



# Activated Platelet-Rich Plasma Improves Locomotor Functional Recovery and Attenuates Glial Scars Formation in Spinal Cord Injury Rats

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## ABSTRACT

Spinal cord injury (SCI) is a severe traumatic disorder of the nervous system, often leading to neuronal death, axonal disruption, glial scar formation, and dysregulated inflammatory responses, ultimately resulting in irreversible sensory and motor dysfunction. The aim of this study was to evaluate the effects of activated platelet-rich plasma (PRP) on locomotor functional recovery and glial scars formation following SCI in rats. A total of 25 female Wistar rats were assigned into 5 groups, with 5 rats per group; Sham, SCI without treatment, SCI with 5  $\mu$ L PRP, SCI with 10  $\mu$ L PRP, and SCI with 15  $\mu$ L PRP. The Sham group underwent laminectomy at the T10 level only. All rats in the SCI groups underwent laminectomy followed by one minute compression of the spinal cord with an aneurysm clip to establish spinal cord injury. Appropriate volumes (5  $\mu$ L, 10  $\mu$ L and 15  $\mu$ L) of activated PRP were injected intrathecally 24 hours post injury through a tiny longitudinal incision between L4-L5 per rat in the different SCI + PRP groups. The BBB locomotor scores for the different experimental groups were recorded on days; 2, 7, 14, 21 and 28. The rats were then sacrificed on the 28<sup>th</sup> day and spinal cord tissue harvested, fixed and processed histologically. Sections were stained by Masson trichrome staining method. The results demonstrated that PRP treatment significantly improves locomotor functional recovery and reduces glial scars formation after SCI in a dose-dependent manner. In conclusion, PRP showed neuroregenerative and neuroprotective effects following SCI in rats.

**Keyword:** Spinal Cord Injury, Locomotor, Laminectomy, Neuroprotective, Glial scars, Neuroregeneration.

## INTRODUCTION

Spinal cord injury (SCI) is a severe traumatic disorder of the nervous system, often leading to neuronal death, axonal disruption, glial scar formation, and dysregulated inflammatory responses, ultimately resulting in irreversible sensory and motor dysfunction. (Xiao *et al.*, 2026). Most SCI patients have a history of trauma, such as a car accident, sports injury, work-related accident, fall, or violence. However, SCI may also arise from non-traumatic causes, such as degenerative myelopathy, spine tumors or epidural abscesses causing cord compression, and vascular disease (Barriga-Martin *et al.*, 2025).

Spinal cord injury is one of the leading causes of morbidity and mortality worldwide (Yadollahi *et al.*, 2023). More than 27 million people globally are reported to suffer from long-term disability after SCI (Wiles, 2022). Generally, young adults are involved, where the burden of permanent neurological damage is unbearable for the patients, their care givers, and the health system (Cofano *et al.*, 2019). It has been estimated that 12,000

new SCI cases are reported in North America annually, and men between 25–35 years of age are the most affected (Bravo-Reyna *et al.*, 2025). Studies conducted by Ishaku *et al.* (2021) in Maiduguri, North-Eastern Nigeria and Ibikunle and Okoro (2018) in South-Eastern Nigeria revealed that individuals between the ages of 18 and 40 years were the most affected by SCI. This age group is often economically active and productive, making them more prone to physical activity-related accidents and hazards, including those encountered in occupational, sports, recreational, and transport-related activities (Ishaku *et al.*, 2021).

Despite decades of investigation, the management of spinal cord injury remains a formidable clinical challenge owing to the complexity of its pathophysiology and the limited effectiveness of current therapies (Wang *et al.*, 2026). Majority of the degeneration of the nervous system that occurs after a traumatic event is caused by multifactorial secondary damage, which includes various molecular processes such as oxidative stress, inflammation, neuronal death, impaired regeneration, ionic dysregulation, free radicals, mitochondrial dysfunction and lipid peroxidation, as well as disconnection of normal nerve pathways, blood-brain barrier dysfunction, apoptosis, and necrosis (Nowacka *et al.*, 2025; Cofano *et al.*, 2019).

Studies have shown that PRP concentrates are source of abundant growth factors and cytokines (Tan *et al.*, 2022), these are important signaling molecules in the healing process (Shang *et al.*, 2025). Multiple preclinical studies demonstrated that PRP administration significantly improves locomotor function and reduces pathological changes in animal models of SCI (Toloui *et al.*, 2024). Chaudhari *et al.* (2025) recently demonstrated that activated PRP fibrin scaffolds significantly reduced glial scarring in a complete spinal cord transection rat model. This study was aimed at evaluating the effects of platelet-rich plasma on locomotor functional recovery and glial scars formation following experimental spinal cord injury in Wistar rats.

## MATERIALS AND METHODS

### Study Location

This study was carried out in collaboration with the Laboratories of Histopathology Department, School of Medical Laboratory Sciences, Usmanu Danfodiyo University, Sokoto, the Service Laboratory of Department of Histopathology, Usmanu Danfodiyo University Teaching Hospital, Sokoto and the Animal House of Faculty of Pharmaceutical Sciences, Usmanu Danfodiyo University, Sokoto.

### Ethical Approval

All the procedures of this research were performed according to the Guideline for the Care and Use of Laboratory Animals, and protocols approval of the research was sorted from and approved by the Ethics and Research Committee on the use of Laboratory Animals for research of the Usmanu Danfodiyo University, Sokoto, with approval number: **NHREC/UDUS-HREC/25/06/2023**.

### Experimental Animals

Twenty five (25) female Wistar rats weighing 270-290g were purchased from Ahmadu Bello University, Zaria. Rats were housed in a standard temperature-controlled animal room at Faculty of Pharmaceutical Sciences, Usmanu Danfodiyo University, Sokoto, with a 12-hour light/dark cycle and free access to water and standard food.

### Experimental Design

The twenty five (25) female Wistar rats for the research were randomized and assigned to five (5) equal groups (n = 5): Group A was the Sham group, where the rats underwent laminectomy without SCI and treatment; Group B, where rats underwent SCI but no treatment was given; Group C, where the rats underwent SCI and were treated with 5  $\mu$ L of activated PRP; Group D, where the rats underwent SCI and were treated with 10  $\mu$ L of activated PRP; and Group E, where the rats underwent SCI and were treated with 15  $\mu$ L of activated PRP.

## Preparation and Activation of Platelet-Rich Plasma

Blood was harvested from healthy Wistar rats through cardiac punctures under anaesthesia. The blood was anticoagulated with 3.2% sodium citrate at a blood/citrate ratio of 9:1. The blood was then centrifuged at 1500 rpm for 10 minutes at room temperature, and the supernatant (containing plasma and buffy coat) was collected and transferred into a new tube and centrifuged at 3500 rpm for 10 minutes at room temperature. The pellet was then extracted and diluted with a portion (about one third) of the supernatant plasma to form the final PRP concentration. The platelet-rich plasma was then activated using sterile 10% CaCl<sub>2</sub> solution in the ratio 0.1 mL of 10% CaCl<sub>2</sub> to 1.0 mL of PRP. The solution was then mixed by gentle swirling to prevent platelet damage. This was then incubated at 37°C for 5 minutes to form a cohesive gel for intrathecal injection.

## Establishment of Spinal Cord Injury

Rats were anaesthetized by intraperitoneal injection with ketamine (80 mg/kg) and xylazine (10 mg/kg). The thoracic area of the rat was shaved following the application of iodine to the skin and then placed on stereotactic frame. Laminectomy of the caudal portion of T9 and all of T10 was performed by using fine Rongeur tool to expose the spinal cord without damage to the dura. The spinal cord at the vertebral T10 segment then underwent a minute compression with an aneurysm clip, horizontally to establish the spinal cord injury. The injury was confirmed by the observation of an immediate area of hematoma over the spinal cord tissue and a nervous twitch over the entire hind limb and tail region. Body temperature of the rat was checked and monitored during the surgery in the range of 36-37°C. After wound closure, iodine was applied to the skin. The rats were maintained at a warm temperature using a heat pad until they recovered from anaesthesia. Subsequently, manual bladder evacuation was performed twice daily to prevent urinary infection and relieve pains. The condition of the wound was checked during the bladder evacuation and iodine applied to the skin once daily.

## Administration of Platelet-Rich Plasma

The rats in the SCI + PRP groups were anaesthetized by intraperitoneal injection with ketamine (80 mg/kg) and xylazine (10 mg/kg) twenty-four (24) hours post SCI surgery, and fixed at the edge of the worktable with forelimbs stretched out and the caudal half of the body hanging off the edge to flex the lumbar vertebral column. The skin covering the L4-L5 vertebrae was shaved and cleaned; a very tiny longitudinal incision was then made through the skin. Appropriate volumes (5 µL, 10 µL or 15 µL) of activated PRP were aspirated using microliter syringes (Hamilton) under sterile condition and injected intrathecally into the lumbar cistern per rat in the different SCI + PRP groups. The tail flick response was used as confirmatory sign of correct insertion of the needle through the dura mater.

## Evaluation of Locomotor Functional Recovery

Locomotor functional recovery of the hind limb was evaluated using the 0 to 21 - point Basso-Beattie-Bresnahan (BBB) locomotion rating scale. The rating scale rates locomotor behaviour of rats after spinal cord injury from 0 to 21 (0 = Complete paralysis, 21 = Normal). The rats (n = 5) from each group were assessed with this scale at days; 2, 7, 14, 21 and 28 after SCI by two independent investigators who were blinded to the group assignment (Basso *et al.*, 1995).

## Histological Techniques

Four weeks post spinal cord injury, the rats (n = 5) from each group were sacrificed through intraperitoneal injection as described earlier. Perfusion was carried out transcardially with 0.9% normal saline and subsequently with 10% neutral buffered formalin via the left ventricle. About 10 mm long sample segment of the spinal cord corresponding to the epicenter of injury was removed and post-fixed in 10% neutral buffered formalin. The samples were then processed and embedded by paraffin embedding technique, and sections were cut using a standard rotary microtome and mounted on clean microscope slides for Masson trichrome staining techniques (Bancroft and Gamble, 2005).

## Masson Trichrome Staining for Collagen (glial scars)

Sections were dewaxed in two changes of xylene and hydrated in descending grades of alcohol and finally washed in water. The sections were then stained with Weigert's iron haematoxylin for 15 minutes, and then washed in water. The sections were then briefly differentiated in 1% acid alcohol and rinsed in distilled water. Sections were then stained in 0.5% acid-fuchsin solution for 5 minutes, then rinsed in distilled water. Sections were then treated with 1% phosphomolybdic acid solution for 5 minutes, and the slides were drained. The sections were then stained with 2% methyl blue for 5 minutes, and then rinsed in distilled water. Sections were then briefly differentiated with 1% acetic acid. The sections were then dehydrated through ascending grades of alcohol, cleared in xylene and mounted in DPX. A light microscope with digital camera (AmScope, USA) was used to examine the deposition of collagenous connective tissues as glial scars, and photographic images were taken at x400 magnification.

## Statistical Analysis

Data generated from the study was expressed as the Mean  $\pm$  SEM (the standard error of the mean) and was analyzed using the SPSS software version 23. Comparisons between different animal groups were performed by one-way analysis of variance (ANOVA). A  $p \leq 0.05$  was considered to be statistically significant.

## RESULTS

### Evaluation of Locomotor Functional Recovery

Table 1 presents the Basso Beattie Bresnahan (BBB) locomotor scale scores for the different experimental groups in the study. The measurements were taken at Day; 2, 7, 14, 21, and 28 post-injury across the five (5) experimental groups. Statistical significance is indicated by superscript letters (a, b, c, d) within each column and groups sharing the same letter are not significantly different, while groups with different letters indicate significant difference at  $p < 0.05$ .

The F values obtained from the generated data range from 44.375 to 132.353 indicating strong group differences. While the P values  $< 0.001$  for all time points, is confirming that the observed differences are highly significant. Superscript letters on Tab. 1 clearly showed a dose-response trend; higher PRP doses lead to better recovery, with 15 $\mu$ L being the most effective.

Table 1: Showing the mean  $\pm$  standard error of the of the BBB scores

Groups	Day 2	Day 7	Day 14	Day 21	Day 28
Sham	20.0 $\pm$ 0.4 <sup>a</sup>	21.0 $\pm$ 0.0 <sup>a</sup>	21.0 $\pm$ 0.0 <sup>a</sup>	21.0 $\pm$ 0.0 <sup>a</sup>	21.0 $\pm$ 0.0 <sup>a</sup>
SCI + No treatment	5.0 $\pm$ 0.7 <sup>b</sup>	11.0 $\pm$ 0.3 <sup>b</sup>	15.0 $\pm$ 0.3 <sup>b</sup>	15.0 $\pm$ 0.3 <sup>b</sup>	15.0 $\pm$ 0.3 <sup>b</sup>
SCI + 5 $\mu$ L PRP	5.0 $\pm$ 0.7 <sup>b</sup>	13.0 $\pm$ 0.5 <sup>bc</sup>	16.0 $\pm$ 0.3 <sup>bc</sup>	17.0 $\pm$ 0.3 <sup>c</sup>	17.0 $\pm$ 0.3 <sup>c</sup>
SCI + 10 $\mu$ L PRP	5.0 $\pm$ 0.6 <sup>b</sup>	14.0 $\pm$ 1.0 <sup>c</sup>	17.0 $\pm$ 0.3 <sup>cd</sup>	18.0 $\pm$ 0.3 <sup>cd</sup>	19.0 $\pm$ 0.3 <sup>d</sup>
SCI + 15 $\mu$ L PRP	5.0 $\pm$ 0.3 <sup>b</sup>	15.0 $\pm$ 0.3 <sup>c</sup>	18.0 $\pm$ 0.3 <sup>d</sup>	19.0 $\pm$ 0.3 <sup>d</sup>	20.0 $\pm$ 0.3 <sup>ad</sup>
F value	132.353	44.375	66.250	62.500	72.500
P value	<0.001	<0.001	<0.001	<0.001	<0.001

Values are mean  $\pm$  standard error of the mean of the BBB scores. Values with different superscript in the same column are significantly different at  $p < 0.05$ , at 95 % confidence interval.

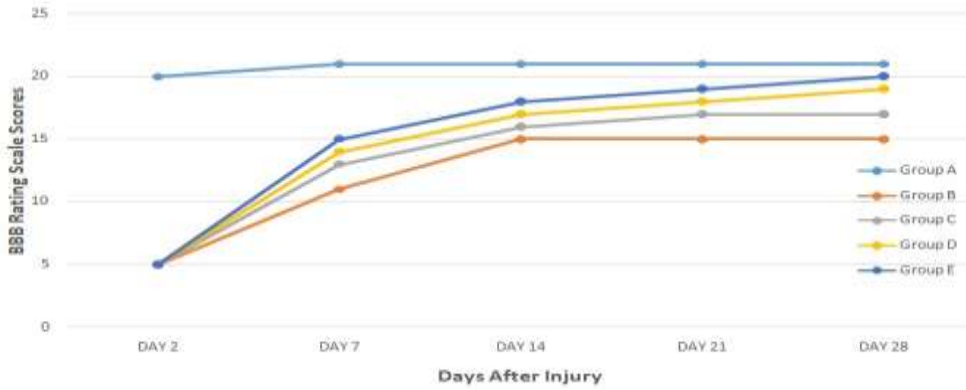


Figure 1: Graph of Basso Beattie Bresnahan Locomotor Rating Scale Scores

Figure 1 shows the Graph of Basso Beattie Bresnahan Locomotor Rating Scale Scores for the different experimental groups in the study. On day 2 post injury, the Sham group scored a near-normal function, as expected, while all the SCI groups showed severe impairment of the hind limbs. On day 7 post injury, the Sham scored the normal BBB value, the no treatment group showed slight recovery, while the PRP treated groups showed better locomotor functional recovery in a dose dependent manner with the 10  $\mu$ L and 15  $\mu$ L PRP groups showing significant locomotor recovery. On day 14 post injury, the Sham group maintained the normal BBB score, while the 5  $\mu$ L group showed slightly better recovery than the no treatment group. The 10  $\mu$ L and 15  $\mu$ L PRP groups showed significantly better functional recovery than the no treatment group.

On day 21 post injury, the Sham group maintained the normal BBB score, while the no treatment group maintained the score recorded on Day 14, showing a plateau phase of functional recovery. The 5  $\mu$ L group showed slightly better recovery than the no treatment group. The 10 $\mu$ L PRP group showed a significantly better functional recovery than the no treatment group. The 15  $\mu$ L PRP group showed the best motor functional recovery approaching the near normal. On day 28, the Sham group maintained the normal BBB score, while the no treatment group maintained the score recorded on Day 14, showing a plateau phase of functional recovery. The 5 $\mu$ L group maintained the BBB score recorded on Day 21, also showing a plateau phase of functional recovery. The 10  $\mu$ L PRP group showed a significantly better functional recovery than the no treatment group, while the 15  $\mu$ L PRP group showed the best motor functional recovery approaching the near normal BBB score.

### Masson Trichrome Staining for Collagen (glial scars)

The Masson trichrome stained sections (Plate 1) across the five different experimental groups revealed different histological changes.

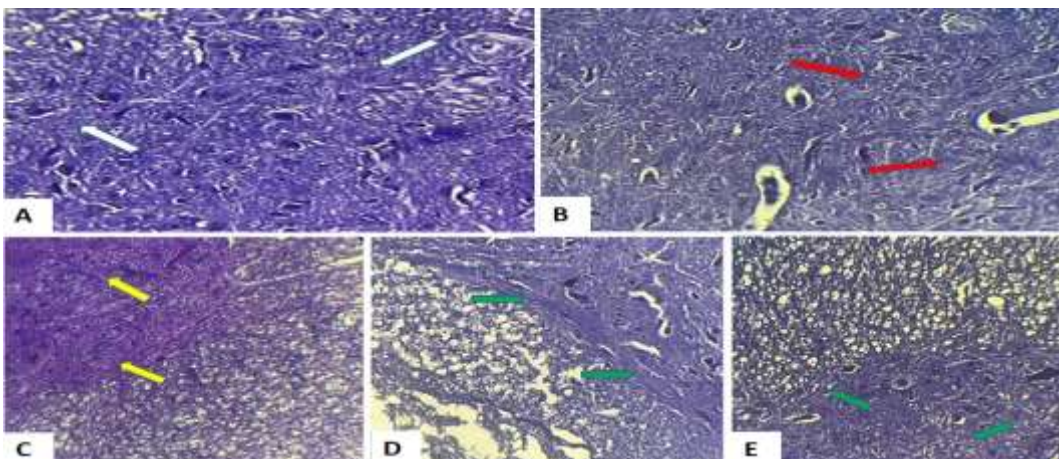


Plate 1: Sections of Spinal Cord Tissue Stained with Masson Trichrome Staining Technique X400

A = Sham, B = SCI without treatment, C = SCI + 5  $\mu$ L PRP, D = SCI + 10  $\mu$ L PRP and E = SCI + 15  $\mu$ L PRP.

Keys: White arrows = No fibrosis, Red arrow = Marked fibrosis, Yellow arrows = Moderate fibrosis, Green arrows = Mild fibrosis.

The Masson trichrome stained sections (Plate 1) across the five different experimental groups revealed different histological changes as follows:

**Group A** (Plate 1A) section revealed normal histological features with the spinal cord tissue showing no formation of fibrotic tissue or fibrosis.

**Group B** (Plate 1B) section showed formation of abundant fibrotic substances within the spinal cord tissue.

**Group C** (Plate 1C) section revealed moderate improvement with few areas of fibrotic tissue formation.

**Group D** (Plate 1D) section showed appreciable improvement in the histological appearance with very scanty deposition of fibrotic tissue in some areas of the stained section.

**Group E** (Plate 1E) section revealed histological features similar to that of group D.

## DISCUSSION

The present study investigated the therapeutic effects of different doses of platelet-rich plasma (PRP) on locomotor recovery following spinal cord injury (SCI) in an experimental model. The results demonstrated a clear dose-dependent improvement in functional outcomes, with the 15  $\mu$ L PRP group achieving near-complete recovery (BBB score of  $20.0 \pm 0.3$  by Day 28), statistically comparable to the sham group. These findings provide compelling evidence for the neuro-regenerative potential of PRP and contribute to the growing body of literature supporting its application in SCI repair.

The most striking finding of this study is the clear dose-response relationship observed across all time points post-injury. While all SCI groups exhibited severe impairment (BBB score of 5.0) at Day 2, indicating consistent injury induction, divergent recovery trajectories emerged by Day 7 and became increasingly pronounced through Day 28. The 15  $\mu$ L PRP group consistently outperformed lower-dose groups, achieving BBB scores of 20.0 by study endpoint; a level statistically indistinguishable from the sham-operated controls.

This dose-dependent effect aligns with the understanding that PRP exerts its therapeutic benefits through the concerted action of multiple growth factors, including PDGF, VEGF, TGF- $\beta$ , and IGF-1, each contributing to different aspects of neural repair. VEGF promotes angiogenesis, potentially improving perfusion to the injured spinal cord and creating a supportive vascular niche for regenerating axons. PDGF and IGF-1 support cell survival and proliferation, while TGF- $\beta$  modulates the inflammatory response and may influence scar formation. Higher PRP volumes presumably deliver greater concentrations of these bioactive molecules to the injury site, creating a more favourable microenvironment for neuroregeneration. Chen *et al.* (2018) directly compared single versus sustained PRP administration in rat SCI models, finding that repeated treatment produced superior histological outcomes, including enhanced angiogenesis and tissue preservation. The superior outcomes observed with 15  $\mu$ L PRP in the present study are consistent with this optimal range.

The functional recovery achieved in the 15  $\mu$ L PRP group compares favourably with findings from recent investigations. Chaudhari *et al.* (2025) developed activated PRP-derived fibrin scaffolds for SCI repair and reported significant functional improvements at 30 days post-implantation in a complete spinal cord transection rat model. Their scaffold-based approach not only enhanced locomotor recovery but also promoted neo-vascularization, reduced glial scarring, and facilitated axonal regeneration mechanisms that likely contributed to the functional outcomes observed in this study as well. Importantly, they demonstrated that PRP-based biomaterials could achieve tissue integration and angiogenesis, supporting the concept that PRP creates a regenerative microenvironment rather than simply supplying growth factors in isolation. The multimodal validation employed in their study, including MRI, retrograde neuronal tract tracing, and

electrophysiological recordings, provides robust mechanistic support for the functional improvements they observed using the BBB scale (Chaudhari *et al.* 2025).

In another recent study, Akbari-Gharalari *et al.* (2025) explored the effects of PRP-derived exosomes loaded with Cerebrolysin in a mouse model of compression SCI. Their study revealed that PRP-based interventions significantly modulated apoptosis-related markers (Bax and Bcl2 expression) and inflammatory cytokines (TNF- $\alpha$  and IL-10), while simultaneously improving tissue organization and motor function. These findings are particularly relevant to our results, as they suggest that PRP may promote recovery through dual mechanisms: reducing secondary injury processes (apoptosis and inflammation) while enhancing tissue repair. The dose-dependent recovery observed in our study may reflect increasingly effective modulation of these pathological processes with higher PRP volumes.

Behroozi *et al.* (2022) investigated human umbilical cord blood-derived PRP (HUCB-PRP) in a rat SCI model and reported significantly enhanced hind limb locomotor performance compared to untreated controls. Their mechanistic analyses revealed that PRP treatment reduced caspase-3, GSK3 $\beta$ , and CSF-tau expression while increasing MAG levels in the spinal cord, indicating suppression of apoptotic pathways and promotion of axonal regeneration. These molecular changes provide a plausible explanation for the functional improvements we observed, particularly the near-complete recovery in our high-dose PRP group. The consistency of findings across different PRP sources (peripheral blood versus cord blood) suggests that the therapeutic potential of PRP may be independent of donor source, enhancing its clinical translatability.

The temporal pattern of recovery observed in our study warrants attention. All PRP-treated groups demonstrated accelerated improvement between Day 7 and Day 14, with the 15  $\mu$ L group achieving a BBB score of 18.0 by Day 14 compared to 15.0 in untreated controls. This early acceleration of recovery is clinically significant, as interventions that expedite functional gains can reduce complications associated with prolonged immobilization and improve quality of life.

The sustained improvement through Day 28, with the 15  $\mu$ L group reaching scores comparable to sham controls, suggests that PRP may promote durable neuroregeneration rather than merely transient symptomatic improvement. This interpretation is supported by Chaudhari *et al.* (2025) observation that PRP fibrin scaffolds facilitated axonal regeneration and tissue integration observable at the histological level. The continued divergence between treatment groups at later time points further argues against a simple anti-inflammatory effect and supports true neuroregenerative activity.

## CONCLUSION

The study demonstrates that PRP improves locomotor functional recovery and attenuates glial scars formation following spinal cord injury in Wistar rats in a clear dose-dependent manner, with the highest dose (15  $\mu$ L) achieving near-complete functional recovery comparable to the sham-operated controls. These findings extend the growing evidence base supporting PRP as a promising therapeutic strategy for SCI and highlight the critical importance of dose optimization in protocol development.

### Limitations of the Study

This study provides valuable data, but several limitations should be acknowledged:

1. The study used female rats only; sex differences in PRP responses should be investigated.
2. The study employed a compression model of SCI; there is need to find if similar result would be obtained in complete transection SCI models.
3. The sample size of five rats per group, while adequate for histological assessment, limits statistical power for detecting subtle differences.

4. The follow-up period of 28 days, while adequate to demonstrate initial recovery, does not address long-term durability of the observed improvements.
5. The present study focused on functional recovery outcomes, but did not work on detailed histological changes.

### Ethical Approval

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed following the ethical standard laid down in 1964 Declaration of Helsinki.

### Disclaimer (Artificial Intelligence)

Authors hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript.

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### Competing interests

Authors have declared that no competing interests exist.

### REFERENCES

1. Akbari-Gharalari, N., Aliyari-Serej, Z., Ghahremani-Nasab, M., Zangbar, H.S., Yahyavi, Y., Nezhadshahmohammad, F. and Ebrahimi-Kalan, A. (2025). Cerebrolysin-loaded platelet-rich plasma exosomes: Restoring immune homeostasis via TNF- $\alpha$ /IL-10 modulation and apoptosis targeting for spinal cord injury repair. *The Journal of Spinal Cord Medicine*; 1-13.
2. Bancroft, J.D. and Gamble, M. (2005) *Theory and Practice of Histological Techniques*, 5<sup>th</sup>edn. Churchill Livingstone.
3. Barriga-Martín, A., Pérez-Ruiz, P., Muñoz-Rodríguez, J.R., Romero-Muñoz, L., Peral-Alarma, M., Ríos-León, M. and Álvarez-Bautista, E. (2025). Epidemiology of traumatic spinal cord injury in Spain: a ten-year analysis of trend of clinical and demographic characteristics. *The Journal of Spinal Cord Medicine*; **48(5)**:884-890.
4. Basso, D.M., Beattie, M.S. and Bresnahan, J.C. (1995). A sensitive and reliable locomotor rating scale for open field testing in rats. *Journal of Neurotrauma*; **12**:1–21.
5. Behroozi, Z., Ramezani, F. and Nasirinezhad, F. (2022). Human umbilical cord blood-derived platelet-rich plasma: a new window for motor function recovery and axonal regeneration after spinal cord injury. *Physiology and Behavior*; **252**:113840.
6. Bravo-Reyna, C.C., Miranda-Galván, V., Reyes-Soto, G., Vicuña, R., Alanis-Mendizabal, J., Escobar-Valderrama, M., Arango, D., Bautista, C.J., Ramírez, V., Torres-Villalobos, G. (2025). Evaluation of the Chetomin effect on histopathological features in a murine acute spinal cord injury model. *World Neurosurgery*; X; **25**:100414.
7. Chaudhari, L.R., Kawale, A.A., Sonkawade, O., Damle, M., Patil, J., Desai, S. and Joshi, M.G. (2025). Activated Platelet-Rich Plasma Fibrin Scaffolds Enhance Axonal Regeneration and Functional Recovery Following Spinal Cord Injury. *Annals of Biomedical Engineering*; 1-20.
8. Chen, N.F., Sung, C.S., Wen, Z.H., Chen, C.H., Feng, C.W., Hung, H.C., Yang, S.N., Tsui, K.H. and Chen, W.F. (2018). Therapeutic Effect of Platelet-Rich Plasma in Rat Spinal Cord Injuries. *Frontiers in Neuroscience*; **12**:252.

9. Cofano, F., Boido, M., Monticelli, M., Zenga, F., Ducati, A., Vercelli, A. and Garbossa, D. (2019). Mesenchymal Stem Cells for Spinal Cord Injury: Current Options, Limitations, and Future of Cell Therapy. *International Journal of Molecular Sciences*; **20**(11):2698.
10. Ibikunle, P.O. and Okoro, E.O. (2018). A fifteen years retrospective study of spinal cord injury in South-Eastern Nigeria. *EC Orthopaedics*; **9**:671-87.
11. Ishaku, C.M., Jawa, B.K., Maduagwu, S.M., Hassan, A.B., Lawan, A., Rufa'i, A.A. and Oyeyemi, A.Y. (2021). Pattern and outcome of traumatic spinal cord injury managed at University of Maiduguri Teaching Hospital, Nigeria: A retrospective study. *Nigerian Postgraduate Medical Journal*; **28**:139-44.
12. Nowacka, A., Sniegocki, M. and Ziolkowska, E. (2025). A review of the potential use of antioxidants in spinal cord injury. *Antioxidants*; **14**(9):1081.
13. Shang K., Liu, Y. and Qadeer, A. (2025). Platelet-rich plasma in peripheral nerve injury repair: A comprehensive review of mechanisms, clinical applications and therapeutic potential. *Experimental Biology and Medicine*; **250**:10746.
14. Tan, Q., Li, J., Yin, Y. and Shao, W. (2022). The role of growth factors in the repair of motor injury. *Frontiers in Pharmacology*; **13**:898152.
15. Toloui, A., Adel, R.H., Aboutaleb, N. and Yousefifard, M. (2024). Effectiveness of platelet-rich plasma in treating spinal cord injury: A systematic review and meta-analysis. *Basic and Clinical Neuroscience*; **15**(4):443-454.
16. Wang, Y., Li, C., Yu, H., Wang, H. and Zhang, X.D. (2026). Molecular diagnosis and interventions for spinal cord injury. *TrAC Trends in Analytical Chemistry*; **196**:118634.
17. Wiles, M.D. (2022). Airway management in patients with suspected or confirmed traumatic spinal cord injury: a narrative review of current evidence. *Anaesthesia*; **77**:1120-1128.
18. Xiao, Y., Cui, T., Zhou, Y., Su, Q. and Yi, D. (2026). Exosomes as regenerative therapeutics for spinal cord injury: mechanisms and clinical prospects. *Frontier in Medicine*; **13**:1810270.
19. Yadollahi, M., Karajizadeh, M., Bordbar, N. and Ghahramani, Z. (2023). Incidence and pattern of traumatic spinal cord injury in a single level I trauma center of southern Iran, *Chinese Journal of Traumatology*; **26**(4):199-203.