated area, corticospinal fibbers, and serotonergic fibbers.	Ten adult female marmosets (280–350 g; Clean Japan Inc., Tokyo, Japan).	Yamane et al., 2010; Kawai et al., 2023
Spinal cord left hemisection. Level T10.	Cell transplant	Cell human spinal GABA dI4 neural progenitor cells (NPCs) from human embryonic stem cell lines expressing hM3Dq.	In the dorsal horn of the spinal cord, there is inhibition of axonal growth and synaptogenesis. There is a pronounced level of cell proliferation and differentiation in human astrocytes, along with heightened connectivity between primates and humans, predominantly of a sensory nature.	Adult male rhesus macaques.	Zheng et al., 2023

Spinal cord injury (Compressive) C5	Cell transplant	Transplantation of pre-evaluated NS/PC (HIPS-NS/PC) derived from the human iPSC clone.	The human induced pluripotent stem cell-derived neural stem/progenitor cells (hiPSC-NS/PCs) exhibited viability within the recipient spinal cord and underwent differentiation, manifesting as Olig1-positive cells. Their impact primarily involved the conservation of existing myelin sheaths rather than actively engaging in remyelination following spinal cord injury (SCI).	10 Adult female common marmosets.	Tsuji et al., 2019
Thoracic Drop weight contusion injury. T10	Cell transplant	Transplants of neural stem cells (NSCs)	NSCs are multipotent, self-renewing stem cells that can differentiate into neural lineage cells. NSCs secrete neurotropic factors that help protect or regenerate the injured spinal cord.	Adult male Rhesus macaques and adult female.	Joo et al., 2022; Nemati, et al. 2014
A moderate injury spinal cord. Level T8-T10.	Cell transplant	Human cell line transplantation NSI-566.	Enhance of two-level sensory and motor improvements (from T8 to T10) bilaterally at 6, 12, and 18 months, and one-level sensory and motor improvement at 27 months, compared to baseline pretreatment.	Humans: Men and women 18-65 years.	Curtis et al., 2018

Spinal cord hemisection at thoracic level T8.	Membranes or scaffolds	Chitosan tube - Neurotrophic factor 3 NT3.	There is evidence of a partial restoration triggered by NT3-chitosan evidencing MEP signals from the muscles of the hind legs.	Thirty-eight female rhesus monkeys (Macaca mulata, 4 to 6 years old).	Rao et al., 2018
A moderate injury spinal cord. Level T8-T10.	Membranes or scaffolds	Mesenchymal stem cell exosomes.	These findings are consistent with a phenotypic switch of inflammatory hypertrophic microglia towards anti-inflammatory, homeostatic functions, which was correlated with enhanced functional recovery.	In vitro study, with human bone marrow aspirates from young adults, non-smoking males.	Go et al., 2020
T8-9 spinal cord transection model.	Membranes or scaffolds	Human neural progenitor cell collagen scaffolds (hscNPC), BDNF GDNF.	The membrane enhances synapses with host sensory and motor axons in the injured spinal cord of rhesus monkeys.	A total of 19 adult female rhesus monkeys (Macaca mulatta), 3 to 4 years old and weighing 4.1 to 5.8 kg, were used.	Xu et al., 2023
Spinal cord T7-9 hemicord excision.	Membranes or scaffolds	Chitosan tube - Neurotrophic factor 3 NT3	Robust axonal regeneration was achieved after thoracic SCI by implanting scaffolds of bioactive material NT3-chitosan in rodents and primates.	Nine adult female rhesus monkeys (Macaca mulatta, 4–6 years, 5 ± 1 kg) were used.	Rao et al., 2022
Hemisection lesions. Level C7	Membranes or scaffolds	Human spinal cord-derived NPCs in fibrinogen membrane with human thrombin with Neurotrophic factors.	Axonal growth rostrally from the spinal cord. Axons extended into white matter tracts that rested directly against the grafts and appeared to maintain growth within these same white matter fascicles to points distant from the graft. This is related to the increased motor control shown.	9 naive male rhesus macaques (Macaca mulatta), 6 to 10 years old.	Rosenzweig et al., 2018

Spinal cord for hemisection. Level T9-T11.	Membranes or scaffolds	Three-dimensional gelatin sponge scaffold (3D-GS) as a vehicle for human umbilical cord mesenchymal stem cells.	Gradually recovered motor function in the ipsilateral hind leg, although strength, support of body weight, Gait, coordination and finger movement remained poor relative to healthy monkeys.	10 males Macaca fascicularis these experiments monkeys were used (from 5 to 8 years, from 6 ± 1 kg in weight; XuRi Biotechnology Inc., Guangzhou, China).	Zeng et al., 2023
Lateral hemisection of the thoracic (T9-T10).	Membranes or scaffolds	Porous poly (lactide-co-glycolide) polymer (PLGA) scaffolds with stem cells and neurotrophic factors.	Behavioral assessments confirmed improvement in postoperative paralysis over time.	The study used four juvenile male African green monkeys weighing between 2.3 and 2.7 kg.	Slotkin et al., 2017
Spinal cord injury complete. evel (T1-T12).	Membranes or scaffolds	“NeuroRegen” loaded with autogenous bone marrow mononuclear cells (BMMCs).	Different degrees of improvement were observed in terms of sensory level, defecation sensation, physiological erection, increased sweating, recovery of superficial sensation and recovery of deep sensation.	The patients were humans, male or female, and was between 18 and 65 years old.	Chen et al., 2020
Complete SCI at the cervical or thoracic level (C5-T12)	Membranes or scaffolds	NeuroRegen loaded with human umbilical cord mesenchymal stem cells (hUCB-MSC).	Over the course of a one-year observational period following scaffold implantation, our findings indicate that 62.5% of subjects exhibited an augmentation in the level of sensory responsiveness. Additionally, among three patients with cervical lesions, there was observed improvement in finger flexibility.	The patients were humans, 8 patients (seven men and one woman) with a mean age of 31.5 years.	Zhao et al., 2017

Transection spinal cord on the left back at thoracic level T10.	Membranes or scaffolds	Biodegradable hydrogel that encapsulates (Human Neuroepithelial stem cells) NESCs and mesenchymal stem cell (MSC).	Together, these results suggest that the beneficial effects of NESC and MSCs involve promoting neurogenesis and myelination, and reducing inflammatory responses.	A total of 9 female rhesus monkeys (13-20 years, weighing 4 ± 2 kg) were used in this study. 6 rhesus monkeys.	Li et al., 2023
Acute thoracic (T9) complete transection.	Membranes or scaffolds.	Collagen binding neurotrophin-3 (CBD-NT3) Modified Collagen Scaffolds	Therefore, we speculate that the newly generated neurons could form neuronal relays to reconnect the injury gap, leading to partial functional recovery in monkeys treated with LOCS+CBD-NT3.	A total of 15 adult male rhesus monkeys (Macaca mulatta) aged 3 to 4 years and weighing 4.1 to 5.8 kg were used in this study.	Han et al., 2019
Spinal cord hemisection at T8 level	Membrane with autologous nerve graft	Peripheral nerve graft (PNG) and acid fibroblast growth factor (aFGF).	The inflammation was mainly in the center of the lesion and gradually decreased proximally and distally.	6 adult male rhesus macaques, weighting 8–10 kg	Ko et al., 2019
T8 spinal cord hemisection.	Membranes with autologous nerve graft	Sural nerve segment transplantation long-term infusion of acid fibroblast growth factor (aFGF) plus therapeutic exercise.	Both treated monkeys were able to start walking 4 weeks after the injury.	In this study, four male rhesus monkeys (Macaca mulatta) weighing 5 to 7 kg were used.	Sun et al., 2021
T9-T10 spinal cord segment.	Cell therapy and graft tissue	Graft of self-genous neural stem cell of subventricular zone (NSC of SVZ).	The monkeys showed recovery of sensory and motor function, regeneration of the spinal tract, and partial reconstruction of the spinal cord.	8 Rhesus monkeys weighing between 3 and 6 kg and aged between 3 and 6 years were obtained.	Jaberi et al., 2023

This table succinctly compiles the most representative and current experimental studies carried out on spinal cord injury in macaques as animal models, emphasizing the utilized materials, experimental population characteristics, and the achieved outcomes. It substantiates the viability of NHP models for use in biological therapies involving cells or tissues derived from humans. Furthermore, it elucidates the evolution of functional recovery resulting from the effects of the employed strategies that demonstrate similarities with human outcomes regarding temporal aspects, motor capacity, and sensory function.