# Spinal Cord Injury without Radiological Abnormality in Adults: Clinical and Radiological Discordance

*Ziya Asan*

BACKGROUND: **Patients with spinal cord injury without radiological abnormality (SCIWORA) show varying clinical prognostic courses independent of radiological findings. The fact that patients cannot be evaluated using a specific terminologic standard has led to the emergence of the real SCIWORA definition. In this study, clinical progressions of 11 patients diagnosed with SCIWORA were analyzed, and terminologic differences were discussed.**

METHODS: **The clinical findings of 11 adults with a diagnosis of SCIWORA at the time of diagnosis and in the long term were analyzed according to the ASIA classification scheme. The presence of a correlation between radiological findings from the early and late periods and the clinical findings was investigated. High-dose methylprednisolone treatment was administered to all newly diagnosed patients in the early period, and the clinical response was observed. Clinical, prognostic, and radiological comparisons with SCIWORA cases reported in the literature were conducted.**

RESULTS: **Seven patients received a diagnosis of cervical SCIWORA, and 4 patients had thoracal SCIWORA. Neurologic findings at the time of diagnosis and in the early and late periods vary independent of radiological findings. In the cases where significant neurologic recovery was not observed within the first 3 days, significant recovery also was not seen in the later period. In the cases where neurologic recovery was seen, improvements in sphincter function and sensory and motor deficits were observed.**

CONCLUSIONS: **In patients diagnosed with SCIWORA, early neurologic response is the determining factor for prognosis. Clinical findings and prognosis demonstrate no correlation with radiological findings.**

## INTRODUCTION

Spinal cord injury without radiological abnormality (SCIWORA) was first defined by Pang and Wilberger[1] in 1982 in children. According to their definition, cases in which a myelopathic effect is present but the spinal fracture or instability cannot be detected radiographically with direct radiography and tomography have been evaluated within this terminology.[1] Considered the gold standard, magnetic resonance imaging (MRI) demonstrates the effect on the cord, and cases in which acute cord injury is detected by MRI are also evaluated with this definition if the X-ray and computed tomography (CT) scan findings are normal.[2]

SCIWORA is identified more frequently in the pediatric age group. It is argued that cord injuries without fracture or dislocation occur more easily in this age group than in adults, owing to the weakness of the paravertebral muscle groups and the elasticity of the spinal column.[3] However, SCIWORA also has been identified in adults.[4,5] In these cases, myelopathic findings and cord edema due to cord injury have been demonstrated on MRI; however, in rare cases, MRI cannot show the traumatic impact on the cord. These cases have been evaluated under the definition of "real SCIWORA".[2,6]

## METHODS

Eleven adult patients diagnosed with SCIWORA were evaluated. Nine patients were followed up with a diagnosis of SCIWORA in the early period after trauma. All patients were started on

**Key words**
- Adults
- Magnetic resonance imaging
- Spinal concussion
- Spinal cord injury
- SCIWORA

**Abbreviations and Acronyms**
CT: Computed tomography
MRI: Magnetic resonance imaging
SCIWORA: Spinal Cord Injury without Radiographic Abnormality

*Department of Neurosurgery, Faculty of Medicine, Ahi Evran University, Kirsehir, Turkey*

*To whom correspondence should be addressed: Ziya Asan, M.D. [E-mail: ziyaasan@gmail.com]*

*Citation: World Neurosurg. (2018) 114:e1147-e1151. https://doi.org/10.1016/j.wneu.2018.03.162*

*Journal homepage: www.WORLDNEUROSURGERY.org*

*Available online: www.sciencedirect.com*

intravenous methylprednisolone in the acute phase. Neurologic findings at the time of admission and in the early and late treatment periods were recorded according to the American Spinal Injury Association (ASIA) classification scheme. All cases were evaluated with CT following trauma at the time of admission, and in cases with no trauma-related pathology determined in the spine, MRI was performed immediately. In all cases, control MRI was performed before discharge. In cases with follow-up in the later period, additional MRI examinations were performed. The demographic characteristics and the clinical and radiological findings of all cases are presented in Table 1. Two patients were diagnosed with SCIWORA in the later period following trauma (Figure 1). Patients with acute cord injury detected on MRI were classified as the "SCIWORA" group, and those who did not demonstrate acute cord injury were classified as the "real SCIWORA" group (Table 1).

### Ethical Approval

Ethical approval for this study was obtained from Ahi Evran University's Clinical Research Ethics Committee (August 8, 2017; 2017-13/142).

## RESULTS

Seven patients were diagnosed with cervical SCIWORA (Figure 2), and 4 patients had thoracic SCIWORA. No pathological structures associated with cord injury were demonstrated on radiological examinations. Neurologic examinations revealed no dermatomal or myotomal symmetry associated with sensory and motor deficits. As lateral findings, asymmetries encompassing 1 or 2 levels were detected. Dynamic X-ray images were obtained. No patient demontrated effects of instability, such as dislocation and listhesis, requiring a cervical collar or corset for stabilization of the spinal column. Nine hospitalized patients were started on intravenous methylprednisolone therapy.

No patient showed neurologic improvement in the first 48 hours. Four patients demonstrated neurologic recovery starting at the 48th hour, which lasted until the 72nd hour. However, total neurologic recovery did not occur in any patient who demonstrated signs of recovery. In 5 patients, no improvement in neurologic function was seen in the early period.

Sphincter dysfunction was detected in 3 patients, and neurologic recovery was seen first in sphincter functions, followed by improvement of sensory loss and then improvement of motor functions. Sensory deficits did not show complete recovery in any patient.

In the follow-up period, 1 patient who had been diagnosed with cervical SCIWORA died on day 10 following trauma. Respiratory insufficiency developed on 3rd day in the patient in whom cord injury was not detected on MRI. Intercostal withdrawals were observed, and mechanical ventilation support was provided by intubation. Pulmonary embolism was not detected. The patient showed no signs of neurologic recovery during 10 days of follow-up.

Two patients were diagnosed with SCIWORA in the late period after trauma, one 3 weeks later and the other 3 months later. In both patients, cord injury was detected on MRI, and the diagnosis was corroborated, but methylprednisolone therapy was not administered. No motor deficits were detected in either patient. Along with a diagnosis of cervical SCIWORA was a sensory level affecting the C6 and C7 dermatomes. Sensory evoked potential findings were within normal limits in both patients. In 2 patients, no response was obtained when low-dose pregabalin therapy was administered, and the pregabalin treatment was also terminated after 3 months.

**Table 1.** Characteristics of the SCIWORA Cases

| Case | Age (Years)/Sex | Accident Type | Affected Level | AIS Grade (At Admission) | Clinical Improvement (Early Period) | Clinical Improvement with Rehabilitation (Late Period) | Real SCIWORA (Normal MRI) |
|---|---|---|---|---|---|---|---|
| 1 | 81/Male | TA | Cervical | A | No/10 days (AIS A) | No/10 days (exitus) | Yes |
| 2 | 35/Male | FFH | Thoracic | B | No/7 days (AIS B) | No/22 months (AIS B) | Yes |
| 3 | 54/Female | TA | Thoracic | B | Yes/11 days (AIS D)* | No/14 months (AIS D) | Yes |
| 4 | 55/Female | FFH | Cervical | D | Yes/8 days (AIS E)* | Yes/27 months (AIS E) | No (SC edema) |
| 5 | 47/Female | TA | Cervical | D | No/12 days (AIS D) | No/17 months (AIS D) | Yes |
| 6 | 45/Female | FDS | Cervical | D | ? | Yes/16 months (AIS E) | No (SC cavitation) |
| 7 | 28/Male | FFH | Thoracic | C | No/11 days (AIS C) | No/34 months (AIS C) | Yes |
| 8 | 54/Female | FDS | Cervical | D | ? | No/4 months (AIS D) | No (SC contusion) |
| 9 | 50/Female | FFH | Thoracic | C | No/13 days (AIS C) | No/6 months (AIS C) | No (SC contusion) |
| 10 | 47/Female | TA | Cervical | C | Yes/12 days (AIS D) | Yes/3 months (AIS E) | Yes |
| 11 | 54/Male | FFH | Cervical | C | Yes/11 days (AIS D)* | No/7 months (AIS D) | Yes |

SCIWORA, spinal cord injury without radiographic abnormality; AIS, American Spinal Injury Association Impairment Scale; MRI, magnetic resoance imaging; TA, traffic accident; FFH, falling from high; FDS, fall down the stairs.
*Clinical improvement begins at day 2–3.

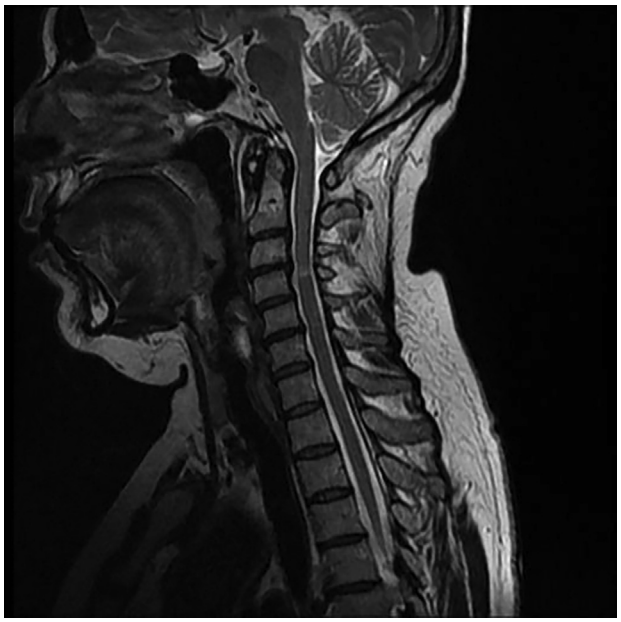

**Figure 1.** Cord contusion at the C3-4 level detected in the late period after trauma.

Complete neurologic recovery was not observed in 7 patients who demonstrated no cord damage on MRI and who were followed up according to the ASIA classification, and thus no correlation could be drawn between radiological findings and neurologic recovery. In these patients, the clinical course was good if neurologic recovery was observed within the first 3 days, but poor if no significant early recovery occurred (Table 1).

## DISCUSSION

It is not possible to predict the prognosis based on the early findings of SCIWORA cases. Yucesoy et al.[2] reported a correlation between radiological findings and clinical progression and suggested a more favorable prognosis in cases without cord injury detected on MRI. However, the prognosis did not follow a favorable course in 4 patients in whom MRI did not reveal cord injury. Moreover, there was no significant correlation between the severity of the clinical findings in patients with cord injury detected on MRI. Similarly, no correlation between MRI findings and clinical progression could be established.

A cervical collar and corset are recommended to support stabilization in diagnosed cases.[7,8] Because SCIWORA is encountered more frequently in childhood, and because spinal stabilization is not as strong in children as in adults, the use of cervical collars or corsets is recommended in the pediatric age group.[1,9]

In patients with SCIWORA with instability detected on dynamic radiographs, daily activities may cause recurrent cord injury. However, spinal elasticity differs between adults and children, and thus the effectiveness of collar and corset use is questionable. If a mobile disk is suspected, dynamic MRI examination can help to confirm the diagnosis. Thin-section and high-magnetic field MRI examinations can reveal lesions not detected on routine MRI scans. Sagittal fluid-sensitive sequences, which can identify edema (on the basis of a high T2 signal) and hemorrhage (on the basis of a low T2 signal), have been shown to have the most significant prognostic value in cases of SCIWORA.[10,11] Because cord edema cannot be detected in the early period, the diagnosis should be supported by MRI examination on subsequent days (Figure 3). In addition, sensory evoked potential examination can help determine the level of cord effect and can provide auxiliary data.

Respiratory failure may emerge in patients with cervical SCIWORA from possible intercostal muscle dysfunction starting on the third day due to the impaired innervation of intercostal

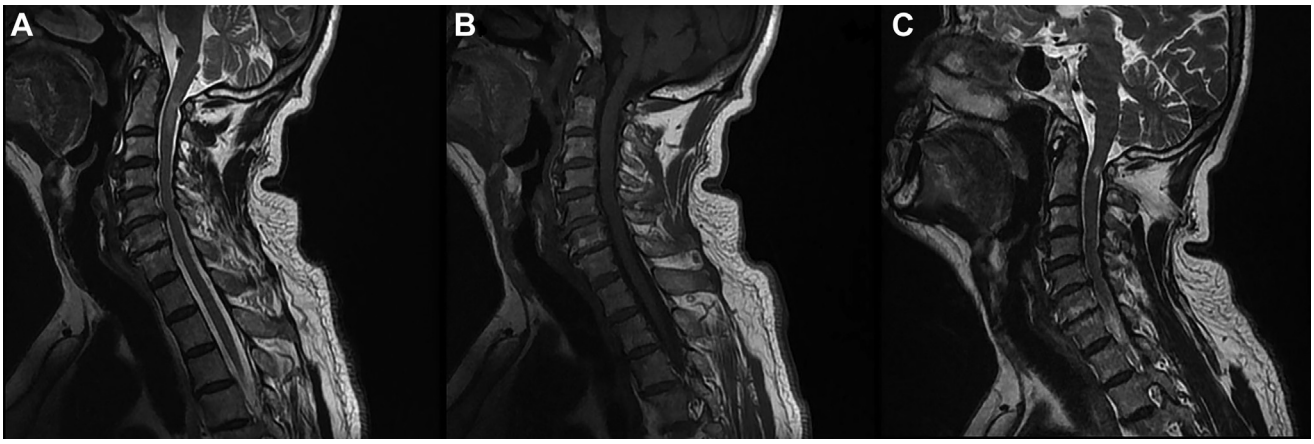


**Figure 2.** (**A**) Sagittal T2-weighted magnetic resonance imaging showing cord contusion at the C2 level at the time of admission. (**B**) Cord edema at day 8 at the same level. (**C**) Hyperintensity at the posterior cord at month 4.

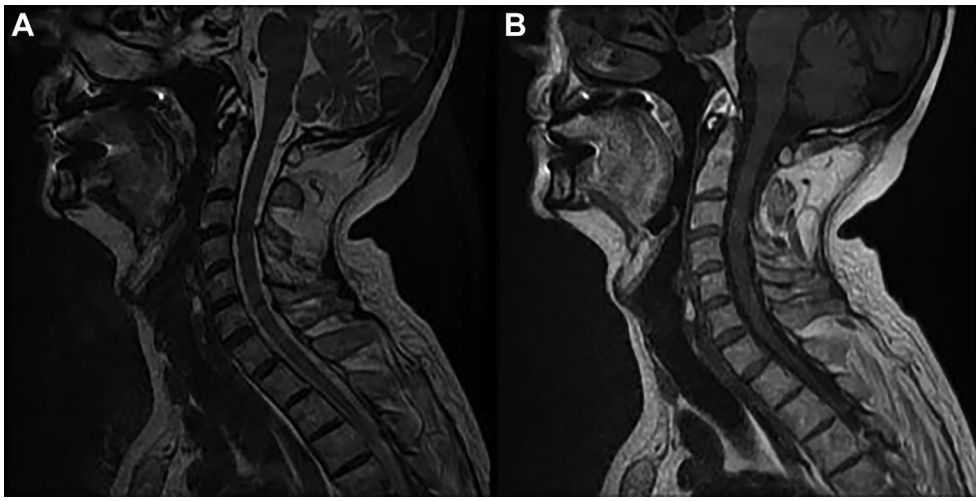


**Figure 3.** (**A**) Magnetic resonance imaging at the time of admission without cord injury. (**B**) Cervical cord edema on day 9.

muscles. In addition, the possibility of pulmonary embolism due to immobilization should be considered in patients with severe neurologic dysfunction.

The clinical manifestations of SCIWORA are similar to those of spinal concussion. Torg et al.[12] first described cervical concussion in 1986. In these cases, characterized as mild cord effect, the neurologic deficits recover entirely within the first 72 hours. The course of these cases, which are defined as cord neuropraxia, is similar to that of cerebral concussion, which is seen after mild traumatic brain injury. Given that the progression of the neurologic condition is revealed within 3 days of follow-up in both SCIWORA and spinal concussion cases, all cases in which no cord damage is detected, including on MRI, should be considered cases without a definitive diagnosis within the first 3 days. Therefore, the definitive diagnosis of SCIWORA can be made only after the third day, because neurologic recovery is not complete before then.

Given that MRI is a radiological examination, patients in SCIWORA-related series who had injuries detected by examinations other than MRI are evaluated using this terminology. However, there are cases that match the definition of SCIWORA even though cord injury is not detected even on MRI. For this reason, some studies have evaluate these cases under the "real SCIWORA" terminology.[2,6] Moreover, MRI is superior to CT regarding imaging of traumatic cord injury and is the gold standard for revealing the extent of cord injury. Moreover, injuries that cannot be detected by routine MRI can be revealed through high-magnetic field and thin-section MRI examination. It is foreseen that with the advances in MRI technology in the coming years, cases currently defined as real SCIWORA may be evaluated with positive MRI findings.

## CONCLUSIONS

MRI cannot determine which tract is affected to what extent in either the SCIWORA group or the real SCIWORA groups. In patients diagnosed with SCIWORA and those diagnosed with real SCIWORA, early neurologic response is the determining factor for prognosis. Thus, no definite correlation between radiological findings and clinical prognosis can be established.

## ACKNOWLEDGMENTS

I thank Omer Asan and Nurhale Asan, who offered support in the preparation and design of the manuscript, and Irem Nur Onay, who revised the translation of the manuscript.

## REFERENCES

1. Pang D, Wilberger JE Jr. Spinal cord injury without radiographic abnormalities in children. *J Neurosurg*. 1982;57:114-129.
2. Yucesoy K, Yuksel KZ. SCIWORA in MRI era. *Clin Neurol Neurosurg*. 2008;110:429-433.
3. Koestner AJ, Hoak SJ. Spinal cord injury without radiographic abnormality (SCIWORA) in children. *J Trauma Nurs*. 2001;8:101-108.
4. Kothari P, Freeman B, Grevitt M, Kerslake R. Injury to the spinal cord without radiological abnormality (SCIWORA) in adults. *J Bone Joint Surg Br*. 2000;82:1034-1037.
5. Gupta SK, Rajeev K, Khosla VK, Sharma BS, Paramjit, Mathuriya SN, et al. Spinal cord injury without radiographic abnormality in adults. *Spinal Cord*. 1999;37:726-729.
6. Dreizin D, Kim W, Kim JS, Boscak AR, Bodanapally UK, Munera F, et al. Will the real SCIWORA please stand up? Exploring clinicoradiologic mismatch in closed spinal cord injuries. *AJR Am J Roentgenol*. 2015;205:853-860.
7. Bracken MB, Shepard MJ, Collins WF, Holford TR, Young W, Baskin DS, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal cord injury. Results of the second National Acute Spinal Cord İnjury Study. *N Engl J Med*. 1990;322:1405-1411.
8. Andreoli C, Colaiacomo MC, Rojas Beccaglia M, Di Biasi C, Casciani E, Gualdi G. MRI in the acute phase of spinal cord traumatic lesions:

relationship between MRI findings and neurological outcome. *Radiol Med*. 2005;10:636-645.

9. Dickman CA, Zabramski JM, Hadley MN, Rekate HL, Sonntag VK. Pediatric spinal cord injury without radiographic abnormalities: report of 26 cases and review of literature. *J Spinal Disord*. 1991;4:296-305.

10. Ajani AE, Cooper DJ, Scheinkestel CD, Laidlaw J, Tuxen DV. Optimal assessment of cervical spine trauma in critically ill patients: a prospective evaluation. *Anaesth Intensive Care*. 1998;26:487-491.

11. Bozzo A, Marcoux J, Radhakrishna M, Pelletier J, Goulet B. The role of magnetic resonance imaging in the management of acute spinal cord injury. *J Neurotrauma*. 2011;28:1401-1411.

12. Torg JS, Pavlov H, Genuario SE, Sennett B, Wisneski RJ, Robie BH, et al. Neurapraxia of the cervical spinal cord with transient quadriplegia. *J Bone Joint Surg Am*. 1986;68:1354-1370.

*Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.*

*Received 25 February 2018; accepted 23 March 2018*

*Citation: World Neurosurg. (2018) 114:e1147-e1151.*
*https://doi.org/10.1016/j.wneu.2018.03.162*

*Journal homepage:* ***www.WORLDNEUROSURGERY.org***

*Available online:* ***www.sciencedirect.com***