ISSN 1220-8841 (Print)
ISSN 2344-4959 (Online)

ROMANIAN
NEUROSURGERY

Vol. XXXIX | No. 2 June 2025

A study of prognostic value of ASIA score in post operative outcome assessment in spine trauma in a tertiary care centre

Mohit Gupta,
Banwari Lal Bairwa

DOI: 10.33962/roneuro-2025-029

Romanian Neurosurgery (2025) XXXIX (2): pp. 159-167
DOI: 10.33962/roneuro-2025-029
www.journals.lapub.co.uk/index.php/roneurosurgery

A study of prognostic value of ASIA score in post operative outcome assessment in spine trauma in a tertiary care centre

Mohit Gupta, Banwari Lal Bairwa

SMS Medical College and hospital, Jaipur, Rajasthan, INDIA

Keywords
spinal cord injuries, neurological recovery, American Spinal Injury Association Impairment Scale, prognostic value, traumatic spinal cord injury, rehabilitation

ABSTRACT

Background: Spinal cord injury (SCI) remains a major cause of long-term disability and reduced quality of life, with significant socioeconomic and healthcare implications. The American Spinal Injury Association Impairment Scale (AIS) is a widely accepted tool for assessing the severity of SCI and predicting neurological recovery. While existing studies have examined AIS grade changes in Western populations, limited data are available from resource-limited settings such as India.

Objectives: (A) To determine the percentage of individuals with complete spinal cord injury (AIS A) who convert to incomplete status within the first post-injury year (B) To evaluate the extent of improvement in AIS grade from baseline to one-year follow-up among patients with initial AIS B injuries.

Methodology: This was a prospective observational study conducted at the Trauma Centre, Department of Neurosurgery, SMS Medical College, Jaipur, from December 2022 to December 2023. A total of 400 patients aged ≥16 years with traumatic SCI admitted within 30 days of injury were enrolled. Baseline AIS grades were recorded at admission, and neurological recovery was assessed at a one-year follow-up using the AIS classification. Statistical analysis involved chi-square tests to assess the significance of AIS grade changes.

Results: Of the 146 patients with initial AIS A injury, 38 (26.0%) improved to an incomplete status (AIS B, C, or D), while 108 (74.0%) remained unchanged. Among 66 patients with initial AIS B injuries, 26 (39.4%) showed improvement to a higher AIS grade, while 33 (50.0%) remained unchanged and 7 (10.6%) worsened to AIS A. AIS C and D patients demonstrated higher rates of recovery (56.5% and 54.4%, respectively), while no significant change was observed among AIS E patients. Statistical analysis confirmed a significant association between baseline AIS grade and post-operative outcomes ($p < 0.001$).

Conclusion: The study demonstrates that AIS scores are valuable in predicting post-operative neurological recovery in SCI patients. While AIS A patients exhibit limited potential for improvement, AIS B–D patients show higher recovery rates, reinforcing the importance of early intervention and targeted rehabilitative strategies. The findings underscore the need for tailored clinical management based on initial AIS grades to optimise patient outcomes in resource-limited settings.

Corresponding author:
Mohit Gupta

SMS Medical College and hospital, Jaipur, Rajasthan, India

mohitkmc11@gmail.com

ISSN online 2344-4959
© Romanian Society of Neurosurgery

First published
June 2025 by
London Academic Publishing
www.lapub.co.uk

Introduction

Spinal cord injury (SCI) represents a significant global health challenge, often resulting in profound neurological deficits and long-term disability. Traumatic SCI is caused by events such as falls, road traffic accidents, and assaults.[3,5] It affects millions annually - an estimated global incidence of 10.5 cases per 100,000 people - as reported in various studies and systematic reviews.[2,4,10] The impact of SCI is pronounced in developing countries, where resource limitations exacerbate outcomes.[18,19] In India - the epidemiology of SCI is shaped by a high prevalence of falls and vehicular accidents and necessitates focussed research into prognostic tools and recovery patterns.

The American Spinal Injury Association Impairment Scale (AIS), part of the International Standards for Neurological Classification of Spinal Cord Injury, is a widely accepted tool for assessing the severity of SCI. Ranging from AIS A (complete injury with no motor or sensory function below the injury level) to AIS E (normal function), this scale provides a standardized framework for evaluating neurological status and tracking recovery. A study by Kirshblum et al. in 2020 emphasized its prognostic utility, noting that baseline AIS grades strongly correlate with long-term functional outcomes. For patients with AIS A injuries, conversion to an incomplete status (AIS B, C, D, or E) within the first year is a critical indicator of recovery potential, while improvement in AIS B patients reflects the capacity for neurological regain post-intervention.[8]

Research on AIS grade conversion rates has yielded variable findings. A study by Spiess et al. in 2004 reported that approximately 20–30% of AIS A patients in Italy converted to incomplete status within one year, influenced by factors such as injury level and timing of intervention. Conversely, a study by Lee et al. in 2016 found lower conversion rates (10–15%) in cervical SCI patients with AIS A.[9] They emphasized the challenges in predicting recovery for complete injuries. For AIS B patients, improvement rates to higher grades (C, D, or E) range from 30–50%, as noted in a study by van Middendorp et al. in 2020; this indicated greater plasticity in incomplete injuries. These discrepancies highlight the need for region-specific data, particularly in resource-constrained settings like India, where surgical and rehabilitative care may differ from Western contexts.[14]

Epidemiology and Burden of SCI in India

In India, the epidemiology of SCI reflects a unique set of socioeconomic and environmental factors. Road traffic accidents and falls are the leading causes of SCI, with workplace injuries and falls from height accounting for a substantial proportion of cases. One study reported that approximately 60% of traumatic SCI cases in India are caused by road traffic accidents, followed by falls (25%) and violence (5%). The majority of affected individuals are young adults (aged 18–40), which amplifies the long-term socioeconomic impact due to loss of productivity and increased caregiving burden.[13,20]

Despite the high incidence of SCI in India, accurate national data remain limited due to underreporting and inconsistent record-keeping, especially in rural areas. It is estimated that nearly 1.5 million people are living with SCI in India, with an annual incidence of approximately 20,000 new cases.[15] However, fewer than 10% of these individuals have access to specialized spinal care or rehabilitation services. There are gaps in studies and information available on recovery patterns and prognostic factors related to SCI.[1]

Healthcare and Rehabilitation Challenges in India

The healthcare infrastructure for SCI management in India faces several systemic challenges that contribute to poor outcomes. First, access to acute trauma care is limited, particularly in rural and semi-urban areas. A study found that fewer than 30% of SCI patients in India receive surgical intervention within the critical first 24 hours post-injury—a key determinant of neurological recovery.[16,17]

Specialized rehabilitation centres are scarce; India has fewer than 15 dedicated spinal rehabilitation centres for a population of over 1.4 billion.[7] Most rehabilitation services are concentrated in urban centres, making them inaccessible to rural populations. Financial constraints further compound these challenges. The cost of long-term care for SCI patients—including surgical, rehabilitative, and assistive care—places a significant burden on families, particularly in the absence of comprehensive health insurance coverage. A study reported that nearly 70% of SCI patients in developing countries experience catastrophic healthcare expenditures, which can push families into poverty. These healthcare

disparities highlight the need for prognostic models to assist and optimize treatments and outcomes.[11]

Our study sought to address some of these gaps by investigating the prognostic value of AIS scores for assessment of post-operative outcomes in traumatic SCI patients at a tertiary care centre in Jaipur, India. We focussed on heterogeneous sample which included tetraplegia and paraplegia. We aimed to assess the percentage of AIS A patients converting to incomplete status and the extent of AIS grade improvement in AIS B patients over one year.

Methodology

Our study was an observational study conducted at the Trauma Centre, Department of Neurosurgery, SMS Medical College, Jaipur, a tertiary care centre in India. The study duration was one year, from December 1, 2022, to December 31, 2023, with patient data collected for traumatic spinal cord injuries (SCI) and occurred between January 1, 2023 - December 31, 2023.

Participants were patients aged 16 years or older who were treated for traumatic SCI at the study site and provided written consent. Exclusion criteria included patients who did not receive a computed tomography (CT) scan within 24 hours of admission or those who suffered fatal injuries upon arrival. A total of 400 patients were enrolled – which we determined using the below sample size formula.

$$N = \frac{Z^2 \cdot P(1-P)}{L^2}$$

Where Z=1.96 (95% confidence interval), P=0.02 (2% proportion of AIS A conversion from literature), Q=0.98 (1 - P) and L=0.01 (1% precision) and this resulted in our sample size of 400. Data collection involved a comparative analysis of traumatic SCI cases admitted within 30 days of injury. Neurological status was assessed using the American Spinal Injury Association Impairment Scale (AIS) at baseline (pre-operative) and at a one-year follow-up post-operatively. Baseline AIS grades (A through E) were recorded upon admission, and follow-up assessments tracked changes in AIS grade after surgical intervention. Additional data included patient demographics (age, sex), diagnosis (fracture level) and mode of injury (e.g., fall from height, road traffic accident, assault, penetrating injury).

Data analysis was performed using SPSS v28 and reported using descriptive statistics to summarize patient characteristics and AIS grade changes; and distributional analysis. Inferential statistics (chi-square tests) employed to assess significance of AIS grade improvements and test our study hypotheses: the null hypothesis (H_0) stated no significant improvement in AIS score from baseline to follow-up, while the alternative hypothesis (H_1) posited significant improvement. Statistical significance was set at $p < 0.05$. All analyses were performed to address the objectives of determining the percentage of AIS A patients converting to incomplete status and the improvement in AIS grade among AIS B patients over one year.

Results

Demographic and Baseline Characteristics

Our study included 400 patients with traumatic spinal cord injuries treated at SMS Medical College, Jaipur, between January 1, 2023, and December 31, 2023. The mean age was about 37.8 years. Ages ranged from 14 to 73 years. Most patients were male (65.5%) and Female patients accounted for 34.5%. The most common cause of injury was falling from a height (47.0%) which was followed by road traffic accidents (38.5%). At the start of the study we observed that 36.5% of patients had a complete spinal cord injury (AIS A) and 16.5% had an AIS B injury.

Table 1. Demographics

Characteristic	Value
Total Patients	400
Mean Age (years)	37.8
Age Range (years)	14–73
Male, n (%)	262 (65.5%)
Female, n (%)	138 (34.5%)

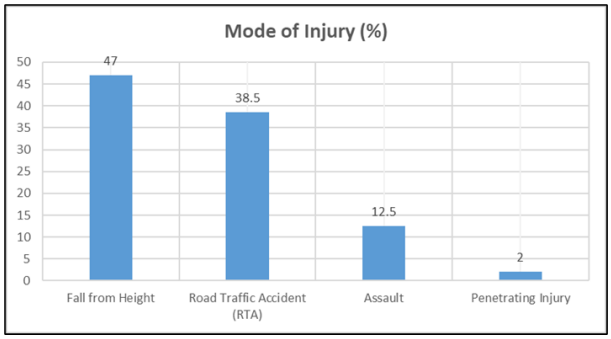

Figure 1. Mode of injury.

Table 2. Mode of Injury

Mode of Injury	Count (n)	Percentage (%)
Fall from Height	188	47
Road Traffic Accident (RTA)	154	38.5
Assault	50	12.5
Penetrating Injury	8	2
p-value (χ^2, df=3)	<0.001	

As illustrated in Table-2 and Figure-1 - Falls from height were the most common (47.0%, 188 patients), followed by road traffic accidents (38.5%, 154 patients). Assault caused 12.5% (50 patients), and penetrating injuries were rare (2.0%, 8 patients). The p-value (<0.001) shows these differences are significant. This indicated that the injury causes were not evenly split—falls and RTAs were the major contributors for mode of injury in our study cohort.

Table 3. Baseline AIS Grades

Baseline AIS Grade	Count (n)	Percentage (%)
A	146	36.5
B	66	16.5
C	62	15.5
D	90	22.5
E	36	9
p-value (χ^2, df=4)	<0.001	

Table-3 and Figure-2 show the starting AIS grades for our 400 patients. AIS A - a complete injury - was the most frequent (36.5%, 146 patients). This was followed by AIS D (22.5%, 90 patients). AIS B had 16.5% (66 patients) and AIS C and E were less common at 15.5% (62 patients) and 9.0% (36 patients). The p-value (<0.001) indicated statistical significance and indicated that more patients started with AIS A and D than expected.

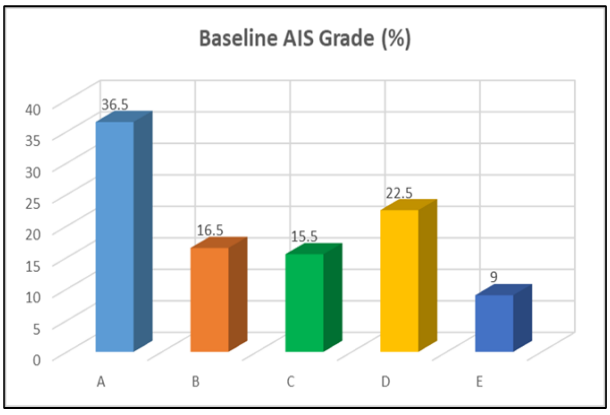

Figure 2. Baseline AIS Grades.

Conversion from AIS A to Incomplete Status

This section examines how many patients with complete spinal cord injuries (AIS A) improved to an incomplete status within one year and the results are illustrated in Table-4 and Figure-3.

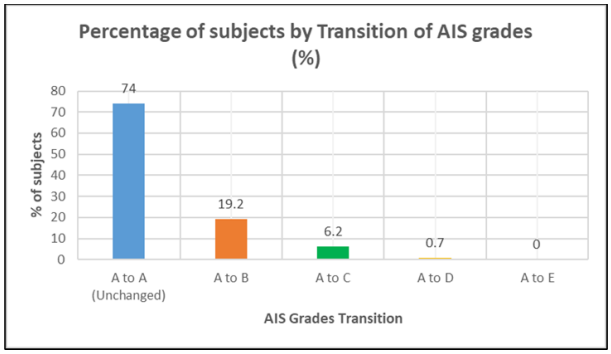

Figure 3. Conversion from AIS A to Incomplete Status.

Table 4. Conversion from AIS A to Incomplete Status

Transition	Count (n)	Percentage (%)
A to A (Unchanged)	108	74
A to B	28	19.2
A to C	9	6.2
A to D	1	0.7
A to E	0	0
p-value (χ^2, df=4)	<0.001	

Table-4 provides details on the 146 patients who started with AIS A (a complete spinal cord injury) out of the total 400 in the study. After one year - 38 of them (26.0%) improved to an incomplete status: 28 (19.2%) moved to AIS B, 9 (6.2%) to AIS C, and 1 (0.7%) to AIS D, with none reaching AIS E. Most, 108 patients (74.0%), stayed at AIS A with no change. The p-value (<0.001) shows these results are significant. This meant that about one in four AIS A patients gained some recovery - though most remained complete.

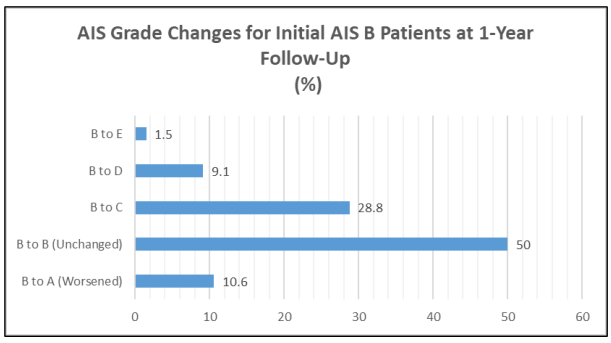

Figure 4. AIS Grade Changes for AIS B subjects.

Table 5. AIS Grade Changes for Initial AIS B Patients at 1-Year Follow-Up

Transition	Count (n)	Percentage (%)
B to A (Worsened)	7	10.6
B to B (Unchanged)	33	50
B to C	19	28.8
B to D	6	9.1
B to E	1	1.5
p-value (χ^2, df=4)	<0.001	

Improvement in AIS Grade for Initial AIS B Injuries

In this section we tracked number of patients with initial AIS B injuries who improved their AIS grade after one year.

Table-5 and Figure-4 focused on the 66 patients who started with AIS B - out of the total 400 in our study. After one year - 26 of them (39.4%) improved: 19 (28.8%) moved to AIS C, 6 (9.1%) to AIS D, and 1 (1.5%) to AIS E. Half, 33 patients (50.0%), stayed at AIS B; 7 (10.6%) got worse and dropped their grade to AIS A. The p-value (<0.001) showed that these changes are significant. This meant that about four in ten AIS B patients improved their grade and showed a good chance of recovery; though some stayed the same or worsened.

Overall AIS Grade Changes

Table-6 summarizes AIS grade changes across all patients from baseline to one-year follow-up. Figure-5 and Table-6 showed the final eventual condition of all 400 patients' AIS grades after one year.

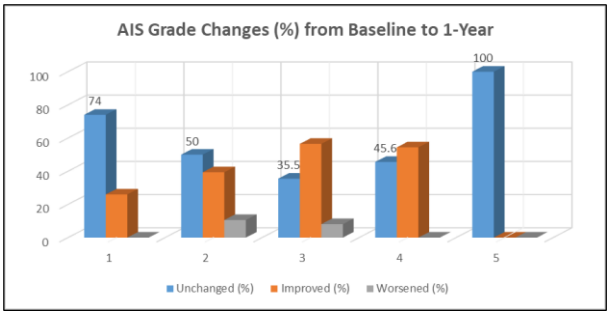

Figure 5. AIS Grade Changes from Baseline to 1-Year Follow-Up.

For AIS A (146 patients), 26.0% (38) improved, but 74.0% (108) stayed the same. For AIS B (66 patients), 39.4% (26) got better, 50.0% (33) didn't fluctuate and 10.6% (7) worsened. AIS C (62 patients) had the highest improvement rate at 56.5% (35), with 35.5% (22) unchanged and 8.1% (5) worse. AIS D (90 patients) saw 54.4% (49) improve to E, with 45.6% (41) staying D. All 36 AIS E patients stayed normal (100%). The p-value (<0.001) shows these patterns are significant. This supports our objectives: 26.0% of AIS A patients improved to incomplete status (Objective 1), and 39.4% of AIS B patients got better (Objective 2), with clear patterns across all grades for charting.

Table 6. AIS Grade Changes from Baseline to 1-Year Follow-Up

Baseline AIS	Count (n)	Unchanged, n (%)	Improved, n (%)	Worsened, n (%)
A	146	108 (74.0)	38 (26.0)	0 (0)
B	66	33 (50.0)	26 (39.4)	7 (10.6)
C	62	22 (35.5)	35 (56.5)	5 (8.1)
D	90	41 (45.6)	49 (54.4)	0 (0)
E	36	36 (100)	0 (0)	0 (0)
p-value (χ^2, df=8)	<0.001			

Statistical Analysis

This section presented statistical tests used to evaluate AIS grade changes and test our study hypotheses. Table-7 showed the statistical tests for our study. For all 400 patients - we observed a strong link between starting AIS grade and their status after one year ($p < 0.001$). This meant outcomes depended on the initial injury. For the 146 AIS A patients - 26.0% improved to incomplete status and the p-value (<0.001) confirmed this isn't random. For the 66 AIS B patients, 39.4% got better with a significant ($p < 0.001$) p-value. These results rejected our null hypothesis (no improvement) and supported our alternative hypothesis (significant improvement) and indicated AIS scores can improve post-surgery in spine trauma patients.

Table 7. Statistical Analysis of AIS Grade Changes

Analysis Focus	Group	Count (n)	Key Finding	Chi-Square (χ^2)	Degrees of Freedom (df)	p-value
Overall AIS Changes	All Patients	400	Significant association between baseline AIS and outcome	114.3	8	<0.001

AIS A Conversion	AIS A Patients	146	26.0% improved to incomplete status	223.45	4	<0.001
AIS B Improvement	AIS B Patients	66	39.4% improved to higher grade	43.39	4	<0.001

Discussion

The findings of our study provide significant insights into the prognostic value of the American Spinal Injury Association (ASIA) Impairment Scale (AIS) in post-operative outcome assessment of spinal cord injury (SCI) patients. Traumatic SCI remains a major cause of morbidity and long-term disability globally, particularly in developing countries where healthcare infrastructure and rehabilitative resources are limited. We conducted Our study at a tertiary care centre in Jaipur, India with the aim of evaluating the degree of recovery in SCI patients post-operatively over a one-year follow-up period. Our results contribute to evidence supporting the utility of AIS scores in predicting neurological recovery.

Age and Gender Distribution

In the present study, the mean age of the patients was 37.8 years (range: 14–73 years), which aligns closely with the findings of Mahmoodkhani et al. (mean age 39.64 years). However, Haque et al. reported a slightly lower mean age of 32.9 years (range: 18–57 years). This suggests that SCI in India and Iran tends to affect individuals in the third to fourth decades of life, reflecting a higher burden on the working-age population. The gender distribution also varied between the studies. In the present study, 65.5% of the patients were male, consistent with the pattern of male predominance observed in Mahmoodkhani et al. (74.7%), but Haque et al. did not report gender-specific findings. The higher proportion of males affected by SCI is consistent with global trends, which have been linked to greater male exposure to occupational and road traffic hazards.[6,12]

Mechanism of Injury

The mode of injury in the present study primarily involved falls from height (47.0%), followed by road traffic accidents (38.5%). In contrast, Mahmoodkhani et al. reported that road traffic accidents were the most common cause of SCI (54.4%); this was followed by falls (36.7%). Haque et al. did not report data on the mechanism of injury. The higher prevalence of falls in the present study may indicate differences in occupational hazards and the rural-urban injury distribution in India. The predominance of road traffic accidents in Mahmoodkhani et al. likely reflects differences in traffic patterns, infrastructure and safety regulations between Iran and India.[6,12]

Baseline AIS Grades

The baseline AIS grade distribution varied across the studies. In the present study, 36.5% of patients presented with complete injuries (AIS A), which was higher than the 15.2% reported by Mahmoodkhani et al. and the 6.45% reported by Haque et al. The higher proportion of AIS A cases in the present study suggests a more severe initial injury profile, which may reflect delays in accessing acute care or differences in injury severity. The proportion of AIS B patients in the present study (16.5%) was similar to Haque et al. (16.1%) but differed significantly from Mahmoodkhani et al., who reported no AIS B cases at baseline. AIS C and D cases were more frequent in Mahmoodkhani et al. (39.2% and 31.6%, respectively) and Haque et al. (41.93% and 35.48%, respectively) compared to the present study (15.5% and 22.5%). This difference may suggest that the population in Mahmoodkhani et al. and Haque et al. included a higher proportion of patients with incomplete injuries, which generally have a better prognosis.[6,12]

One of the key findings of Our study was that 26.0% of patients with complete spinal cord injuries (AIS A) converted to an incomplete status (AIS B, C, or D) within one year. This aligns with previous studies that have reported AIS A conversion rates ranging from 10% to 30% depending on factors such as injury level, early surgical intervention, and the quality of rehabilitative care. Spiess et al. (2004) observed similar rates of conversion in cases where early decompression and aggressive rehabilitative strategies were implemented.[21] The finding that 74% of AIS A patients remained unchanged implicates the challenges associated with neurological recovery in cases of complete injury. Complete SCI - by definition - involves total loss of motor and sensory function below the level of injury; this limited the potential for

spontaneous neurological recovery even with optimal surgical and rehabilitative management. This is also comparable to the 33.3% reported by Mahmoodkhani et al. but higher than rates reported in other Western studies (ranging from 10–15% in cervical injuries). Haque et al. did not report specific conversion rates for AIS A patients but noted that 48.38% of AIS B patients showed improvement by at least one AIS grade at discharge, which is higher than the 39.4% improvement rate observed in the present study.[12]

Our study also demonstrated that AIS B patients exhibited a higher rate of improvement, with 39.4% improving to higher grades (C, D, or E) over the course of one year. This finding is consistent with the work of van Middendorp et al. (2020) – who also reported that AIS B patients show greater neurological plasticity compared to AIS A patients.[14] They attributed this to preserved sensory pathways - which may facilitate motor recovery through neuroplastic mechanisms. Our study also noted that 10.6% of AIS B patients worsened to AIS A, highlighting the dynamic nature of SCI recovery and the potential for secondary complications such as spinal cord ischemia, progressive myelopathy, or mechanical instability contributing to neurological decline. Mahmoodkhani et al. reported that 84% of AIS D and 77% of AIS C patients showed improvement within 24 months post-surgery. This indicated a higher degree of functional recovery in incomplete injuries. Additionally, Mahmoodkhani et al. reported that 38% of all patients achieved full recovery (AIS E), while no AIS A patient in the present study converted to AIS E within one year.[12]

The overall pattern of AIS grade changes across the study cohort further supports the predictive value of the AIS system in SCI prognosis. Notably, 56.5% of AIS C patients and 54.4% of AIS D patients showed improvement, reinforcing the hypothesis that incomplete injuries (AIS B–D) have a higher likelihood of functional recovery due to preserved motor and sensory pathways. The absence of any improvement among AIS E patients reflects the ceiling effect of the AIS system; patients with normal baseline function (AIS E) are unlikely to demonstrate further improvement. The statistically significant association ($p < 0.001$) between baseline AIS grade and outcome highlights the strength of AIS as a prognostic tool.

Mahmoodkhani et al. noted a 5% mortality rate within 24 months, with 75% of the deceased patients being AIS A at the time of admission. The higher mortality among AIS A patients is consistent with the well-established correlation between injury severity and survival outcomes. Haque et al. did not report mortality rates but documented post-operative complications, including dysphagia (35.48%), donor site infection (9.67%), cerebrospinal fluid (CSF) leak (3.22%), and catheter-related urinary tract infections (9.67%). The present study documented similar rates of complications - a higher frequency of urinary tract infections and wound infections[6,12]

Our study's findings have several important clinical implications. (1) The relatively high rate of improvement among AIS B patients suggests that early surgical intervention and comprehensive rehabilitative care should be prioritized for this subgroup to maximize functional recovery. (2) The lower conversion rate among AIS A patients highlights the need for further research into neuroprotective and neuroregenerative strategies. This includes stem cell therapy, pharmacological interventions and rehabilitative techniques - to enhance recovery potential in complete SCI cases. (3) Our study emphasized the importance of patient stratification based on baseline AIS grades to customize their rehabilitative strategies and set realistic recovery goals.

The single-centre design may limit the generalizability of the findings to other settings with different healthcare infrastructure and patient demographics. The short follow-up period of one year may not capture the full trajectory of long-term recovery in cases of incomplete injury where neurological recovery may continue for several years. AIS scores provided a valuable measure of neurological function. However they do not fully capture functional independence or quality of life - which are critical outcomes for SCI patients.

Our study observed prognostic values of AIS scores in assessing post-operative recovery in SCI patients. Our findings highlighted potential for neurological recovery in incomplete injuries (AIS B–D); as well as the challenges associated with complete injuries (AIS A).

Conclusion

Our study delivered insights into how patients with spinal cord injuries (SCI) recover. Especially in a

setting with limited healthcare resources. It shows that 26.0% of patients with complete injuries (AIS A) improved to an incomplete status within one year. This means that even patients with severe injuries have a chance to recover, especially if they receive early surgery and proper rehabilitation. The study also found that 39.4% of patients with AIS B injuries improved to a higher grade, showing that incomplete injuries have a better chance of recovery. However, 10.6% of AIS B patients worsened to AIS A, highlighting the unpredictable nature of SCI recovery. This suggests that complications like poor blood flow to the spinal cord or further damage can affect recovery. This makes early rehabilitation and close monitoring very important. Our study also showed that in India, falls from height (47.0%) are the most common cause of SCI, while in other countries like Iran, road traffic accidents are more common. This means that injury prevention strategies in India should focus more on reducing falls - especially at construction sites and in rural areas.

Patients with incomplete injuries (AIS C and D) showed higher recovery rates (56.5% and 54.4%), confirming that patients with some preserved motor and sensory function are more likely to improve with proper care. Our findings highlighted need to improve trauma care facilities and to increase access to rehabilitation centres.

References

1. Barbiellini Amidei C, Salmaso L, Bellio S, Saia M. Epidemiology of traumatic spinal cord injury: a large population-based study. Spinal Cord. 2022;60(9). doi:10.1038/s41393-022-00795-w
2. Chiu WT, Lin HC, Lam C, Chu SF, Chiang YH, Tsai SH. Epidemiology of traumatic spinal cord injury: Comparisons between developed and developing countries. Asia-Pacific Journal of Public Health. 2010;22(1). doi:10.1177/1010539509355470
3. Dinata IGS, Yasa AAGWP. The Overview of Spinal Cord Injury. Ganesha Medicine. 2021;1(2). doi:10.23887/gm.v1i2.39735
4. Ding W, Hu S, Wang P, Kang H, Peng R, Dong Y, Li F. Spinal Cord Injury: The Global Incidence, Prevalence, and Disability From the Global Burden of Disease Study 2019. Spine. 2022;47(21). doi:10.1097/BRS.0000000000004417
5. Gutierrez PA, Young RR, Vulpe M. Spinal cord injury: An overview. Urologic Clinics of North America. 1993;20(3).
6. Haque MA, Hossain SS, Rahman MM, Islam MR, Kadir S, Sagir G, Hasanat MA. Determination of Early Neurological Outcome by ASIA score following Delayed Anterior Decompression and Stabilization of Lower Cervical Spine Injury. Journal of National Institute of Neurosciences Bangladesh. 2018;4(2). doi:10.3329/jninb.v4i2.38919
7. International Health Policies. Spinal Cord Injuries in India: Towards a Comprehensive Preventive and Rehabilitative Response. 2025. https://www.internationalhealthpolicies.org/featured-article/spinal-cord-injuries-in-india-towards-a-comprehensive-preventive-and-rehabilitative-response/
8. Kirshblum S, Snider B, Eren F, Guest J. Characterizing Natural Recovery after Traumatic Spinal Cord Injury. Journal of Neurotrauma. 2021;38(9):1267–1284. https://doi.org/10.1089/neu.2020.7473. doi:10.1089/neu.2020.7473
9. Lee BA, Leiby BE, Marino RJ. Neurological and functional recovery after thoracic spinal cord injury. The Journal of Spinal Cord Medicine. 2016;39(1):67–76. https://doi.org/10.1179/2045772314Y.0000000280. doi:10.1179/2045772314Y.0000000280
10. Liu Y, Yang X, He Z, Li J, Li Y, Wu Y, Manyande A, Feng M, Xiang H. Spinal cord injury: global burden from 1990 to 2019 and projections up to 2030 using Bayesian age-period-cohort analysis. Frontiers in Neurology. 2023;14. doi:10.3389/fneur.2023.1304153
11. Magaqa Q, Ariana P, Polack S. Examining the availability and accessibility of rehabilitation services in a rural district of south africa: A mixed-methods study. International Journal of Environmental Research and Public Health. 2021;18(9). doi:10.3390/ijerph18094692
12. Mahmoodkhani M, Rezvani M, Farshin A, Ghasemi P, Tehrani DS. Outcomes of Operative Treatment of Traumatic Spinal Injuries: 2 Year Follow Up. Advanced Biomedical Research. 2023;12(1). doi:10.4103/abr.abr_82_23
13. Mathur N, Jain S, Kumar N, Srivastava A, Purohit N, Patni A. Spinal Cord Injury: Scenario in an Indian State. Spinal Cord. 2015;53(5). doi:10.1038/sc.2014.153
14. van Middendorp JJ, Hosman AJ, Pouw MH, Group E-SS, de Meent H. ASIA impairment scale conversion in traumatic SCI: is it related with the ability to walk? A descriptive comparison with functional ambulation outcome measures in 273 patients. Spinal Cord. 2009;47(7):555–560. https://doi.org/10.1038/sc.2008.162. doi:10.1038/sc.2008.162
15. Neyaz O, Kanaujia V, Yadav RK, Sarkar B, Azam MQ, Kandwal P. Epidemiology of Traumatic Spinal Cord Injury in the Himalayan Range and Sub-Himalayan Region: A Retrospective Hospital Data-Based Study. Annals of Rehabilitation Medicine. 2024;48(1). doi:10.5535/arm.23107
16. Pandey V, Nigam V, Goyal T, Chhabra H. Care of post-traumatic spinal cord injury patients in India: An analysis. Indian Journal of Orthopaedics. 2007;41(4). doi:10.4103/0019-5413.36990
17. Purkayastha T, Debnath A, Debroy S, Debbarma S. Short-term neurological and functional outcome of surgical intervention in spinal cord injuries: a single center

prospective observational study. The Pan African medical journal. 2023;45. doi:10.11604/pamj.2023.45.138.37180

18. Rahimi-Movaghar V, Sayyah MK, Akbari H, Khorramirouz R, Rasouli MR, Moradi-Lakeh M, Shokraneh F, Vaccaro AR. Epidemiology of traumatic spinal cord injury in developing countries: a systematic review. Neuroepidemiology. 2013;41(2):65–85. https://doi.org/10.1159/000350710. doi:10.1159/000350710
19. Ranjbar Hameghavandi MH, Khodadoust E, Hassan Zadeh Tabatabaei MS, Farahbakhsh F, Ghodsi Z, Rostamkhani S, Ghashghaie S, Abbaszade M, Arbabi A, Hossieni SM, et al. Challenges in traumatic spinal cord injury care in developing countries - a scoping review. Frontiers in Public Health. 2024;12:1377513. https://doi.org/10.3389/fpubh.2024.1377513. doi:10.3389/fpubh.2024.1377513
20. Singh R. Epidemiology of spinal cord injuries: Indian perspective. In: Epidemiology of Spinal Cord Injuries. 2012.
21. Spiess M, Müller R, Rupp R, Schuld C, van Hedel H. Conversion in ASIA Impairment Scale during the First Year after Traumatic Spinal Cord Injury. Journal of neurotrauma. 2009;26:2027–2036. doi:10.1089/neu.2008-0760