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Original Research Article

Functional Outcome of Early vs Delayed Decompression in Acute Cervical Spinal Cord Injury: A Prospective Comparative Study

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Conflict of interest: Nil

Abstract

Background: Acute cervical spinal cord injury (CSCI) is a devastating condition associated with significant neurological deficit and long-term disability. Early surgical decompression has been proposed to improve outcomes by limiting secondary injury; however, the optimal timing of intervention remains controversial.

Objective: To compare neurological and functional outcomes between early (<24 hours) and delayed (>24 hours) surgical decompression in patients with acute cervical spinal cord injury.

Methods: This prospective comparative study included 80 patients with acute traumatic CSCI managed at a tertiary care neurosurgical center. Patients were divided into two groups: early decompression (Group A, n=40) and delayed decompression (Group B, n=40). Neurological status was assessed using the American Spinal Injury Association (ASIA) Impairment Scale (AIS) and motor scores at admission and at 6-month follow-up. Functional outcome was evaluated using the Modified Barthel Index. Statistical analysis was performed using appropriate tests, with $p < 0.05$ considered significant.

Results: Baseline demographic and injury characteristics were comparable between the groups. At 6 months, ≥ 2-grade AIS improvement was observed in 35% of patients in Group A compared to 15% in Group B ($p = 0.008$). Mean ASIA motor score improvement was significantly greater in the early decompression group (23.8 ± 8.5 vs 14.6 ± 7.9; $p < 0.001$). Functional independence was achieved in 55% of patients in Group A compared to 30% in Group B ($p = 0.03$).

Conclusion: Early surgical decompression within 24 hours is associated with significantly improved neurological recovery and functional outcomes in acute cervical spinal cord injury. These findings support early intervention as a key determinant of favorable prognosis.

Keywords: Cervical spinal cord injury; early decompression; ASIA score; AIS grade; Neurological recovery; Functional outcome.

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Introduction

Acute cervical spinal cord injury (CSCI) is a catastrophic neurological condition associated with significant morbidity, long-term disability, and increased mortality. It commonly affects young and middle-aged individuals following high-energy trauma such as road traffic accidents and falls, resulting in a substantial socioeconomic burden.

Despite advances in trauma care and surgical techniques, the optimal timing of surgical decompression remains a subject of ongoing debate. The pathophysiology of spinal cord injury involves a biphasic process comprising primary mechanical injury followed by a cascade of secondary injury mechanisms. The latter includes ischemia, edema, excitotoxicity, inflammation, and apoptosis, which contribute to progressive neuronal damage and worsening neurological deficits. As these secondary processes evolve over time, early therapeutic intervention is critical in limiting further spinal cord damage [14].

Surgical decompression plays a pivotal role in the management of CSCI by relieving cord compression, restoring perfusion, and mitigating secondary injury. Early decompression, typically

defined as intervention within 24 hours, has been shown to improve neurological outcomes. The STASCIS study demonstrated significantly higher rates of AIS grade improvement in patients undergoing early surgery compared to delayed intervention [1]. These findings are further supported by multiple systematic reviews and meta-analyses reporting superior neurological recovery and functional outcomes with early decompression [2,4,13].

However, the timing of surgery remains controversial, as some studies have reported no significant difference in long-term neurological outcomes between early and delayed intervention, despite faster recovery in the early surgery group [3]. Additionally, practical constraints such as delayed presentation, associated injuries, and limited resources often influence surgical timing.

Given these inconsistencies, further prospective evaluation is warranted. The present study aims to compare early versus delayed decompression in acute cervical spinal cord injury and assess their impact on neurological and functional outcomes.

Aims and Objectives

Primary Objective: To compare neurological recovery in patients with acute cervical spinal cord injury undergoing early (<24 hours) versus delayed (>24 hours) surgical decompression.

Secondary Objectives

- To assess functional outcomes using the American Spinal Injury Association (ASIA) Impairment Scale (AIS).
- To evaluate improvement in ASIA motor scores following surgical intervention.
- To compare functional independence between the two groups at follow-up.

Materials and Methods

Study Design and Setting: This prospective comparative study was conducted in the Department of Neurosurgery at a tertiary care referral center over a defined study period.

Study Population: A total of 80 consecutive patients presenting with acute cervical spinal cord injury were included and evaluated.

Inclusion Criteria

- Patients aged between 18 and 70 years
- Acute traumatic cervical spinal cord injury
- Radiological evidence of spinal cord compression on CT/MRI
- Patients deemed suitable for surgical decompression

Exclusion Criteria

- Associated severe head injury or polytrauma affecting neurological assessment
- History of prior cervical spine surgery
- Non-traumatic causes of cervical spinal cord compression (e.g., tumors, infections, degenerative myelopathy)

Patient Grouping: Patients were categorized based on the timing of surgical decompression:

- **Group A (Early Decompression):** Surgery performed within 24 hours of injury
- **Group B (Delayed Decompression):** Surgery performed after 24 hours of injury

Clinical Assessment: All patients underwent detailed neurological evaluation at admission and during follow-up using:

- ASIA Impairment Scale (AIS) grading
- ASIA motor scoring system

Outcome Measures: The primary and secondary outcomes assessed were:

- Improvement in AIS grade at follow-up
- Change in ASIA motor score from baseline
- Functional outcome assessed in terms of independence at 6 months

Follow-up: Patients were followed up at regular intervals, with final outcome assessment performed at 6 months post-surgery.

Statistical Analysis: Data were analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation and compared using the student's t-test. Categorical variables were analyzed using the Chi-square test or Fisher's exact test as applicable. A p-value of <0.05 was considered statistically significant.

Results

A total of 80 patients with acute cervical spinal cord injury were included in the study and equally distributed into early decompression (Group A) and delayed decompression (Group B). Baseline demographic and clinical characteristics were comparable between the two groups.

Table 1: Demographic Profile of Study Population

Variable	Group A (n=40)	Group B (n=40)	p-value
Mean Age (years)	42.3 ± 12.5	44.1 ± 11.8	0.52
Male (%)	30 (75%)	29 (72.5%)	0.79
Road Traffic Accident	24 (60%)	25 (62.5%)	0.82
Fall from Height	16 (40%)	15 (37.5%)	0.82

Interpretation: There was no statistically significant difference between the two groups with respect to age, sex distribution, or mechanism of injury, indicating comparability at baseline.

Table 2: Preoperative AIS Grade Distribution

AIS Grade	Group A (n=40)	Group B (n=40)	p-value
A	10 (25%)	12 (30%)	0.78
B	12 (30%)	10 (25%)	
C	10 (25%)	9 (22.5%)	
D	8 (20%)	9 (22.5%)	

Interpretation: The preoperative neurological status, as assessed by AIS grading, was comparable between the two groups ($p > 0.05$).

Table 3: AIS Grade Improvement at 6 Months

Improvement	Group A (n=40)	Group B (n=40)	p-value
≥2 Grade Improvement	14 (35%)	6 (15%)	
1 Grade Improvement	16 (40%)	14 (35%)	
No Improvement	10 (25%)	20 (50%)	**0.008**

Interpretation: Patients in the early decompression group demonstrated significantly greater neurological improvement than those in the delayed group. A higher proportion of patients achieved ≥2 grade improvement in AIS in Group A (35% vs 15%). This difference was statistically significant ($p = 0.008$).

Table 4: ASIA Motor Score Improvement

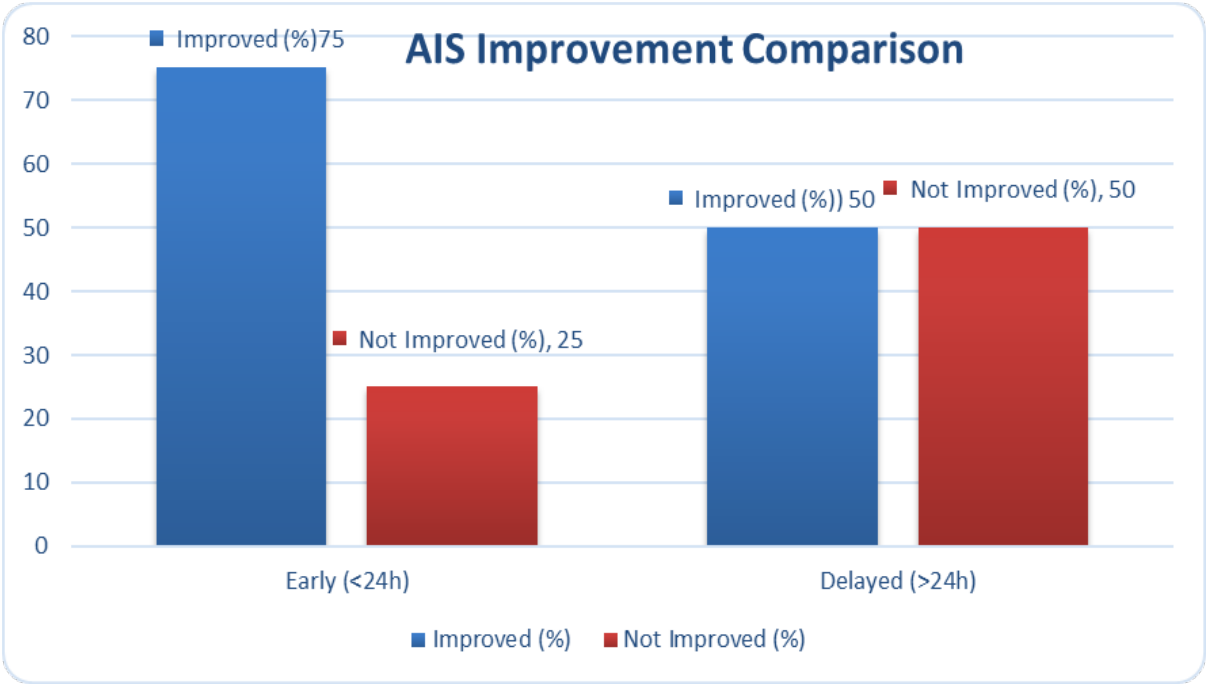
Parameter	Group A (n=40)	Group B (n=40)	p-value
Preoperative Score	38.5 ± 10.2	37.8 ± 9.5	0.74
6-month Score	62.3 ± 12.1	52.4 ± 11.6	
Mean Improvement	23.8 ± 8.5	14.6 ± 7.9	**<0.001**

Interpretation: Although baseline motor scores were similar, Group A showed significantly greater improvement in ASIA motor scores at 6 months compared to Group B. The difference in mean motor score gain was highly significant ($p < 0.001$).

Table 5: Functional Outcome (Modified Barthel Index at 6 Months)

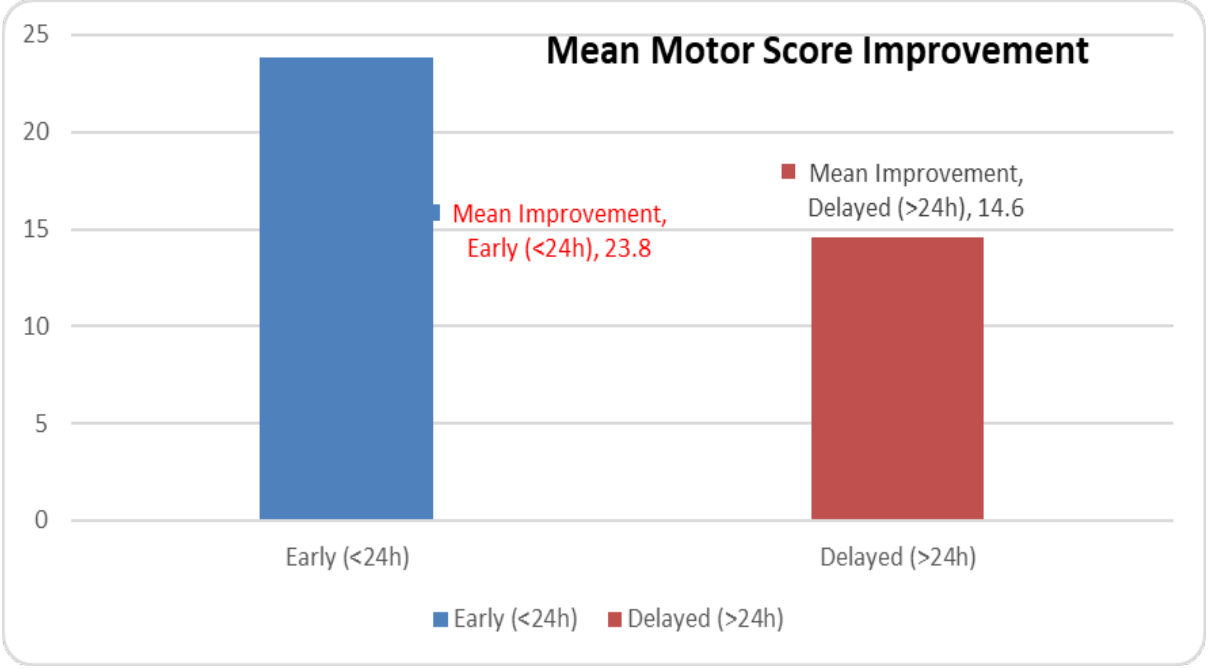
Outcome	Group A (n=40)	Group B (n=40)	p-value
Independent	22 (55%)	12 (30%)	
Assisted	12 (30%)	16 (40%)	
Dependent	6 (15%)	12 (30%)	**0.03**

Interpretation: Functional independence was significantly higher in the early decompression group, with 55% of patients achieving independence compared to 30% in the delayed group ($p = 0.03$).



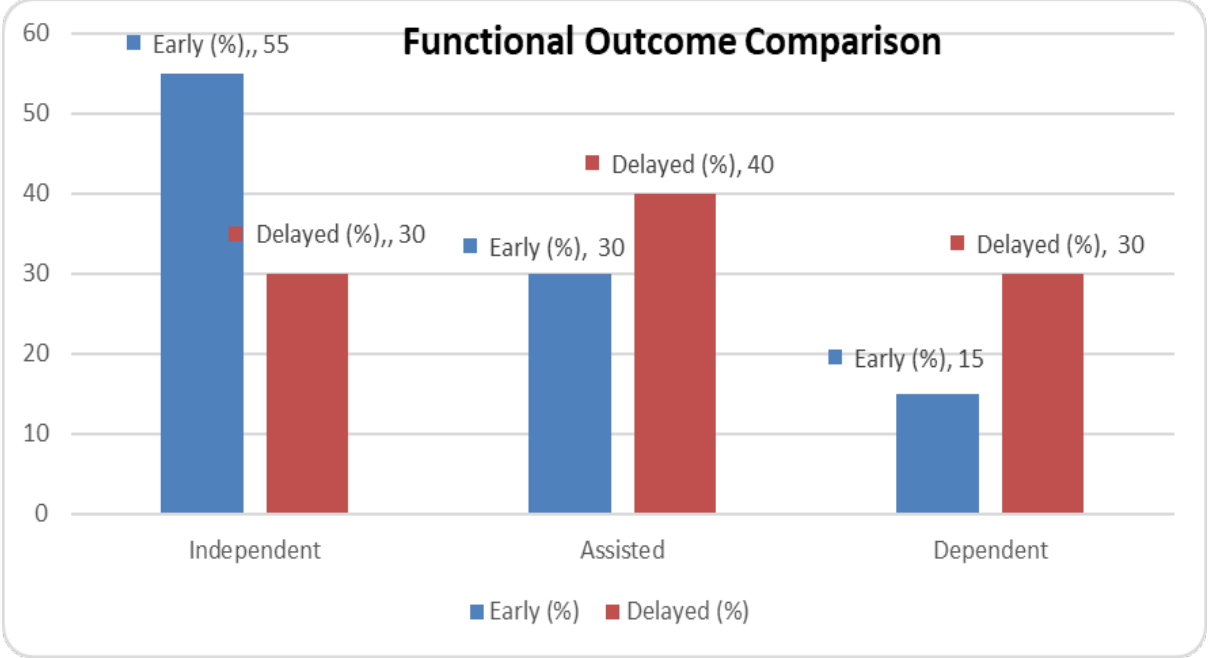
Graph 1: Overall Neurological Improvement (AIS)

Shows a higher proportion of neurological improvement in the early decompression group (75%) compared to delayed group (50%), supporting statistically significant better recovery.



Graph 2: Mean Motor Score Improvement

Demonstrates greater mean motor score gain in early surgery (23.8 vs 14.6), indicating superior neurological recovery.



Graph 3: Functional Independence at 6 Months

Illustrates improved functional independence in early decompression (55% vs 30%), with fewer dependent patients.

Key Findings

- Early decompression resulted in significantly better AIS grade improvement ($p = 0.008$)
- Motor recovery was significantly higher in early surgery group ($p < 0.001$)
- Functional independence was superior in early intervention ($p = 0.03$)

Discussion

The present study demonstrates that early surgical decompression (<24 hours) in acute cervical spinal cord injury is associated with significantly improved neurological and functional outcomes when compared to delayed intervention. Patients undergoing early decompression showed superior improvement in AIS grade, greater gains in ASIA motor scores, and higher rates of functional independence at 6 months. In our study, a significantly higher proportion of patients in the early decompression group achieved ≥2 grade improvement in AIS compared to the delayed group (35% vs 15%, p = 0.008). These findings are consistent with the landmark STASCIS trial, which reported improved neurological recovery in patients undergoing surgery within 24 hours [1]. Similar observations have been reported in multiple systematic reviews and meta-analyses, which demonstrate that early decompression increases the likelihood of meaningful neurological improvement, particularly in patients with incomplete injuries [2,4,13]. Motor recovery, as assessed by ASIA motor score, was also significantly greater in the early intervention group in the present study (p < 0.001). This finding supports the hypothesis that early decompression limits ongoing secondary injury and preserves viable neural pathways. Experimental evidence suggests that early relief of spinal cord compression improves microvascular perfusion and reduces intramedullary pressure, thereby mitigating ischemia and neuronal apoptosis [14]. Clinical studies have similarly demonstrated that early surgery results in better motor outcomes and enhanced recovery trajectories [7,10].

Functional outcome, assessed using the Modified Barthel Index, was significantly better in patients undergoing early decompression, with a higher proportion achieving independence (55% vs 30%, p = 0.03). This is of particular clinical relevance, as functional independence is a key determinant of long-term quality of life and socioeconomic reintegration. Previous studies have also emphasized that even modest improvements in AIS grade can translate into substantial gains in functional status and rehabilitation potential [11].

Despite these findings, the issue of optimal surgical timing remains debated. Some large cohort studies have reported no significant difference in long-term neurological outcomes between early and delayed decompression, although early surgery may be associated with faster neurological recovery and shorter hospital stay [3]. These discrepancies may be attributed to heterogeneity in study design, patient selection, injury severity, and timing thresholds used to define "early" intervention. From a practical standpoint, early decompression may not always be feasible, particularly in resource-limited settings where delays in referral, imaging, and surgical availability are common. Additionally, associated injuries, hemodynamic instability, and anesthetic risks may necessitate postponement of surgery in certain patients. Nevertheless, our findings support the growing body of evidence advocating for early surgical intervention whenever clinically feasible. The strengths of this study include its prospective design and uniform assessment of neurological and functional outcomes. However, certain limitations must be acknowledged. The study was conducted at a single center with a relatively modest sample size, and long-term outcomes beyond 6 months were not evaluated. Furthermore, potential confounding factors such as rehabilitation protocols and variability in surgical techniques were not analyzed in detail.

Conclusion

Early surgical decompression within 24 hours of injury is associated with significantly better neurological and functional outcomes in patients with acute cervical spinal cord injury. Patients undergoing early intervention demonstrated greater improvement in AIS grade, higher gains in ASIA motor scores, and improved functional independence at 6 months compared to those treated with delayed decompression. These findings support the role of early decompression as a critical component in the management of acute cervical spinal cord injury, likely due to its ability to mitigate secondary injury mechanisms and preserve viable neural tissue. While practical constraints may limit the feasibility of early surgery in certain settings, every effort should be made to perform decompression at the earliest possible time in appropriately selected patients.

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