

## A study of Spinal Cord Injury without Radiographic Abnormalities in Children

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### Abstract

Background: “Spinal Cord Injury without Radiographic Abnormality” (SCIWORA) is a term that denotes objective clinical signs of posttraumatic spinal cord injury without evidence of fracture or malalignment on plain radiographs and computed tomography (CT) of the spine. SCIWORA is most commonly seen in children with a predilection for the cervical spinal cord due to the increased mobility of the cervical spine, the inherent ligamentous laxity, and the large head-to-body ratio during childhood. Aim and Objective: This study was carried out to analyze the incidence, clinical features, diagnosis, including MRI features, and therapeutic approaches. Material and Method: Out of seventy cases of spinal injury below 12 years of age admitted in the emergency neurosurgery ward of Rani Durgawati Medical college, Banda between December 2022 and December 2023, 15 patients diagnosed with SCIWORA were included in this study. The patients were assessed for mechanism of injury, radiographic assessment by X-ray of the spine in all patients, and a CT scan in some patients. All patients underwent an MRI. Observation and Result: Clinical assessment of patients was done using the ASIA impairment scale at the time of admission, discharge, and follow-up at a 3-month and 6-month interval. The majority of patients were below 4-8 years of age (46.67%). Fall was the most common mode of injury, and the cervical spine was the most common site of injury. The majority of patients had an abnormality on the MRI. Conclusion: SCIWORA is relatively common in pediatric patients with spinal injuries, and early treatment is associated with a good outcome. MRI is helpful in predicting the outcome.

**Keywords:** Cervical Spine, Spinal Cord, Spinal Cord Injury, MRI, CT.

### Introduction

The acronym SCIWORA (Spinal Cord Injury without Radiographic Abnormality) was first defined in 1982 by Pang and Wilberger Jr. in a series of 24 children who suffered traumatic myelopathy with no radiographic evidence of fractures, dislocations, or malalignment of the spine [1]. Pang and Pollack described SCIWORA as a syndrome in which there are clinical signs of traumatic spinal cord injury (SCI) without overt traumatic vertebral column disruption as demonstrated by spine X-rays, computed tomographic (CT) scans, myelograms, and dynamic flexion/extension X-rays [2]. The first human magnetic resonance imaging (MRI) scan was done in 1977, and distinctive MRI signal patterns of acute SCI were first described in 1987 [3, 4]. Hence, the original report from Pang and Wilberger Jr. that introduced SCIWORA into medical literature did not include MRI in the definition of this syndrome; Pang acknowledged the diagnostic potential of MRI in patients with SCIWORA two decades later [5]. It might be sensible to ask, “Would SCIWORA still exist if MRI was readily available for use in acute SCI only a few years earlier?” The answer would probably be “yes,” since MRI is never the first-line imaging modality in the setting of acute spinal trauma. Plain X-rays and CT are almost invariably performed before MRI, since MRI scans require more time, space, and patient transfer, which might not be practical in the emergency management of trauma patients.

SCIWORA is more commonly seen in the pediatric age group than in adults and involves the cervical spine more frequently than the thoracolumbar spine. These incidences have been reported in between 13 and 19% and 10 and 12% of spinal injuries in children and adults, respectively [6–9]. SCIWORA is far more common in males than females [6, 8–10]. In a systematic review, Carroll et al. [10] documented that, of 368 pediatric patients with SCIWORA, approximately 68.5% were male and 31.5% were female. Cervical spine was involved in 87% of the patients; thoracic spine was involved in 9.5%; lumbar spine was involved in 1.5%; and in 2%, the SCI spanned the cervical and thoracic levels.

Evidence from the adult population indicating that the thoracolumbar spine can also be involved with SCIWORA is limited to occasional case reports [11, 12]. The reasons for the increased frequency of SCIWORA in the pediatric age group with a predilection for the cervical spinal cord include the large head-to-body ratio, increased mobility of the cervical spine, inherent ligamentous laxity, immaturity of the neck musculature, incomplete ossification of the vertebrae, and shallow angulation of the facet joints during childhood [2, 5, 12]. Interestingly, several studies showed that the upper cervical spine was more susceptible to SCIWORA in

younger children than in older children, where the lower cervical spine is more commonly affected [2, 10, 13]. This finding is supported by the fact that the fulcrum of movement is at the upper levels of the cervical spine (between C2 and C4) in younger children and shifts to lower levels (C5-C6) in adolescents and adults [14, 15]. It is conceivable that SCIWORA is seen less frequently in adults as a result of age-related changes in bone morphology and a decrease in ligamentous laxity. Furthermore, the thoracic spine has a more stable and stiff structure compared to the cervical spine due to the surrounding rib cage and costovertebral articulations. Similarly, both the thoracic and lumbar spines have larger bony surfaces that increase axial loading capacity and stability [12].

The diagnosis can be difficult if the potential for its occurrence is not considered, as the injury is not identifiable in routine radiographs or CT scans. However, as SCIWORA is most often caused by serious trauma (motor vehicle accident, significant fall, sports injury, or child abuse) and can result in serious and irreversible consequences for the patient, the most important challenge for the clinician is to recognize this syndrome as quickly as possible so that treatment can be instituted early [13]. With the increasing use of MRI for investigation and predicting the outcome of patients with spinal injuries, the term SCIWORA has come under criticism [14]. However, there is no uniform consensus regarding the classification of SCIWORA based on MRI features. Spinal cord injury without radiological abnormality (SCIWORA) was defined in the era when magnetic resonance images were not popularly used as diagnostic tools. Although it is generally accepted that MR imaging can effectively illustrate the level and severity of spinal cord injury in the acute phase of trauma, only a few reports of MR imaging studies of SCIWORA have been published.

This study was carried out to analyze the incidence, clinical features, diagnosis, including MRI features, and therapeutic approaches to emphasize the importance of the early diagnosis and outcome of patients with SCIWORA in the light of existing literature.

## Materials and Methods

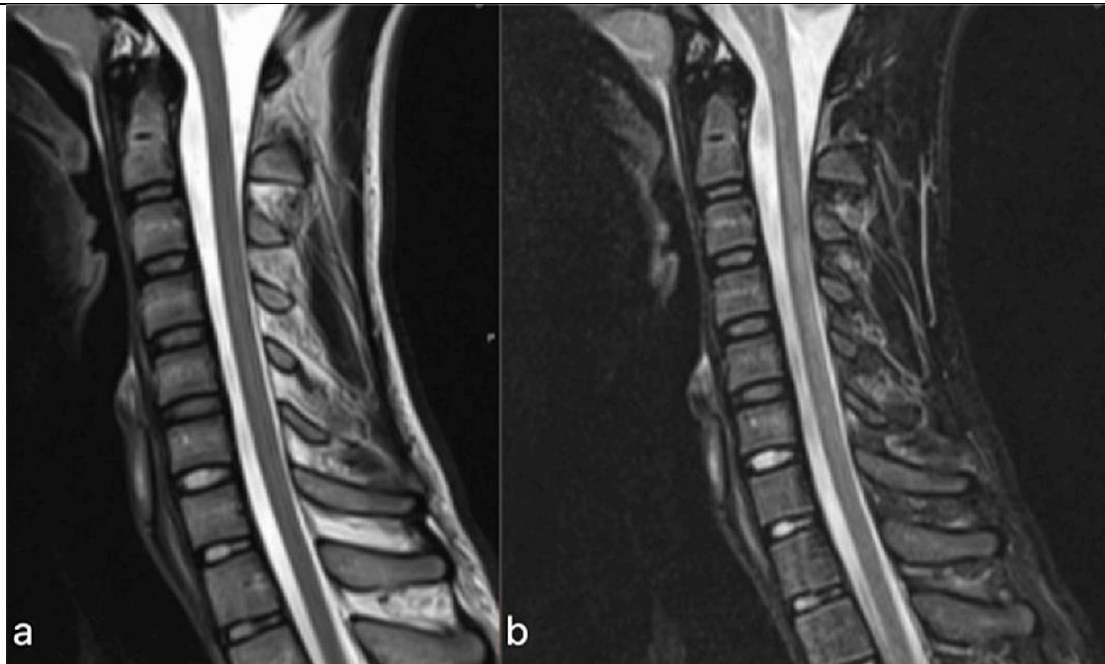
This prospective study was done between December 2022 and December 2023 in a tertiary care center in Rani Durgawati Medical college, Banda, UP. Out of 70 cases of spinal injury below 12 years of age admitted in the emergency neurosurgery ward of IPGMER, Kolkata, during this period, 15 patients diagnosed with SCIWORA were included in this study. The children with spinal injuries without any visible injury on plain radiographs were included in this study. The age and gender of each patient were recorded. The patients were assessed for mechanism of injury, neurological deficit by thorough clinical examination, radiographic assessment by X-ray of the spine in all patients, and CT scan in some patients. All patients underwent an MRI of the cervical spine. The clinical assessment of patients was done at the time of admission and discharge. The patients were followed up at 3 months and 6 months intervals. The clinical neurologic deficit was graded using the ASIA impairment scale in each case during the entire follow-up [15].

Table 1: Showing the ASIA grade

Grade	Category	Description
A	Complete	Complete loss of motor and sensory function
B	Incomplete	Complete loss of motor function with intact sensation
C	Incomplete	Incomplete loss of motor function with the power of the majority of key muscles <3
D	Incomplete	Incomplete loss of motor function with the power of the majority of key muscles >3
E	Normal	Normal sensory and motor function

The patients with the following injuries were excluded:

- 1) Radiographically demonstrable fracture and/or dislocation involving the spine at the clinical level of neurodeficit.
- 2) Associated plexus injury of the upper or lower limbs
- 3) Peripheral nerve injury
- 4) Extensive fractures of the upper and lower limbs



**FIGURE 1: Cervical MRI scan showing no appreciable changes**

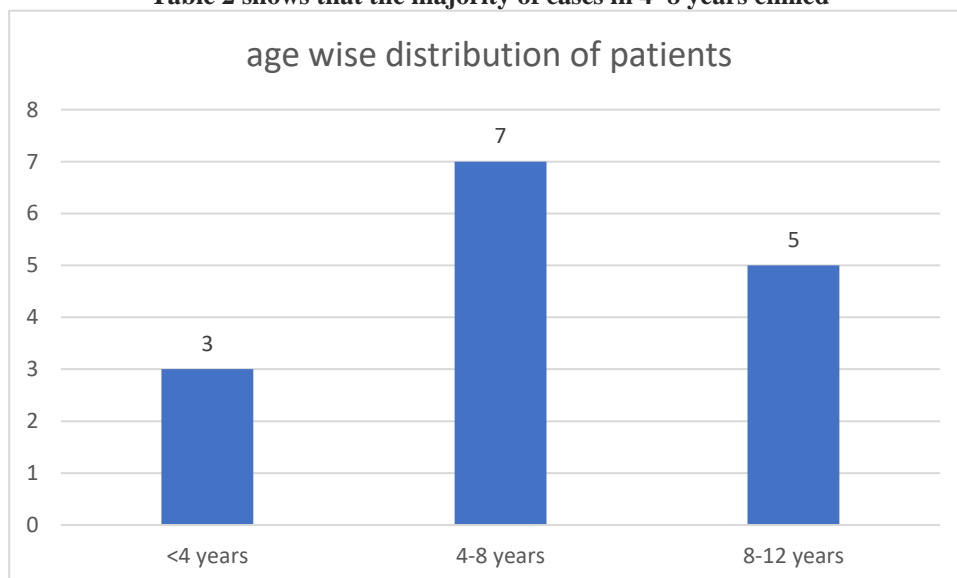
### OBSERVATION AND RESULTS

Among the 70 children with spinal injuries, 15 (21.43%) were found to have SCIWORA. Among the 15 children with SCIWORA, 9 (60%) were males and 6 (40%) were females. The following table shows the age-wise distribution of the cases.

**Table 2 shows the age-wise distribution of patients.**

Age	Number of cases
<4 years	3(20%)
4-8 years	7(46.67%)
8-12 years	5(33.33%)

**Table 2 shows that the majority of cases in 4–8 years chilled**



**Graph no.1: age wise distribution of patients**

**Table 3: Showing the Mechanism of Injury**

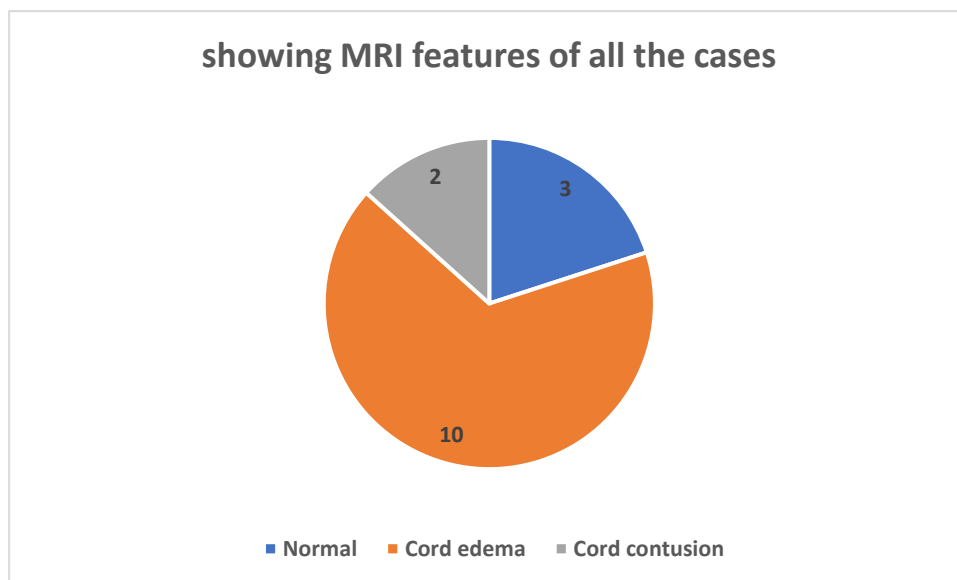
Mechanism of injury	Number of cases (n = 15)
Road traffic accident	3(20%)
Fall from height	9(60%)
Fall of an object over the spine	3(20%)

Clinically, 9 (60%) cases had involvement of the cervical spine presenting with quadriparesis, while 3 (20%) cases had involvement of the dorsal spine presenting with paraparesis. Among these 3 (20%) patients, one had a neurogenic bladder. Each of these patients had no detectable abnormality on radiography. However, MRI revealed abnormalities in 9 (60%) cases. The following table reveals the MRI features of different patients.

**Table 4: showing MRI features of all the cases**

MRI Features	Number of cases (n = 9)
Normal	3 (20%)
Cord edema	10(67.67%)
Cord contusion	2(13.33%)

The patients with MRI abnormalities also had extraneural injuries. The following table reveals the types of extraneural injuries found in our patients.



**Graph no.2: showing MRI features of all the case**

**Table 5 shows the types of extraneural injuries.**

MRI abnormality (extraneural)	No. of cases (n = 9)
Anterior and posterior longitudinal ligament injury	6(66.67%)
Posterior longitudinal ligament injury with disc herniation	3(33.33%)

The onset of neurodeficit was within 2 hours of the onset of injury in 9 patients (60%), while 6 patients (40%) presented with neurodeficit after 24 hours. An earlier onset of neurodeficiency was observed in patients with MRI abnormalities. The severity of the neurological deficit was graded according to Frankel grade at the time of admission, at discharge, and at 3 months and 6 months of follow-up.

The treatment of SCIWORA in this study was conservative, which included external rigid immobilization for 12 weeks and bladder and back care. Nine children who presented early were administered a high-dose, 24-hour

course of methylprednisolone based on the recommendation of the National Acute Spinal Cord Injury Study II study [16–17].

The following table shows the severity of the neurological deficit and subsequent improvement during follow-up. All patients showed improvement in their clinical grading. 12 patients (80%) made complete recovery, while 3 (20%) showed partial improvement.

**Table 6: showing the clinical status of the patients assessed by ASIA grading**

ASIA grade on admission	ASIA grade on discharge	on ASIA grade at 6 months	ASIA grade at 3 months
A-1	A-1	C-1	D-1
B-1	C-1	D-1	D-1
C-7	C-1, D-6	D-3, E-4	E-7

## Discussion

In the present study, the frequency of SCIWORA among children with spinal injuries was found to be 13.33%. A meta-analysis of 392 published cases in 2005 of patients recently diagnosed with spinal cord injuries without radiographic abnormalities (SCIWORA) estimated the incidence of SCIWORA in the pediatric population at 19–34% of all spinal cord injuries [18]. The lower frequency in the present study could be due to a lower number of road traffic accident cases. In the present series, the majority of patients were between 4 and 8 years of age (46.67%), and children below 8 years accounted for 66.67% of cases. Various other studies have also reported SCIWORA more commonly in children below 8 years of age [19, 18, 20–22].

Our studies found that the involvement of the cervical spine was more common (60%) as compared to the thoracic spine (40%). Children younger than 8 years are more likely to develop cervical spine injuries, while older children tend to develop lower cervical and thoracic spine injuries. The majority of the cases were younger than 8 years, which could account for a higher incidence of injury in the cervical spine region. In our series, 60% of patients had abnormal MRIs, with cord edema being the most common abnormality (67.67%) and cord contusion in 13.33%. In 40% of our patients, the MRI was normal. Normal MRI has been reported in up to 25% of SCIWORA patients [23]. MRI has been mostly employed to prognosticate the outcome.

A similar study by Vishwanath Sidram M. Ch. et al. found that clinical assessment of patients was done using the ASIA impairment scale at the time of admission, discharge, and follow-up at a 3-month and 6-month interval. The majority of patients were below 8 years of age (66.67%). Fall was the most common mode of injury, and the cervical spine was the most common site of injury. The majority of patients had an abnormality on the MRI. SCIWORA is relatively common in pediatric patients with spinal injuries, and early treatment is associated with a good outcome. MRI is helpful in predicting the outcome. [24]

All the patients in our study were managed conservatively and showed recovery, which is similar to findings in other studies [18, 25]. In our study, one patient with a cord contusion showed partial improvement, whereas all patients with normal MRI and cord edema except one showed dramatic improvement and returned to normal function. The patients who did not return to normal function, however, had a partial recovery with motor power of 4. Minor hemorrhage or edema alone is associated with moderate to good recovery [26–29], and the absence of any abnormal cord signal suggests the patient will make a complete recovery [30–31], which was also found in our study. With the increasing use of MRI in the evaluation of patients with spinal injuries, the term SCIWORA has taken on an ambiguous meaning. At present, some researchers believe that 'real-SCIWORA' should be determined as 'Spinal Cord Injury Without Neuroimaging Abnormality' in cases with normal MRI [14]. Three of our patients who had normal MRIs fall into this category.

## Conclusion

SCIWORA is relatively common in pediatric patients with spinal injuries, the awareness of which helps in early diagnosis and treatment. Conservative treatment is associated with a good outcome. MRI is helpful in predicting the outcome.

## Strengths and Limitations of the Present Study

There are a few limitations to the study. In the present study, only 4–12-year-old subjects participated in the research. Hence, in the future, we would like to include an increase in the number of participants to reach a concrete conclusion. The present study had an impact on understanding that SCIWORA is relatively common in pediatric patients with spinal injuries, whose awareness helps in early diagnosis and treatment.

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**Conflicts of interest statement:** The authors have no conflicts of interest relevant to this article.

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