# High-frequency Repetitive Transcranial Magnetic Stimulation in A Patient with Acute Complete Spinal Cord Injury: A Case Report

**Sangita Kuparasundram[1] and Nicodemus E Oey[1], Michael CY Chu[2], YL Lo[3], Chen Jing[4*]**

[1]Rehabilitation Medicine, Singhealth Residency, Singapore

[2]Internal Medicine, Singhealth Residency, Singapore

[3]Department of Neurology, National Neuroscience Institute (Singapore General Hospital Campus) and Duke NUS Medical School, Singapore;

[4]Department of Rehabilitation Medicine, Singapore General Hospital, Singapore

***Corresponding Author:** Chen Jing, Department of Rehabilitation Medicine, Singapore General Hospital, Singapore.

**Received date:** 28 March 2023; **Accepted date:** 02 May 2023; **Published date:** 07 June 2023

**Citation:** Kuparasundram S and Oey NE, Chu MCY, Lo YL, Jing C (2023) High-frequency Repetitive Transcranial Magnetic Stimulation in A Patient with Acute Complete Spinal Cord Injury: A Case Report. J Med Case Rep Case Series 4(10): https://doi.org/10.38207/JMCRCS/2023/JUN04100158



## Abstract

Following scoliosis correction surgery, a 25-year-old female sustained a T6 complete spinal cord injury (SCI) from intramedullary hemorrhage. A comprehensive rehabilitation program was provided, including the innovative application of high-frequency repetitive transcranial magnetic stimulation (rTMS) to promote motor recovery. The neurological and functional progress of the patient is described.

**Keywords:** spinal cord injury; repetitive transcranial magnetic stimulation; rehabilitation

## Case

A 25-year-old South Asian female with Marfan's syndrome, previous mitral clip operation for mitral regurgitation, and restrictive lung disease from scoliosis was admitted for a T6 to T10 thoracoscopic anterior release, discectomy, and fusion operation for scoliosis. After recovery from general anesthesia, she reported no movement or sensation from T6 and below. An urgent Magnetic Resonance Imaging (MRI) scan showed a bone fragment which was displaced into the thoracic spinal canal with the suggestion of intramedullary hemorrhage **(Figure 1)**. A T6 to T9 posterior decompression laminectomy was performed urgently. However, there was no motor or sensory recovery after the second surgery.

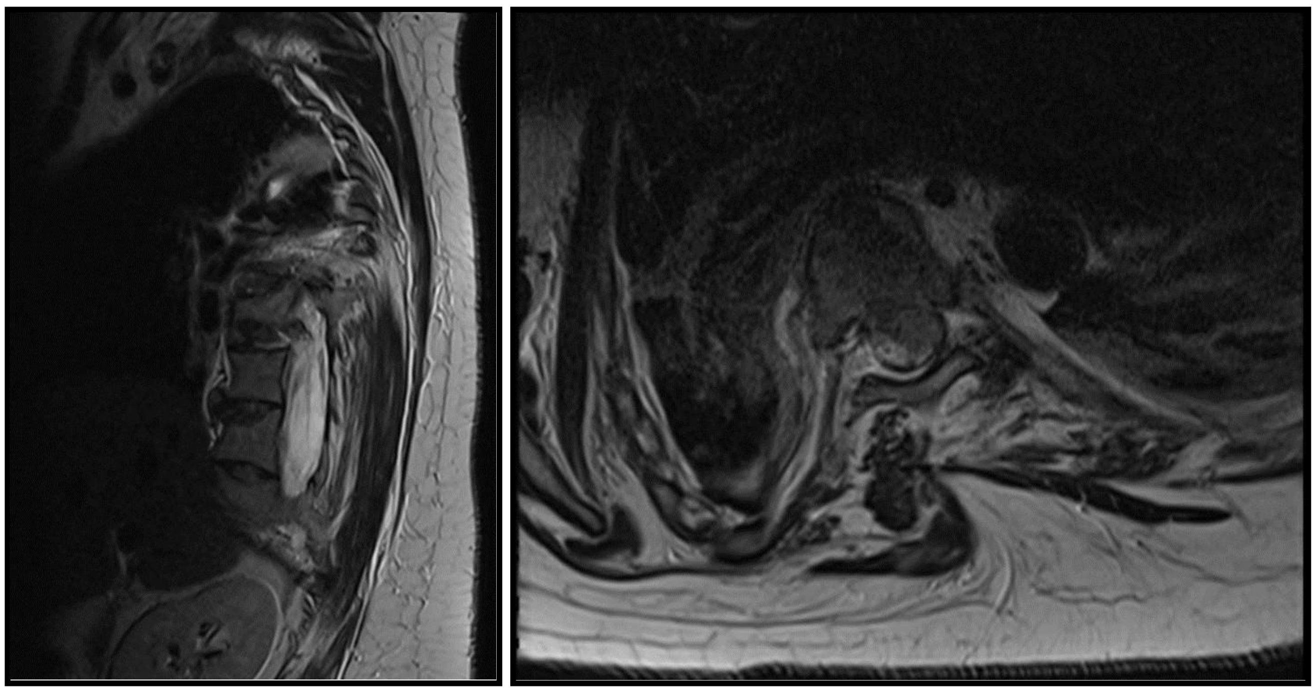

**Figure 1**: Thoracic MRI scan showing displaced bone fragment

She sustained a T6 level American Spinal Injury Association Impairment Scale (AIS) Grade A Spinal cord injury (SCI) **[1]**. This was corroborated by absent lower limb motor evoked potentials (MEPs) on transcranial magnetic stimulation (TMS) and impaired dorsal column somatosensory pathways above the lumbar segments on testing somatosensory evoked potentials (SSEP). Repeat MRI spine scans showed an intramedullary fluid collection suggestive of a possible surgical bed seroma with cord edema.

She was transferred to inpatient rehabilitation and received multidisciplinary team-based care. She participated in two to three 60-minute physical and occupational therapy sessions daily, five days a week, focusing on upper limb strengthening, truncal control, sitting balance, and transfers. She was also trained on using an electronically controlled ergometer augmented by functional electrical stimulation and motor imagery involving visualization of quadriceps and hamstrings movement in a cycling scenario. Though sensory levels improved to T8 with reduced sensation to T10 level bilaterally, there was minimal motor recovery. After 2 months, she remained T8 AIS A.

Repetitive transcranial magnetic stimulation (rTMS) was offered to enhance motor and sensory recovery. The lower limb rTMS stimulation protocol was adapted from Krogh et al. 2002 **[2]**. ]. An air-cooled figure-of-8 coil with a Magstim Rapid2 rTMS System (Magstim, Whitland, UK) was utilized. The coil was positioned 2 cm anterior to the vertex, targeted at the bilateral lower extremity motor cortices. Patient was seated and was encouraged to use motor imagery during sessions. The Resting Motor Threshold (RMT) was obtained through stimulation of the motor cortex M1 hand representation. RMT was the minimum stimulation intensity that elicited MEPs of ≥ 50 μV amplitude in ≥ 5 of 10 trials. An apparent focal twitch of the left first dorsal interossei muscle was obtained at an amplitude of 55 %. Stimulation parameters were: 45 trains of 40 pulses at 20 Hz at 90 % of RMT, with 28s between trains for 1800 pulses. Twenty sessions were completed. As there was no significant change in repeat TMS and SSEP findings, an additional 10 sessions at 100 % of RMT with the same pulse train parameters were conducted.

At 4 months post-injury, her neurological status remained at T8 AIS A. Nevertheless, she achieved modified independence in basic activities of daily living and could also perform community mobilization with a wheelchair **(Table 1)**. She was discharged and continued rehabilitation on an outpatient basis.

**Table 1:** Outcome measures

| | Immediate post injury | Before rTMS | After rTMS |
|---|---|---|---|
| Time from injury onset | 72 hours | 2 months | 4 months |
| AIS Grading | T6 AIS A | T8 AIS A | T8 AIS A |
| Penn Spasm Frequency Scale | Spasm frequency: 2<br>Spasm severity: 2 | Spasm frequency: 2<br>Spasm severity: 1 | Spasm frequency: 1<br>Spasm severity: 1 |
| Modified Ashworth Scale (MAS) | Hip adductors: 2<br>Quadriceps: 1+<br>Plantar flexors: 1+ | Hip adductors: 1+<br>Quadriceps: 1<br>Plantar flexors: 1 | Hip adductors: 1+<br>Quadriceps: 1<br>Plantar flexors: 1 |
| FIM score (Total) | 56 | 94 | 101 |
| Motor FIM score (excluding Bladder and Bowel) | 21 | 51 | 57 |
| Self- Care FIM scores (Combined Eating, Grooming, Bathing, Dressing, Toileting scores) | 16 | 32 | 34 |
| Bladder and Bowel management FIM scores | 2(Indwelling urinary catheter, diapers) | 8(Intermittent urinary catheterization, diapers) | 9(Intermittent urinary catheterization, diapers) |
| Transfers FIM scores | 3 | 13 | 15 |
| Locomotion FIM scores | 1 | 5(motorized wheelchair mobilization) | 7 (motorized wheelchair mobilization) |
| SCIM score | 21 | 43 | 63 |

AIS: American Spinal Injury Association Impairment Scale, FIM: Functional Independence Measure, MAS: Modified Ashworth Scale; SCIM: Spinal Cord Independence Measure

## Discussion

Iatrogenic SCI resulting from spinal surgery is rare but a devastating condition. The rates of new neurological deficits following spinal surgery for scoliosis may range from 1.32 % to 10.42 % **[3]**. A single-center study of 65 patients with neurological deficits following scoliosis correction surgery reported six cases (9.2 % incidence) with AIS A complete paraplegia, two of which did not show recovery **[4]**.

Various types of neuro modulation have tried to restore neurological function following SCI. rTMS is theorized to induce plasticity at the cortical and spinal cord level through long-term potentiation or depression of neural circuits **[5]**. The clinical implications of neuromodulation on spasticity, neuropathic pain, and motor recovery following SCI have been researched. However, the study protocols evaluating rTMS in SCI are heterogeneous **[5,6]**, and the efficacy of high-frequency rTMS remains to be determined for patients with complete SCI **[6]**, given limited research.

This case report adds to the existing literature on rTMS use in complete SCI. In this case, a high-frequency protocol involving 20Hz pulses over 4 weeks with a cumulative total dose of 36000 pulses was employed. This protocol was based on previous studies which showed that higher frequency (>5Hz) rTMS can increase corticospinal pathway excitability while reducing cortical inhibition **[3]**. In this case report, high-frequency rTMS was well tolerated with no adverse events. of note, functional electrical stimulation was applied concurrently in this case.

Paired associative stimulation, combining peripheral nerve stimulation with cortical impulses from rTMS, has been reported to induce positive outcomes **[5]**. Despite rTMS and FES, this case failed to show a measurable objective change in motor scores. This could potentially be due to an insufficient duration and/or intensity of rTMS. Future studies may consider increasing stimulation intensity or changing the stimulation frequency to yield a positive effect on sensorimotor function. Non-invasive therapeutic stimulation is a developing field with potential for further exploration. Animal studies of trans-spinal magnetic stimulation suggest that it modulates scar formation, decreases demyelination, and promotes neural cell proliferation and axonal growth **[7]**. In conjunction with other treatments, such as epidural spinal cord stimulation, it may be part of future treatment considerations for our patients and others with complete SCI.

Despite no measurable motor recovery, the patient improved spasticity control, spasms frequency, and functional status. It is unclear whether rTMS has contributed to her active recovery and spasticity control through modulation of cortical inhibition **[8]** or whether those are the effects of the concurrent traditional rehabilitation strategies provided. This case report highlights that a comprehensive rehabilitation program with conventional rehabilitation strategies should be implemented concurrently to achieve favorable functional outcomes.

## Conclusion

In conclusion, complete SCI secondary to intramedullary hemorrhage following idiopathic scoliosis surgery is a rare complication. In this case, a comprehensive rehabilitation program combined with rTMS and FES failed to yield neurological recovery. Yet tremendous functional recovery was achieved. The role of neuromodulation in complete acute SCI needs to be further explored.

## References


1. ASIA and ISCoS International Standards Committee (2019) The 2019 revision of the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI)—what's new? Spinal Cord. 57(10): 815-817.
2. Krogh S, Aagaard P, Jønsson AB, Figlewski K, Kasch H (2022) Effects of repetitive transcranial magnetic stimulation on recovery in lower limb muscle strength and gait function following spinal cord injury: a randomized controlled trial. Spinal Cord. 60(2): 135-141.
3. Hamilton DK, Smith JS, Sansur CA, Glassman SD, Ames CP, et al. (2011) Rates of new neurological deficit associated with spine surgery based on 108,419 procedures: a report of the scoliosis research society morbidity and mortality committee. Spine. 36(15): 1218-28.
4. Li J, Hu Z, Qian Z, Tang Z, Qiu Y, et al. (2022) The prognosis and recovery of major postoperative neurological deficits after corrective surgery for scoliosis: An analysis of 65 cases at a single institution. The Bone & Joint Journal. 104-B (1): 103-111.
5. Ellaway PH, Vásquez N, Craggs M (2014) Induction of central nervous system plasticity by repetitive transcranial magnetic stimulation to promote sensorimotor recovery in incomplete spinal cord injury. Frontiers in Integrative Neuroscience. 8: 42.
6. Tazoe T, Perez MA (2015) Effects of repetitive transcranial magnetic stimulation on recovery of function after spinal cord injury. Archives of physical medicine and rehabilitation. 96(4 Suppl): S145-55.
7. Chalfouh C, Guillou C, Hardouin J, Delarue Q, Li X, et al. (2020) The regenerative effect of trans-spinal magnetic stimulation after spinal cord injury: Mechanisms and pathways underlying the effect. Neurotherapeutics. 17(4): 2069-2088.
8. Nardone R, Höller Y, Thomschewski A, Brigo F, Orioli A, et al. (2014) rTMS modulates reciprocal inhibition in patients with traumatic spinal cord injury. Spinal Cord. 52(11): 831-5.