Title: Bone Marrow Mesenchymal Stem Cells Attenuate Neuropathic Pain in Rats by Reducing Oxidative Stress

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Abstract

Neuropathic pain (NP) results from injuries or diseases of the sensory nervous system. Symptoms of this condition include spontaneous pain, hyperalgesia, and allodynia. Due to the complexity of the mechanism, conventional painkillers are ineffective. Recent preclinical research has shown promising results in treating NP with stem cells.

Despite the importance of the beneficial effects of stem cells, there remains a paucity of evidence on optimizing the dose and cell delivery routes of stem cells during NP. To this end, we evaluated two doses and routes of administration of bone marrow mesenchymal stem cells (BM-MSCs) in the chronic constriction injury (CCI)-induced neuropathic pain model. To compare doses and routes of administration (intravenous and intralesional injections), pain sensitization, oxidative stress, and astrogliosis assessments were performed.

We found that a significant reduction in pain sensitization parameters was observed on most experimental days. High-dose treatment (intravenous and intralesional injections) and low dose treatment (intralesional injection) produced an antinociceptive effect. Although the low dose (intravenous injection) decreased pain sensitization parameters, the reduction in neuropathic pain did not reach statistical significance compared to the CCI group. Our data demonstrated that intravenous and intralesional injections of BM-MSCs significantly improved oxidative stress by inhibiting the level of malondialdehyde (MDA) compared to the CCI group. In addition, intravenous and intralesional injections of BM-MSCs decreased astrogliosis in the dorsal horn of the spinal cord, as indicated by GFAP.

In conclusion, BM-MSC transplantation alleviated NP sensitization in the CCI model. These results suggest that optimized dosing and delivery routes of BM-MSCs may represent a promising therapeutic approach for neuropathic pain management.

Keywords: Neuropathic Pain; Neuroinflammation; Bone Marrow Mesenchymal Cells; Oxidative Stress; Cell Therapy; Regenerative Medicine

1. Introduction

Neuropathic pain occurs when an injury is seen in the somatosensory nervous system that may involve the peripheral or central nervous system, according to the International Association for the Study of Pain (IASP)(Leoni et al., 2025; Liu, Li, Wang, Zhao, & Jiang, 2020). The burden of neuropathic pain has shown a steady increase and has one of the highest medical expenditures(Cavalli, Mammana, Nicoletti, Bramanti, & Mazzon, 2019; Szewczyk, Jamroz-Wiśniewska, Haratym, & Rejdak, 2022). Doctors and scientists face a significant obstacle because of the insufficient effectiveness of the present pharmacotherapy. Furthermore, a considerable number of patients experience neuropathic pain symptoms, thus leading to an urgent need to discover new therapeutic alternatives (Asgharzade, Talaei, Farkhondeh, & Forouzanfar, 2020; Balanaser et al., 2023).

Among the different origins of neuropathic pain, sciatica is one of the predominant subtypes of neuropathic pain(Sayad-Fathi, Nasiri, & Zaminy, 2019). Excessive neuroinflammation usually takes place in neuropathic pain, which may be implicated in the initiation and continuation of persistent chronic pain(Xavier et al., 2012). Overwhelming evidence suggests that peripheral inflammatory responses caused by injury can reach the central nervous system by infiltrating peripheral immune cells (Beggs & Salter, 2010). Glia cells play a big part in the making of persistent pain syndromes in response to the peripheral inflammatory pathways(Vallejo, Tilley, Vogel, & Benyamin, 2010). In animal models of pain, astrocytic activation is usually seen as long-standing (Colburn, Rickman, & DeLeo, 1999; Romero-Sandoval, Chai, Nutile-McMenemy, & DeLeo, 2008; Tanga, Raghavendra, & DeLeo, 2004). In the context of neuropathic pain, morphological changes (i.e., astrocyte enlargement) and the overexpression of intermediate filament proteins (e.g., GFAP, vimentin, and the calcium-binding peptide S100β) are the

hallmarks of astrocyte responses (Ellis & Bennett, 2013). Therefore, modulating astrocyte activation can alleviate neuropathic pain's pathogenesis.

Numerous studies have indicated that stem cell therapy modulates neurotoxic reactive astrocytes in different neurological animal models(Du et al., 2024; Kim et al., 2025). Furthermore, stem cells' beneficial effects have been illustrated in neuropathic pain models(Forouzanfar et al., 2020; Zhang, Pi, Hu, Liu, & Wu, 2025). At present, different types of stem cells, including adipose-derived stem cells (ADSCs), human amniotic fluid-derived mesenchymal stem cells (hAFMSCs), bone marrow mesenchymal stem cells (BMSCs), and GABAergic intermediate neuron progenitor cells, have strong therapeutic potential in the treatment of NP, and the results are promising. Different studies use stem cells in different delivery sites(Liu et al., 2020). This study, therefore, sets out to compare two doses and delivery routes of BMSCs on oxidative stress and reactive astrocytes at the spinal cord level after an NP model.

We hypothesized that BMSC treatment, depending on the administration route and dose, would reduce neuropathic pain, oxidative stress, and reactive activation of astrocytes at the spinal cord level after NP.

2. Materials and methods:

2.1 Chemicals

Ketamine and xylazine were procured from Alfasan Pharmaceutical Co., situated in Woerden, Netherlands. 5,5´-dithio-bis-(2 nitrobenzoic acid) (DTNB), Tris-HCl, ethylenediaminetetraacetic acid (EDTA), 2-thiobarbituric acid (TBA), and Trichloroacetic acid (TCA) were purchased from Sigma-Aldrich, located in St. Louis, MO. Primary antibodies, rabbit anti-GFAP, and horseradish-peroxidase (HRP)–conjugated goat anti-rabbit were purchased from Abcam, USA. Cell culture material, including Dulbecco's Modified Eagle Medium (DMEM), penicillin-streptomycin, Fetal

Bovine Serum (FBS), and other related items, was obtained from Gibco Life Technologies, situated in Grand Island, NY, USA.

2.2 Cell isolation and culture

Six weeks of Male Wistar rats were utilized to isolate bone marrow mesenchymal stem cells (BM-MSCs). The rats were anesthetized with xylazine and ketamine through intraperitoneal injection. Under sterile conditions, bone marrow was collected from the femur and tibia and washed with phosphate-buffered saline (PBS) containing 10% penicillin and streptomycin. After cutting the bone using an insulin syringe, the bone marrow was washed with DMEM medium. The bone marrow cells were centrifuged at 1500 rpm for 5 minutes and then transferred to 25-cm2 flasks (Gibco, Germany) cultivated in DMEM-F12 supplemented with 20% FBS and 2% penicillin/streptomycin. The cells were kept at 37°C and maintained in an atmosphere of 5% CO2 and humidity. Every 2 to 3 days, the medium was replaced.

2.3 Animals

Male Wistar rats from Mashhad University of Medical Sciences (MUMS) Laboratory Animal Center were utilized for these investigations. The present study used adult Wistar rats weighing 250-280 g. These rats were retained in standard cages and provided unlimited food and water access. They were exposed to a 12-hour light/dark cycle and kept at approximately 21±2 °C with adequate humidity. The Ethical Committee of Mashhad University of Medical Sciences approved the procedures with the reference number 990996, IR.MUMS.REC.1399.542.

2.4 Induction of neuropathic pain in rats

To induce neuropathic pain, a method involving chronic constriction injury (CCI) of the sciatic nerve was implemented, as described in the work of Bennett and Xie in 1988 (Bennett & Xie,

1988). The rats were anesthetized with xylazine and ketamine through intraperitoneal injection. An incision was made in the skin above the right femoral area, and the sciatic nerve was exposed. Similarly, the sciatic nerve was also exposed to the right hind limb, and four chromic catgut sutures were tied at 1-mm intervals using ligatures. Finally, the skin layer was closed using sutures.

2.5 Treatment schedule

To test our hypothesis, the rats were divided into six groups (n=8/group): in the sham group, animals submitted to skin cut; in the model group, animals subjected to CCI; in the third and fourth groups, following the CCI, animals were intravenously treated with 5×10^5 (intravenous administration of the low dose of stem cells) and 1×10^6 (intravenous administration of the high dose of stem cells) numbers of MSCs; in the fifth and sixth groups, following the CCI, animals were received 5×10^4 (local administration of the low dose of stem cells in the sciatic nerve) and 1×10^5 (local administration of the high dose of stem cells in the sciatic nerve) numbers of MSCs through intralesional injection in three different areas of the sciatic nerve. Treatments were administered immediately after the injury. Behavioural assessments, including tests for mechanical allodynia, thermal hyperalgesia, and cold allodynia, were conducted on separate days: one day before CCI and the 3rd, 7th, 10th, and 14th days post-CCI.

2.6 Mechanical pain sensitivity (von Frey hair test)

The von Frey hair test was employed to evaluate mechanical allodynia-like behavior. Rats were placed in cages with a raised metal mesh floor measuring 30 × 30 × 30 cm. Mechanical allodynia was assessed using calibrated von Frey filaments (Bioseb, USA) after a 15-minute acclimatization period. Filaments were used in an ascending manner on the plantar surface (cutoff weight = 60

grams). The paw withdrawal threshold (PWT) refers to withdrawing paws at least three out of five times(Negah, Hajinejad, Nemati, Roudbary, & Forouzanfar, 2023).

2.7 Cold allodynia test

In the experiment, rats were placed within a plexiglass chamber, which allowed for a 15-minute adaptation period. Subsequently, an acetone droplet was applied to the plantar aspect of the rat's hind paw, resulting in a harmless temperature reduction due to the evaporation process. This procedure was repeated five times for each rat. A reaction was deemed positive if the rat either retracted or shook its hind paw as a response to the acetone application. The Thermal Withdrawal Frequency (TWF) was computed using the provided equation. This percentage represents the frequency of the rat's withdrawal response to the thermal stimulus(Negah et al., 2023):

$$\frac{numbers\ of\ trials\ accopained\ by\ foot\ withdrawal\ \times 100}{number\ of\ total\ trials}$$

2.8 Thermal hyperalgesia (hot-plate test)

The examination of thermal hypersensitivity was conducted utilizing a hot plate method. The heat stimulus was consistently maintained at 50 °C for the duration of the study, and the time taken until the initial indication of either paw licking or a jumping response to evade the heat-induced pain was recorded as the Paw Withdrawal Latency (PWL). A maximum limit of 12 seconds was established to prevent any potential tissue damage (Forouzanfar, Mansourian, Hajali, & Eslahi, 2026).

Biochemical assays (lipid peroxidation and total thiol group)

Spinal cords were rapidly extracted with a saline-filled syringe, and the lumbar sections were dissected on dry ice. The L4 and L5 spinal segments were specifically chosen because they are the primary contributors to the sciatic nerve (Negah et al., 2023).

2.9 Estimation of lipid peroxidation

The L4-L6 lumbar segment of the spinal cord was homogenized in 0.1 M ice-cold phosphate-buffered saline (PBS, pH 7.4). TCA-TBA-HCl reagent (2 mL) was added to the homogenate sample (1 mL) and incubated in a boiling water bath for 45 minutes. After that, the solutions were centrifuged at 3000 rpm for 10 minutes, and the absorbance was measured at 535 nm. Finally, the MDA concentration was determined using the following equation: Absorbance / 1.56×10^5 (Negah et al., 2023).

2.10 Estimation of the total thiol group

The sample's absorbance was determined by measuring it at 412 nm, compared to the absorbance of Tris-EDTA buffer alone (R1). Once the 10 mM DTNB prepared in methanol was added to the mixture, the sample's absorbance was again measured (R2). A blank absorbance reading was taken for the DTNB reagent (B). The total thiol concentration was determined as follows (Negah et al., 2023):

$$\frac{(R2 - R1 - B) \times 1.07}{0.05 \times 13.6}$$

2.11 Tissue preparation and immunohistochemistry

Immunohistochemistry for GFAP was performed on rat spinal cord tissue sections.

Rats were anesthetized, and transcardial perfusion was performed using 4% paraformaldehyde and PBS on day 14 after CCI to evaluate reactive astrocytes. Spinal cord tissues were initially collected and preserved in 10% formalin. Following this, the samples were sliced into 5-µm serial coronal sections using a microtome after embedding in paraffin. To reveal the antigens, the spinal cord sections were hydrated, deparaffinized, and then boiled in PBS for 20 minutes before conducting immunohistochemistry. The slides were then treated with 3% H2O2 in methanol to prevent endogenous peroxidase activity and incubated with bovine serum albumin for one hour. After applying rabbit anti-glial fibrillary acidic protein (GFAP) overnight at four °C, sections were washed and treated with horseradish-peroxidase (HRP)–conjugated goat anti-rabbit as the secondary antibody for one hour at room temperature. The sections were mounted and analyzed using a bright-field microscope (Olympus 30X23, Japan). Representative photomicrographs were captured for figure presentation.

2.12 Statistics

The statistical analysis was carried out using GraphPad Prism 8.0 Software (Inc., San Diego, CA, USA). The data has been presented as mean ± standard error of the mean (SEM). One-way ANOVA and Tukey's post hoc tests were used to examine oxidative stress measures. A two-way ANOVA and post hoc Bonferroni's multiple comparisons were used to analyze the behavioral data. p-value < 0.05 is considered statistically significant.

3. Results:

3.1 Culture of Mesenchymal Stem Cells

Mesenchymal stem cells were isolated from bone marrow and expanded using an adherent method. The characterization of MSCs was previously performed(Negah et al., 2023).

3.2 Pain Sensitization Parameters

Our results showed that CCI reduced the PWT value from days 3 to 14 in a persistent manner (P<0.001). On the other hand, the groups that were administered with high doses of stem cells, even intravenously or intralesionally lead to increment of PWT on day 3 post surgery (P<0.05) as compared to the CCI group. From day 7 to day 14, PWT was significantly increased when animals were treated with SC-HD-IV, SC-LD-SCI, and SC-HD-SCI administration (P<0.001) as compared to the CCI group (days 7-14; Fig 1A). Moreover, the group that received SC-HD-IV significantly increased the PWT when the CCI rats were treated with the SC-LD-IV (day 14; P <0.01, Fig. 1A). Moreover, the group that received SC-HD-SCI or SC-LD-SCI significantly increased the PWL when the CCI rats were treated with the SC-LD-IV (day 14; P <0.05, Fig. 1A).

After the injury, TWF significantly increased on day 3 after the operation in comparison to the sham group, and this increase persisted for at least 14 days after the operation (P<0.001). We demonstrated that TWF was significantly decreased at predetermined time points when animals were treated with the stem cells intralesionally (P<0.05 was observed for day 10 in low dose, while P<0.01 for day 7, and P<0.001 was seen on day 10 and 14 high dose; Fig 1B). The inhibitory effects of stem cells on TWF had a delay (day 10 after transplantation) when they were intravenously injected at a high dose of stem cells (day 10, P<0.05; Fig 1B).

The results of the antihyperalgesia effect analysis on the hot plate test revealed that the rats with CCI had noticeable thermal hyperalgesia from days 3 to 14, compared to the sham group (P<0.001; Fig 1C). The groups that were administered with high doses of stem cells, even intravenously or intralesionally lead to increment of PWT on day 3 post surgery (P<0.05) as compared to the CCI group. However, the PWL of rats in the SC-HD-SCI showed significant improvement on days 7 post-operation compared to the CCI group (P<0.01) and on days 10 and 14 (P<0.001).

Additionally, the PWL was considerably increased when the CCI rats were treated with the SC-HD-IV (days 7-14; P<0.001; Fig 1C). Additionally, the PWL was considerably increased when the CCI rats were treated with the SC-LD-SCI (days 7-10; P<0.001 and day 14; *P* <0.01; Fig 1C). Moreover, the group that received SC-HD-IV significantly increased the PWL when the CCI rats were treated with the SC-LD-IV (days 7 and 14; *P*<0.5; and day 10, *P*<0.01) (Fig. 1C). Moreover, the group that received SC-HD-SCI significantly increased the PWL when the CCI rats were treated with the SC-LD-IV (day 10, *P* <0.05) (Fig. 1C). Moreover, the group that received SC-LD-SCI significantly increased the PWL when the CCI rats were treated with the SC-LD-IV (day 10; *P*<0.05; Fig 1C).

3.3 Stem cell transplantation inhibits oxidative stress

The study's findings suggest that CCI caused a notable rise in MDA levels compared to the sham group (P<0.001; Fig.2A). However, all groups receiving treatment exhibited a significant drop in MDA levels versus the CCI group (P<0.01 for SC-LD-IV and P<0.001 for other treatment groups). Moreover, the group that received SC-HD-IV significantly decreased the MDA levels when the CCI rats were treated with the SC-LD-IV (P<0.05; Fig 2A).

Furthermore, CCI led to a significant decrease in thiol levels compared to the sham group (P<0.05). Nonetheless, all treatment groups resulted in a promising increase in thiol levels, but there was no significant change compared to the CCI group (Fig.2B).

3.4 BMMSCs have powerful mechanisms against astrocyte activation

Our study showed that all treatment groups showed decrease in reactive astrocytes compared to the CCI group (Fig 3).

4. Discussion

We aimed to explore the optimization of stem cells concerning route and dose in a neuropathic pain model. We found that stem cell administration significantly improved oxidative stress and astrogliosis in the right dorsal horn of the spinal cord, in addition to enhancing behavioral outcomes, compared to control groups.

In the present study, we used the CCI model in rats to induce neuropathic pain, which is a peripheral nerve injury accompanied by pain sensitivity, providing a model system to investigate the efficacy of potential therapeutic agents for the study of chronic neuropathic pain (Austin, Wu, & Moalem-Taylor, 2012). Injuries can cause neuropathic pain and reduced sensory and motor nerve function in the peripheral nerve. The peripheral nerve comprises nerve fibers known as axons and supportive cells called Schwann cells, which produce myelin (Balakrishnan et al., 2021). Although axonal regeneration can occur following an injury, this process is limited(R. Li et al., 2017). Oxidative stress and post-injury inflammation restrict functional recovery following sciatic nerve injury (Qian et al., 2018).

BM-MSCs can differentiate into different cell types, including neurons and cells resembling Schwann cells. They have been observed to contribute positively towards the regeneration of peripheral nerves (Sayad-Fathi et al., 2019). BMMSCs also secrete numerous neurotrophins in response to peripheral nerve injury and enhance regeneration(Kubiak et al., 2020). Their potent immunomodulatory and immunosuppressive characteristics make them appropriate for autologous and heterologous transplantation without demanding immunosuppressive therapy. The ability of

BMSCs to modify the inflammatory milieu has made BMSCs an attractive treatment possibility for numerous pain conditions(Huh, Ji, & Chen, 2017).

Our findings indicated that the administration of BMMSCs resulted in practical improvements following CCI. Our study showed that administering BMMSCs in SC-HD-IV, SC-LD-IL, and SC-HD-IL groups improved the pain behaviors compared to CCI. A previous study reported that transplantation of about 1 million BMMSCs alleviated allodynia and hyperalgesia following spinal cord injury(Yousefifard et al., 2016). Another study demonstrated that both local (5×10^4) and intravenous BM-derived MSCs (1×10^6) administration significantly enhanced nerve regeneration and functional recovery after sciatic nerve repair and hindlimb transplantation in rats. Systemic MSCs improved electromotor recovery more, while local MSCs were more effective at increasing axon and fiber counts(Cooney et al., 2016).

A recent study showed that intravenous injection of BMSCs in CCI mice improved cognitive performance. Also, BMSCs reduced the CXCL12/CXCR4 expression in blood and hippocampus, enhanced neurogenesis in the dentate gyrus of CCI mice, and increased the expression of BDNF and c-Fos in the hippocampus(Sun, Qi, Zhang, Wang, & Zhang, 2026).

Oxidative stress in neural tissue disrupts hemostasis and is one of the major concerns in peripheral nerve regeneration(Qian et al., 2018). Our research showed that the MDA level was diminished in all BM-MSC groups versus CCI. In line with our findings, BM-MSCs have been found to induce the reestablishment of redox homeostasis(Evangelista et al., 2018). After CCI, there is an extensive accumulation of reactive oxygen species (ROS) at the injury site, which leads to increased cell apoptosis rates and death(Lu et al., 2019). Inflammation is another phenomenon activated following peripheral nerve injury(Gu et al., 2024). In the injury site, glial cells are activated, and

innate immune cells are recruited, which increases the pro-inflammatory cytokines(Gu et al., 2024; Xu et al., 2018). It has been reported that MSCs exhibit immunosuppressive and anti-inflammatory capabilities by suppressing the expression of inflammatory cytokines in various types of diseases, which can promote tissue regeneration(Hajinejad & Sahab-Negah, 2021; X. Li et al., 2022). Our study found that administering BMMSCs via different routes and doses could dramatically reduce the number of astrocytes in the dorsal horn of the spinal cord. These findings confirm that BM-MSCs can potentially suppress inflammatory cells and further inflammatory cascades.

One limitation of this study is that we did not assess the fate or long-term behavior of the transplanted stem cells. Although our results indicate significant functional improvements and therapeutic outcomes associated with stem cell transplantation, the specific mechanisms underlying these effects—such as cell survival, integration, differentiation, or paracrine activity—remain unexamined in this research. Employing techniques like fluorescent labeling, genetic markers, or advanced imaging modalities to track the transplanted cells could offer valuable insights into their distribution, persistence, and functional contributions to the observed outcomes. Future investigations should aim to incorporate these methodologies to further elucidate the mechanisms of action and enhance the optimization of stem cell-based therapies. Addressing this area will deepen our understanding of the therapeutic process and provide crucial information for translating these findings into clinical applications.

5. Conclusion

Progress in comprehending the intricate mechanisms underlying peripheral nerve injury has paved the way for exploring novel therapeutic strategies. It has been observed that the presence of BM-MSCs can help alleviate oxidative stress and inflammation, which are two significant obstacles in

peripheral nerve regeneration. BM-MSCs possess properties that can suppress the immune system and help reduce inflammation, promoting tissue regeneration. The study's findings imply that BM-MSCs can inhibit inflammatory cells and subsequent inflammatory cascades, thereby enhancing functional recovery post-peripheral nerve injury. The study's results suggest that releasing paracrine factors could be the principal mechanism through which MSCs counteract CCI pathophysiology. However, further studies are required to delve into the molecular mechanisms that underpin the effects of MSCs on CCI.

Statements and Declarations:

- **Acknowledgment:**

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- **Conflict of interest:**

The authors declare no conflict of interest.

- **Contributions:**

F.F. performed experimental tests, wrote the first draft of the manuscript, and assisted in experimental design and data analysis. M.H. performed experimental tests, assisted in data analysis, and wrote the first draft of the manuscript. S.N. assisted in the experimental test. All authors have approved the final manuscript.

- **Consent for publication**

Not applicable

- **Availability of data and material**

The data supporting this study's findings are available on request from the corresponding authors.

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Legends:

Figure 1. Effect of bone marrow mesenchymal stem cell (BM-MSCs) on A. Paw Withdrawal Threshold (g), B. Thermal Withdrawal Frequency (%), C. Paw Withdrawal Latency (s). Data are expressed as mean ± SEM (n=8/group). ### indicates *P*<0.001 vs. sham group, * indicates *P*<0.05, ** indicates *P*<0.01, and *** indicates *P*<0.001 vs. the CCI group.

+indicates P<0.05, and ++ indicates P<0.01 SC-HD-IV vs. the SC-LD-IV group.

$ indicates P<0.05 SC-HD-SCI vs. the SC-LD-IV group.

&indicates P<0.05 SC-LD-SCI vs. the SC-LD-IV group.

Abbreviations: CCI: chronic constriction injury, SC-HD-IV: intravenous administration of the high dose of stem cells, SC-LD-IV: intravenous administration of the low dose of stem cells, SC-HD-IL: local administration of the high dose of stem cells in the sciatic nerve, SC-LD-IL: local administration of the low dose of stem cells in the sciatic nerve.

Figure 2. Effect of bone marrow mesenchymal stem cell (BM-MSCs) on A. MDA, B. thiol levels. Data are represented as the mean ± SEM of six animals for each experimental group. Abbreviations: CCI: chronic constriction injury, SC-HD-IV: intravenous administration of the high dose of stem cells, SC-LD-IV: intravenous administration of the low dose of stem cells, SC-HD-IL: local administration of the high dose of stem cells in the sciatic nerve, SC-LD-IL: local administration of the low dose of stem cells in the sciatic nerve. +indicates P<0.05 SC-HD-IV vs. the SC-LD-IV group.

Figure 3. Immunohistochemistry analysis of spinal cord reactive astrocytes in response to the bone marrow mesenchymal stem cell (BM-MSCs) in the CCI model. A-E) Photomicrographs present coronal spinal sections stained against GFAP. Abbreviations: CCI: chronic constriction injury, SC-HD-IV: intravenous administration of the high dose of stem cells, SC-LD-IV: intravenous

administration of the low dose of stem cells, SC-HD-IL: local administration of the high dose of stem cells in the sciatic nerve, SC-LD-IL: local administration of the low dose of stem cells in the sciatic nerve.

Fig 1A.

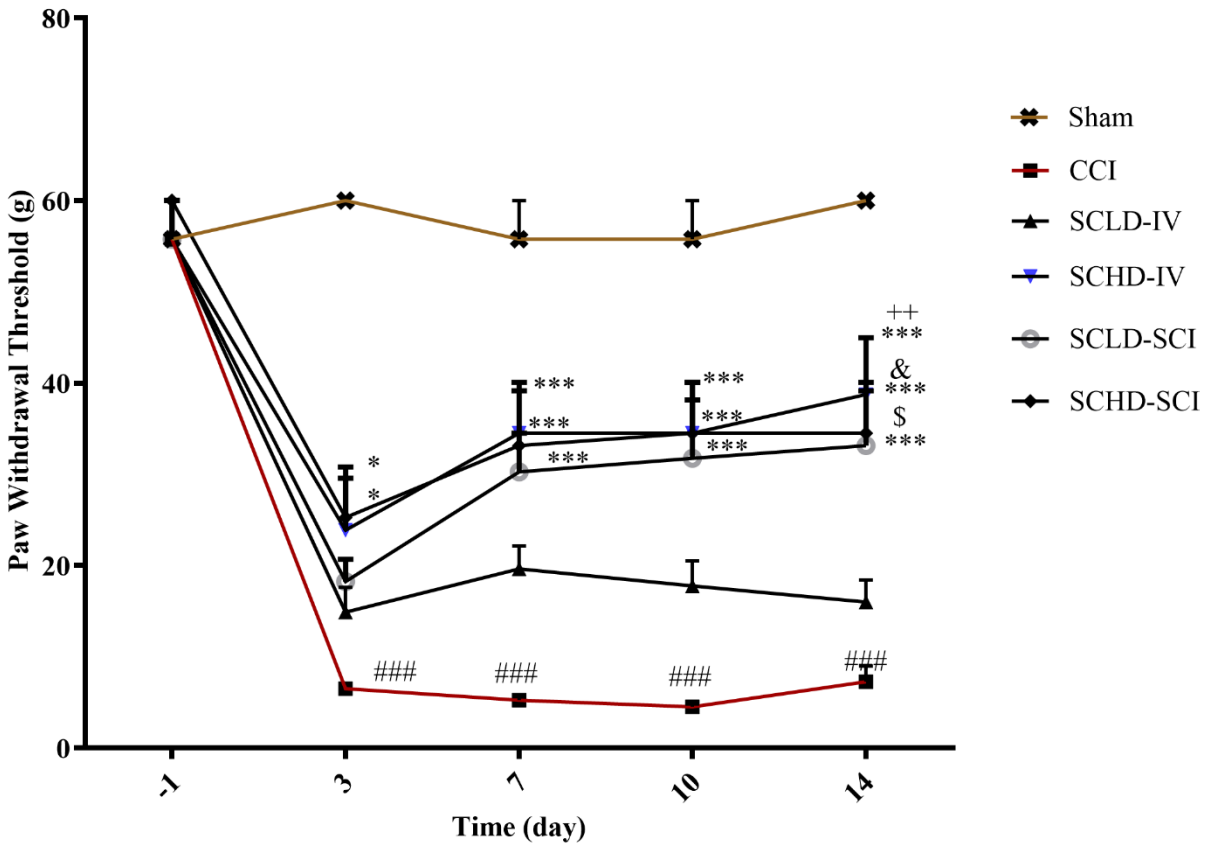

Fig 1B.

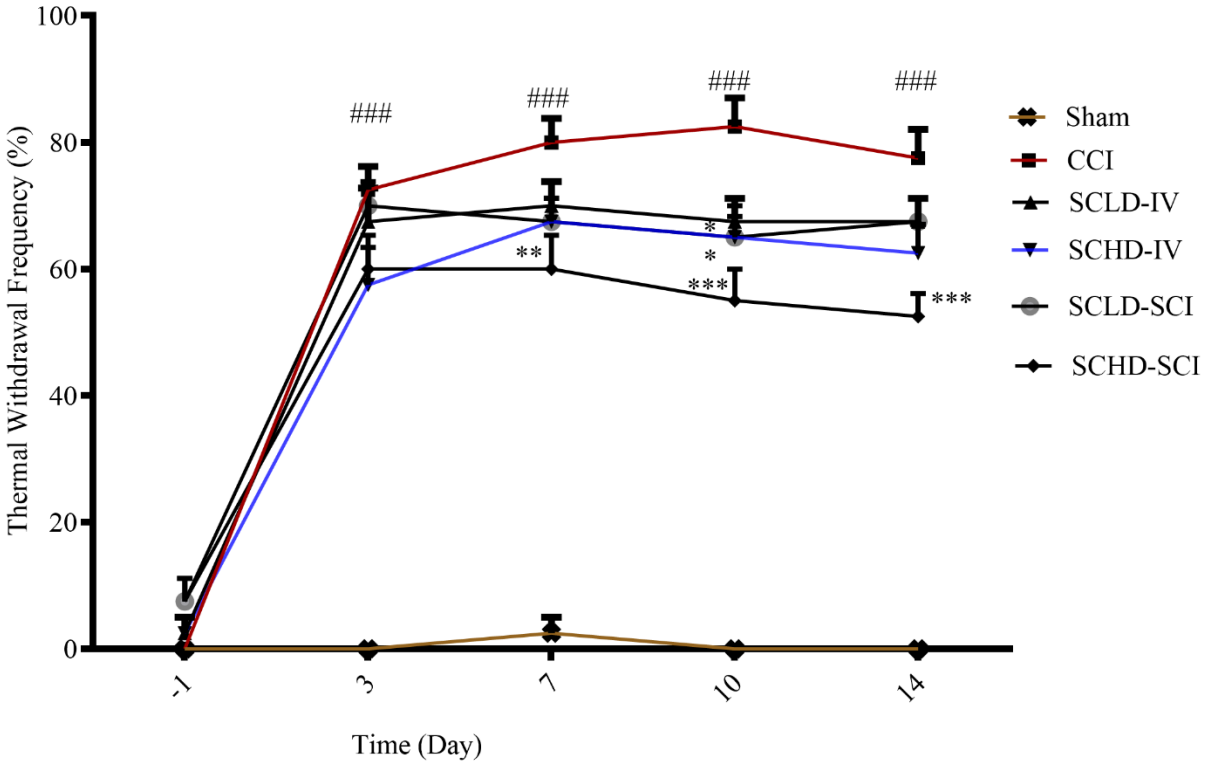

Fig 1C.

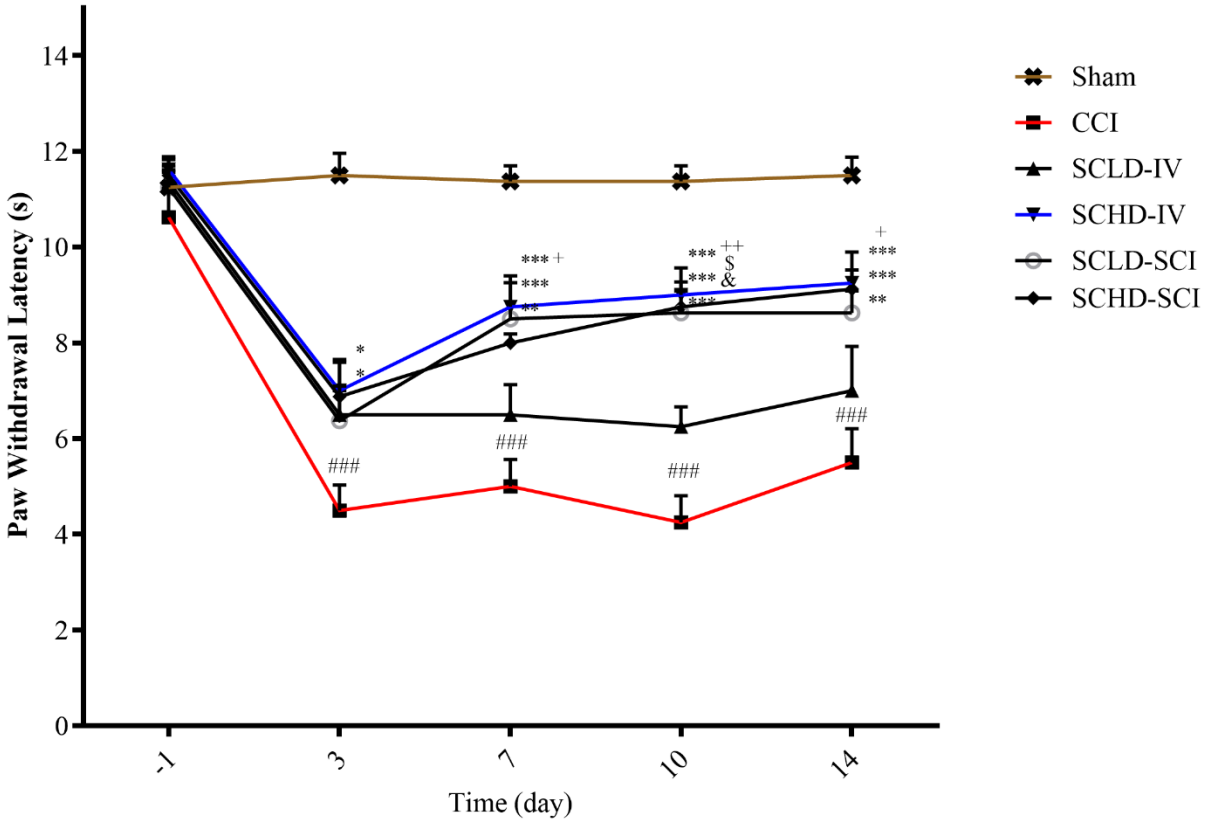

Fig 2A.

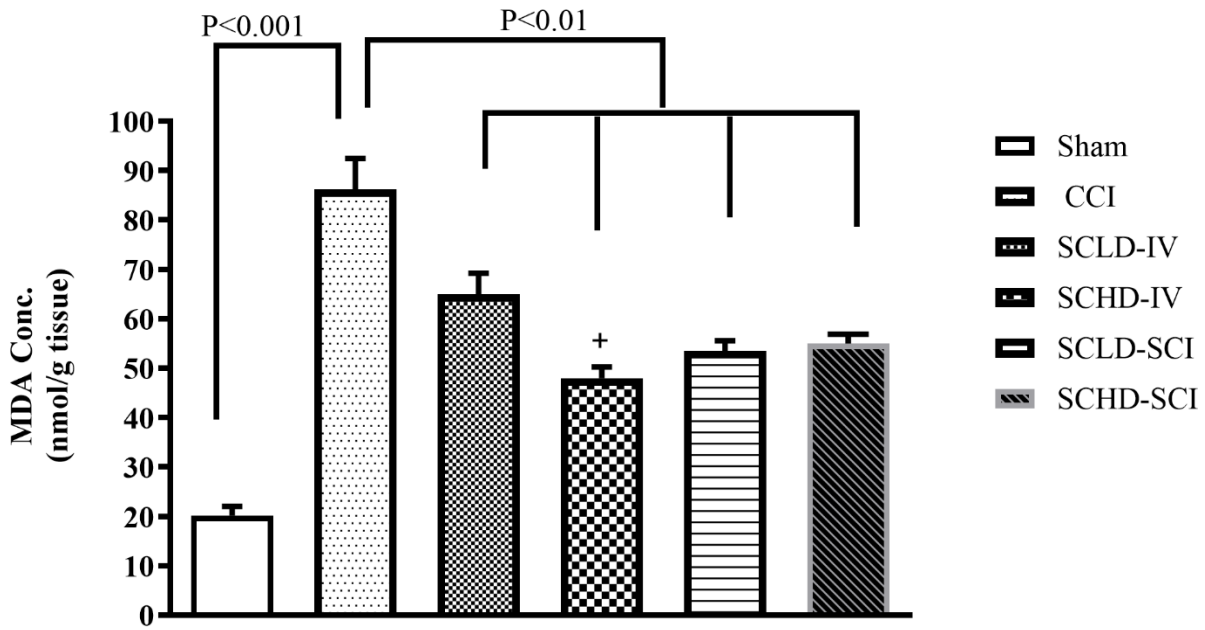

Fig 2.B

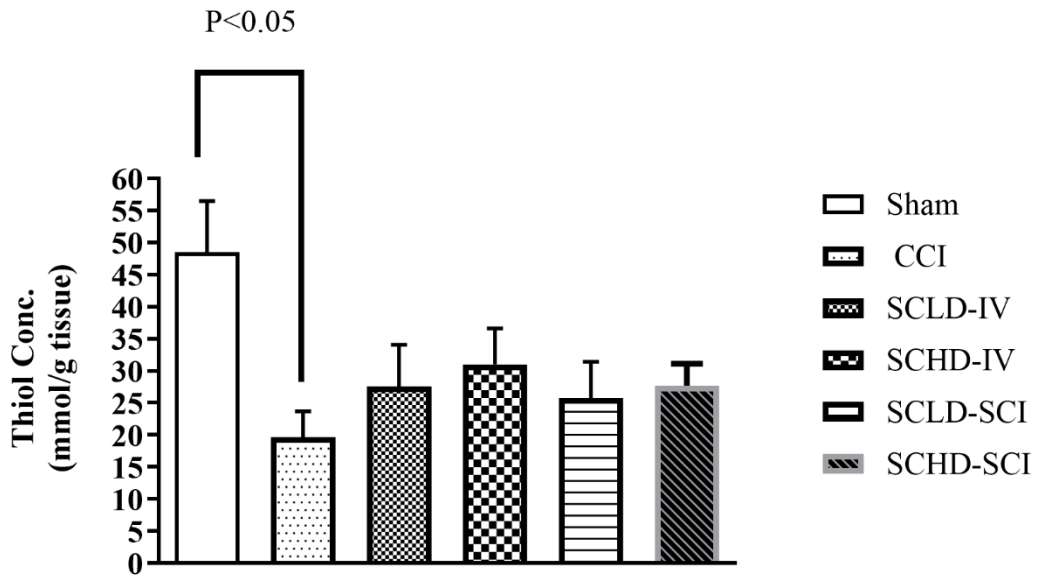

Fig 3.