

Functional Recovery During Conservative Rehabilitation in Cervical Spinal Cord Injury Associated with Degenerative Cervical Myelopathy: A Case Report

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ABSTRACT

Background: Degenerative cervical myelopathy (DCM) is the most common cause of spinal cord dysfunction and progressive neurological disability in adults, and patients with incomplete cervical spinal cord injury classified as AIS C may retain substantial potential for neurological and functional recovery. However, the role of structured conservative rehabilitation in patients who do not undergo surgery remains unclear. This case report aims to describe functional recovery following conservative rehabilitation in a patient with DCM.

Case presentation: This was a case report conducted at Nurdin Hamzah General Hospital, Tanjung Jabung Timur, Jambi, Indonesia. The subject was a 41-year-old man with progressive spastic tetraparesis, documented as American Spinal Injury Association Impairment Scale (AIS C) cervical spinal cord injury associated with DCM, confirmed by cervical Magnetic Resonance Imaging (MRI) showing multilevel spondyloarthrosis, degenerative disc disease, grade I retrolisthesis at C3–C6, and severe canal stenosis with cord compression at C5–C7. Data were obtained from medical records, including serial clinical examination and International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) motor scores. The patient declined surgical decompression and underwent structured outpatient conservative rehabilitation comprising progressive strengthening, functional training, transcutaneous electrical nerve stimulation (TENS), and short-wave diathermy (SWD). Neurological and functional recovery were evaluated descriptively based on serial motor scores and ambulation status.

Results: Total ISNCSCI motor score improved from 40 to 90, with UEMS increasing from 30 to 50 and LEMS from 10 to 40. The patient achieved assisted ambulation by the third month and independent ambulation by the fourth month of rehabilitation.

Conclusion: Neurological and functional improvement was observed during structured conservative rehabilitation in patients with AIS C cervical spinal cord injury associated with degenerative cervical myelopathy.

Keywords: cervical myelopathy, cord injury, functional recovery, tetraparesis.

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BACKGROUND

Degenerative cervical myelopathy (DCM) is the most common form of spinal cord impairment in adults and is associated with substantial disability and reduced quality of life. It results from degenerative changes involving the cervical vertebrae, intervertebral discs, and ligamentous structures that lead to chronic spinal cord compression. Clinical manifestations vary widely, ranging from neck pain and sensory disturbances to severe motor deficits, gait impairment, and functional disability (Gibson et al., 2018).

Neurological impairment in patients with DCM may vary considerably according to the severity of spinal cord involvement, ranging from mild sensory disturbances to substantial motor deficits and severe functional limitations. Standardized instruments such as the American Spinal Injury Association Impairment Scale (AIS) and serial motor scores are commonly used to classify injury severity and monitor neurological recovery over time (Kirshblum et al., 2011).

MRI examination is the primary imaging modality in the evaluation of cervical myelopathy because it is able to depict the source of spinal cord compression and detect intramedullary signal changes that reflect spinal cord injury (Badhiwala et al., 2020).

Management of degenerative cervical myelopathy depends on clinical severity, symptom progression, and radiological findings. Surgery is generally recommended for patients with moderate to severe neurologic deficits or progressive symptoms, with the goal of relieving spinal cord compression and preventing further neurologic deterioration (Fehlings et al., 2017; Nouri et al., 2020).

However, evidence for non-operative management in DCM remains limited. A systematic review of structured non-

operative treatment found very low-quality evidence regarding improvements in function, pain, and quality of life, making its role in DCM difficult to determine; 23–54% of patients in the included studies subsequently underwent surgery (Tetreault et al., 2017). An updated systematic review also found limited evidence supporting non-operative management and reported a higher rate of subsequent spinal cord injury hospitalization among non-operatively managed patients, although the overall quality of evidence was low (Rhee et al., 2017).

Evidence from traumatic spinal cord injury indicates that incomplete injuries, including AIS C, may demonstrate substantial neurological and functional recovery, while spontaneous neurological recovery is an important consideration when interpreting changes observed during rehabilitation (Kirshblum et al., 2021; Khorasanizadeh et al., 2019). These considerations highlight the limited evidence regarding structured conservative rehabilitation in patients with DCM-associated incomplete cervical spinal cord injury who decline surgical decompression.

Therefore, this case report aims to describe the clinical course, structured rehabilitation program, neurological recovery, and functional outcomes of a patient with AIS C cervical spinal cord injury associated with DCM who underwent conservative rehabilitation after declining surgical decompression.

CASE PRESENTATION

A 41-year-old man presented with progressive weakness involving all four extremities without bowel or bladder dysfunction. Approximately six months before the onset of these symptoms, the patient sustained a fall from a height of approximately 3 meters while working in cons-

truction. He landed in a seated position and experienced a transient loss of consciousness. Upon regaining consciousness, he reported pain and difficulty moving both his upper and lower extremities. Despite these symptoms, he remained ambulatory and was able to return to work after approximately 10 days of rest. No neurological evaluation or imaging studies were performed at that time; therefore, his neurological status during the acute phase could not be determined retrospectively.

Approximately six months after the fall, the patient began experiencing numbness in his extremities, followed by gradually progressive weakness. The symptoms initially affected the upper extremities and

subsequently involved the lower extremities. Over the following months, he underwent repeated neurological evaluations. Neurological examination revealed signs of an upper motor neuron lesion of undetermined etiology, prompting further diagnostic investigations.

As the neurological deficits continued to worsen, the patient was referred to a neurosurgeon for further evaluation. A non-contrast cervical MRI demonstrated grade I retrolisthesis of the C3–C6 cervical vertebrae (Meyerding classification), cervical spondyloarthrosis with multilevel degenerative disc disease, and cervical myelopathy at the C5–C7 level associated with severe spinal canal stenosis.



Figure 1. Sagittal non-contrast cervical MRI showing multilevel degenerative disc disease with severe spinal canal stenosis and spinal cord compression at the C5–C7 levels, accompanied by mild retrolisthesis at C3–C6 and cervical myelopathy.

Based on the clinical and radiological findings, surgical decompression was recommended. However, the patient declined surgical intervention and subsequently sought treatment at the Medical

Rehabilitation Clinic for further management.

On his first visit to the Medical Rehabilitation Clinic (baseline), the patient arrived in a wheelchair and was unable to walk. He was unable to move either lower

extremity, including the great toes. Residual movement was present in the upper extremities; however, it was insufficient for functional activities of daily living, particularly fine motor tasks such as buttoning clothes. Physical examination revealed increased deep tendon reflexes with mild spasticity in both lower extremities (Modified Ashworth Scale 1+ bilaterally), while no spasticity was observed in the upper extremities. Muscle strength testing demonstrated weakness in all extremities, which was more pronounced in the lower extremities.

The patient was documented as having AIS C cervical spinal cord injury associated with degenerative cervical myelopathy in the medical record based on the initial assessment performed by the treating Physical Medicine and Rehabilitation specialist. The original complete ISNCSCI examination worksheet, including sacral sensory and anorectal examination findings, was not available in the medical records accessible to the authors. Therefore, the AIS C classification was retained as a historically documented diagnosis but could not be independently reconstructed according to current ISNCSCI criteria. A conservative medical rehabilitation program was initiated, consisting of structured therapeutic exercises and adjunctive physical modalities. The rehabilitation program was provided approximately twice per

week, with each session lasting approximately 45 minutes. Approximately 30 minutes of each session were allocated to physical modalities. Exercise progression included passive, active-assisted, active, and resisted exercises, followed by balance training and gait training using parallel bars. TENS was applied using an intermittent/pulsed mode at a frequency of 80–100 Hz, with a reported application duration of approximately 10–15 minutes. Electrodes were placed over the cervical, elbow, and lumbar regions. SWD was applied to the cervical and lumbar regions using a longitudinal applicator as an adjunctive physical modality. However, detailed technical parameters, including TENS pulse width and amplitude/intensity, as well as SWD power/intensity and thermal dose, were not consistently documented in the available rehabilitation records. Therefore, these parameters could not be accurately reconstructed retrospectively and were not estimated or inferred. During the first month of rehabilitation, the patient demonstrated improvement in upper extremity and hand movement, although finger extension remained limited. He also regained the ability to move his great toes. Neurological and functional improvements continued progressively throughout follow-up. Changes in muscle strength during the rehabilitation program are summarized in Table 1.

Table 1. Serial ISNCSCI motor scores during conservative rehabilitation

Month	C5	C6	C7	C8	T1	L2	L3	L4	L5	S1	UEMS	LEMS	Total
Baseline	3/3	3/3	3/3	3/3	3/3	1/1	1/1	1/1	1/1	1/1	30	10	40
Month 1	3/3	3/3	3/3	3/3	3/3	2/2	2/2	2/2	2/2	2/2	30	20	50
Month 2	4/4	4/4	4/4	3/3	3/3	3/3	3/3	3/3	2/2	2/2	36	26	62
Month 3	4/4	4/4	4/4	4/4	3/3	3/3	3/3	3/3	3/3	3/3	38	30	68
Month 4	5/5	5/5	5/5	5/5	5/5	4/4	4/4	4/4	4/4	4/4	50	40	90
Final follow-up	5/5	5/5	5/5	5/5	5/5	4/4	4/4	4/4	4/4	4/4	50	40	90

Values are presented as right/left according to the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) motor examination. Manual muscle testing graded using the Medical Research Council (MRC) scale (0–5). UEMS, upper extremity motor score; LEMS, lower extremity motor score.

By the third month of rehabilitation, the patient was able to ambulate with a walking aid, although mild weakness persisted, particularly in the right lower extremity. Upper extremity function also improved substantially, allowing him to perform fine motor tasks such as buttoning his shirt independently. By the fourth month of follow-up, the patient was able to walk independently without assistive devices. This functional improvement was accompanied by marked gains in muscle strength, particularly in the lower extremities, which had been the most severely affected at baseline. At the final evaluation, the patient remained ambulatory without assistance and demonstrated sustained neurological improvement. Upper extremity motor function had recovered fully, while only mild residual weakness persisted in the lower extremities. Overall, the total motor score improved from 40 at baseline to 90 at the final follow-up.

DISCUSSION

Degenerative cervical myelopathy (DCM) is the most common cause of spinal cord dysfunction in adults and results from chronic compression of the cervical spinal cord caused by degenerative changes of the cervical spine. Clinical manifestations range from mild sensory symptoms to severe neurological deficits affecting motor function, hand dexterity, gait, and balance. In the present case, the patient presented with progressive DCM accompanied by severe neurological impairment and was classified as AIS C at the initial rehabilitation assessment (Badhiwala et al., 2020; Davies et al., 2018; Nouri et al., 2020).

The patient demonstrated substantial neurological and functional improvement during the documented rehabilitation period. The total ISNSCI motor score increased from 40 at a baseline to 90 at

final follow-up, with the UEMS increasing from 30 to 50 and the LEMS from 10 to 40. Functionally, the patient progressed from wheelchair dependence to assisted ambulation by the third month and independent ambulation by the fourth month. These changes are clinically notable given the severe neurological impairment and radiological evidence of multilevel spinal cord compression.

The MRI findings demonstrated multilevel degenerative disc disease, cervical spondyloarthrosis, grade I retrolisthesis from C3 to C6, and severe cervical spinal canal stenosis with spinal cord compression at C5–C7. The pathogenesis of DCM involves not only static spinal cord compression but also dynamic factors, including segmental instability and repetitive mechanical stress during cervical movement, which may contribute to progressive neurological dysfunction (Badhiwala et al., 2020; Nouri et al., 2020).

In this case, a history of significant trauma preceded the neurological deterioration. However, the patient remained ambulatory and returned to work approximately 10 days after the fall, whereas progressive neurological symptoms developed approximately six months later. The subsequent MRI demonstrated multilevel degenerative cervical changes with severe spinal canal stenosis and cervical myelopathy, particularly at the C5–C7 levels. Taken together, the delayed neurological progression and radiological findings supported DCM as the predominant contributor to the patient's spinal cord dysfunction. Nevertheless, a contribution from the preceding trauma, including possible traumatic decompensation of a pre-existing stenotic cervical spinal cord, could not be completely excluded retrospectively.

Neurologically, the patient showed upper motor neuron findings, including

increased reflexes and mild lower-extremity spasticity. The patient was documented as having incomplete SCI AIS C based on the initial assessment by the treating Physical Medicine and Rehabilitation specialist. Incomplete SCI is associated with greater potential for neurological and functional recovery than motor-complete injury because some neural pathways remain preserved (Curt et al., 2008; Burns et al., 2012). However, the complete initial ISNCSCI examination worksheet was unavailable, and therefore the historical AIS C classification could not be independently reconstructed from the available documentation. This limitation is important when interpreting the magnitude of neurological recovery in this case.

Natural neurological recovery is an additional consideration when interpreting the improvement observed in this patient. Recovery after incomplete SCI can occur spontaneously, particularly during the early months following injury, and the extent of recovery varies according to the initial severity and neurological characteristics of the injury. A systematic review and meta-analysis by Khorasanizadeh et al. (2019) reported substantial variability in neurological recovery after SCI according to injury severity, neurological level, and other clinical factors. Longitudinal evidence also indicates that neurological recovery after traumatic SCI is most rapid during the first several months after injury, although recovery may continue beyond this period (Kirshblum et al., 2021). Therefore, because the present case involved incomplete neurological impairment and was followed over several months, spontaneous neurological recovery may have contributed to the observed changes. The relative contributions of spontaneous recovery and rehabilitation cannot be separated in this single case.

For patients with moderate to severe or progressive DCM, surgical decompression remains the generally recommended treatment because of the risk of continued neurological deterioration (Fehlings et al., 2017; Badhiwala et al., 2020; Tetreault et al., 2022). Evidence supporting non-operative management remains limited. Systematic reviews have reported very low-quality evidence regarding structured non-operative treatment, with limited evidence of clinically significant functional improvement and a proportion of patients subsequently undergoing surgery (Rhee et al., 2017; Tetreault et al., 2017). Therefore, the present case should not be interpreted as evidence that conservative rehabilitation is an alternative to surgical decompression in patients with progressive or moderate-to-severe DCM. When surgery is declined, as in this case, rehabilitation may be undertaken as an individualized management strategy with close monitoring for neurological deterioration and reassessment of the need for surgical intervention when indicated (Fehlings et al., 2017). In the present case, conservative management was pursued because the patient declined surgical decompression.

Evidence specifically addressing rehabilitation in DCM also remains limited. Smith et al. (2025) highlighted the limited and heterogeneous evidence base regarding rehabilitation approach. These findings provide an important context for the present case, which describes neurological and functional changes occurring during structured rehabilitation in a patient who did not undergo decompressive surgery. However, the available evidence remains insufficient to establish the effectiveness of conservative rehabilitation as a treatment for DCM.

The rehabilitation program in this case consisted of progressive strengthening,

postural control, sit-to-stand training, functional activities, balance training, and gradual gait training according to the patient's clinical tolerance. These interventions were directed toward maximizing available motor function and promoting functional independence. Activity-dependent neural plasticity and repetitive, functionally meaningful practice have been proposed as mechanisms contributing to recovery after incomplete SCI (Curt et al., 2008). Evidence-based recommendations for locomotor training also support task-specific walking practice to improve walking-related outcomes in individuals with incomplete SCI (Hornby et al., 2020). In the present case, the progression from wheelchair dependence to assisted ambulation and subsequently independent ambulation occurred during the period in which progressive functional and gait training was provided. However, this temporal association does not establish that rehabilitation was the direct cause of the neurological recovery.

The potential for walking recovery in incomplete SCI is influenced by several neurological and clinical factors. Previous evidence has identified AIS grade, lower-extremity motor function, age, and other neurological characteristics as important determinants of walking recovery after SCI (Scivoletto et al., 2014). Similarly, clinical prediction models have demonstrated that early neurological characteristics can help predict later ambulation outcomes following SCI (van Middendorp et al., 2011). These findings provide context for the walking recovery observed in the present case, although they cannot be directly extrapolated to DCM-associated spinal cord dysfunction.

The patient's rehabilitation program also included TENS and SWD as adjunctive physical modalities. TENS was used

primarily for symptom management rather than as a treatment intended to reverse spinal cord compression. A meta-analysis by Yang et al. (2022) demonstrated that TENS can reduce pain intensity in individuals with pain after SCI, supporting its role as an adjunctive modality for symptom control and potentially facilitating participation in functional rehabilitation. Therefore, in the present case, TENS should be interpreted as a supportive intervention rather than an intervention responsible for neurological recovery. SWD was similarly used as an adjunctive modality. SWD produces tissue heating and may contribute to changes in local blood flow, tissue extensibility, and pain perception (Ahmed et al., 2023). However, evidence specifically supporting SWD for neurological recovery in DCM is limited. Therefore, in this case, SWD should be considered a symptom-oriented adjunct intended to facilitate participation in active rehabilitation rather than an intervention responsible for the observed neurological improvement.

The role of gait rehabilitation in incomplete SCI has also been investigated in controlled studies. A systematic review and network meta-analysis by Patathong et al. (2023) evaluated different gait rehabilitation approaches in individuals with incomplete SCI and demonstrated that several locomotor rehabilitation strategies can improve walking-related outcomes. Although these findings were derived primarily from traumatic incomplete SCI populations and cannot be directly generalized to DCM, they provide supporting evidence for the use of structured, task-specific gait training as part of rehabilitation for individuals with preserved motor pathways.

Overall, the substantial improvement observed in this case is best interpreted as a multifactorial clinical outcome occurring

during a structured rehabilitation program. The patient's incomplete neurological status, preserved motor function, progressive strengthening, functional task practice, and gait training may all have contributed to the observed functional gains. At the same time, spontaneous neurological recovery cannot be excluded. The multimodal nature of the rehabilitation program also prevents determination of the contribution of any individual intervention. Importantly, the available evidence does not establish the efficacy of conservative rehabilitation as a substitute for decompressive surgery in progressive DCM.

The functional outcome observed in this patient is nevertheless clinically meaningful. Independent ambulation was achieved by the fourth month following assisted ambulation at month three, and the final assessment demonstrated sustained independent ambulation with substantial improvement in motor scores. Previous studies have shown that individuals with incomplete SCI have greater potential for walking recovery than those with motor-complete injuries. Curt et al. (2008) reported greater neurological, functional, and walking recovery among individuals with incomplete SCI, while Burns et al. (2012) reported that approximately 20–75% of individuals with incomplete SCI may regain some walking ability within one year. Thus, the functional improvement observed in this case is compatible with the recovery potential described in incomplete SCI, although the present case cannot establish whether the outcome was attributable primarily to rehabilitation, spontaneous recovery, or a combination of both.

This case has several limitations. First, the complete initial ISNCSCI examination worksheet, including sacral sensory and anorectal findings, was not available, limiting independent verification of the

retrospectively documented AIS C classification. Second, detailed technical parameters of the physical modalities, including TENS pulse width and amplitude/intensity and SWD power, intensity, and thermal dose, were not consistently documented and therefore could not be accurately reconstructed retrospectively. Third, this was a single case without a control or comparator, preventing separation of spontaneous neurological recovery from recovery occurring during rehabilitation. Fourth, follow-up cervical MRI after rehabilitation was not available to determine whether the underlying structural pathology had changed. Finally, the multimodal nature of the rehabilitation program makes it impossible to determine the contribution of any individual rehabilitation component to the observed neurological and functional improvements. These limitations should be considered when interpreting the findings of this case.

AUTHORS CONTRIBUTIONS

HA contributed to data collection, literature review, manuscript preparation, and manuscript revision. PWG contributed to clinical management and supervision, critical review of the manuscript, and final approval of the manuscript. Both authors approved the final version of the manuscript.

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CONFLICT OF INTEREST

There are no conflicts of interest.

ETHICAL CONSIDERATIONS

Written Informed consent was obtained from the patient for publication of this case report and the accompanying clinical data and MRI images. Identifying information was withheld to protect the patient's privacy.

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