Revisiting cruciate paralysis: A case report and systematic review

ABSTRACT

Objective: Cruciate paralysis is a rare, poorly understood condition of the upper craniovertebral junction that allows for selective paralysis of the upper extremities while sparing the lower extremities. Reported cases are few and best treatment practices remain up for debate. The purpose of this study was to conduct a systemic literature review in an attempt to identify prognostic predictors and outcome trends associated with cases previously reported in the literature.

Materials and Methods: We conducted a systematic literature review for all cases using the term “Cruciate Paralysis,” reviewing a total of 37 reported cases. All outcomes were assigned a numerical value based on examination at the last follow-up. These numerical values were further analyzed and tested for statistical significance.

Results: Of the 37 cases, 78.4% were of traumatic causes. Of these, there were considerably worse outcomes associated with patients over the age of 65 years (P < 0.001). Those patients undergoing surgical treatment showed potentially worse outcomes, with a P value approaching significance at P = 0.08.

Conclusion: Numerous cases of trauma-associated cruciate paralysis have been reported in the literature; however, there remains a strong need for further study of the condition. While certain risk factors can be elicited from currently reported studies, insignificant data exist to make any sound conclusion concerning whether surgical intervention is always the best method of treatment.

Key words: Central cord syndrome; craniovertebral junction trauma; cruciate paralysis; paralysis.

Introduction

Termed first by Bell in 1970, “Cruciate Paralysis” is a rare neurological disease of the cervicomedullary junction. Cruciate paralysis often presents with bilateral paresis of the upper extremities while sparing the lower extremities. Patients may also present with difficulty breathing, cranial nerve deficits, or a comatose state. While trauma is the most common cause of cruciate paralysis, the exact mechanism for these symptoms is not entirely understood. The leading hypothesis involves disruption of the anatomy of the pyramidal decussation at the cervicomedullary junction. The anatomical decussation extends longitudinally, spanning from the cervicomedullary junction to the C-2 level. Within this region, the motor tract fibers of the upper extremities cross both ventrally and superiorly to the fibers supplying the lower extremities. By crossing at a spatially different location, the independent upper extremity fibers provide a way for lesions to preferentially damage upper extremity fibers while sparing those of the lower extremities. However, cruciate

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paralysis is a rare condition with few reported studies; hence, treatments have been variable and are often without supportive evidence.

**Materials and Methods**

In this report, we conducted a systematic literature review from 1966 to the present of patients diagnosed with cruciate paralysis to identify potential prognostic predictors for the outcome. Using MEDLINE and PubMed Central, a comprehensive search for all papers under MeSH and keyword term “Cruciate Paralysis” was performed. Additional information and cases were obtained through Google and Google Scholar, and appropriate search of relevant sources was performed using the same keywords. A case was included if it met the following criteria: (1) The paper under review demonstrated appropriate signs and symptoms of cruciate paralysis as defined above; (2) a mechanism of injury was noted; (3) the type of intervention and treatment was noted; and (4) a follow-up examination was documented. Cases with patients presenting in a comatose state were excluded along with papers written in languages other than English. Our study focused on patients who were noncomatose and carried the diagnosis of cruciate paralysis. This is due to the fact that different states of coma may affect appropriate examination of the upper and lower extremities and hence the diagnosis. We were able to identify 38 cases from the literature. One additional case treated at our institution was also added. Of the 39 cases initially found, 37 of them met our criteria [Table 1]. Follow-up results were classified into three categories of recovery: Insignificant recovery, moderate recovery, or full recovery. A case was considered to have made a full recovery if, at the time of the last documented follow-up, upper extremity neurologic deficits had completely resolved. A case was considered to have made a moderate recovery if, at the time of the last follow-up, symptomatic improvement was documented, but residual upper extremity neurologic deficits still remained. Finally, a case was considered to have made an insignificant recovery if, at the time of the last follow-up, there was little to no change in upper extremity neurologic deficits since the time of initial presentation. Each category was assigned a numerical score of 1, 2, or 3, respectively, for simplicity of analysis. Treatments were further characterized into two groups: Those who underwent surgical intervention and those who did not. Each of the 36 cases was analyzed for outcome trends based on cause (trauma or nontrauma related), and an appropriate ANOVA test was run using the mean numerical scores of each category [Table 2]. The 28 cases associated with trauma were further analyzed, and respective ANOVA tests were run to determine trends and associations of outcomes categorized by age, gender, and type of intervention [Table 3].

**Results**

In patients who carried the diagnosis of cruciate paralysis and who were not comatose, the overall reported outcome was favorable with 54% of patients achieving full recovery and 29.7% of patients achieving moderate recovery. The overall outcomes associated with cruciate paralysis secondary to trauma did not differ significantly from other nontraumatic causes, $P = 0.5$ [Table 2]. Since the majority of cases of cruciate paralysis were traumatic (29 patients, 78.4%), we analyzed factors that might impact outcomes of traumatic cruciate paralysis [Table 3]. Patients over the age of 60 years showed significantly worse outcomes as compared to those under the age of 60, $P < 0.001$. Similarly, patients in the both 0–20 and the 20–40 age ranges had statistically better outcomes when compared to the rest of the cohort, $P = 0.02$ and $P = 0.02$, respectively. Male patients also seemed to have slightly better outcomes on average than female patients, $P = 0.08$. Finally, patients treated without surgical intervention had better prognoses than those treated surgically but did not reach statistical significance, $P = 0.08$ [Table 3]. We included the details of the patient with traumatic cruciate paralysis that was treated at our institution in Figures 1-3.

**Discussion**

Cruciate paralysis is a syndrome that results from cervicomedullary compression. It resembles central cord

![Figure 1](https://example.com/image1.png) A 59-year-old woman suffered a motor vehicle accident. She was intubated at the scene. Her neurological examination showed a motor strength of 1/5 in the upper extremities and 3/5 in the lower extremities. Sagittal T2-weighted sequence magnetic resonance imaging of the cervical spine demonstrating a Type III odontoid fracture with posterior subluxation causing compression of the cervicomedullary junction with upper cervical spine signal cord change
Table 1: Clinical studies investigating the management of cruciate paralysis

| Study                        | Age | Sex | Type of injury                           | Intervention                                      | Initial exam presentation                                                                                                                                     | Examination at the last follow-up                                                                                      | Duration of follow-up |
|------------------------------|-----|-----|------------------------------------------|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Bell, 1970[1]                | 53  | Female | Large meningioma on the right side of posterior fossa | Suboccipital craniectomy and upper cervical laminectomy | Marked ataxia of all four extremities, unable to walk because of marked loss of balance, no weakness                                                          | Leg strength normal, 20% weakness in the left arm and 50% weakness in the right arm. Moderate improvement of ataxia | 2 months              |
| Current study                | 59  | Female | Odontoid Type III fracture               | SOMI brace and Philadelphia collar                | No upper extremity movement                                                                                                                                      | Complete recovery                                                                                                      | Not mentioned         |
| Dai et al., 1995[3]          | 26  | Male  | Odontoid fracture                        | Occipital traction and plaster cast                | Upper limbs right: 2/5, left: 2/5. No lower limb deficiencies, sensory deficits, or cranial nerve deficits                                                 | Complete recovery                                                                                                      | 9 years               |
| Current study                | 59  | Female | Odontoid Type III fracture               | Crown halo vest                                   | Motor strength 1/5 in upper extremities and 3/5 in bilateral lower extremities, dysphagia, and dysarthria                                                      | Moderate recovery                                                                                                      | 6 months              |
| Current study                | 53  | Male  | Jefferson’s fracture                     | SOMI brace and Philadelphia collar                | No upper extremity movement                                                                                                                                 | Complete recovery                                                                                                      | Not mentioned         |
| Dickman et al., 1990[4]      | 8   | Male  | Atlantoaxial instability, spastic torticollis | Open reduction and occiptocervical fusion          | Upper extremity weakness (right: 2/5, left: 2/5). Respiratory insufficiency, Cranial nerve IX, X, XI, XII deficits, urinary dysfunction | Died of aspiration pneumonia                                                                                            | 6 months              |
| Current study                | 8   | Male  | Atlantoaxial dislocation, compression fracture of C6 | Suboccipital craniectomy and upper cervical laminectomy | Flaccid paralysis of upper left extremity, the left leg strength 4/5 proximally and 5/5 distally, The right arm and leg normal motor function. Absent bicep, brachioradialis, and triceps reflexes on the left. Babinski responses present in both lower extremities and hyperreflexia with ankle clonus (more pronounced on the left) | Mild spastic weakness (4/5) in the left arm with hyperreflexia and positive Hoffman’s sign in this limb. Follow-up flexion and extension roentgenograms of cervical spine were normal | 5 months              |

Contd...
| Study | Age | Sex | Type of injury | Intervention | Initial exam presentation | Examination at the last follow-up | Duration of follow-up |
|-------|-----|-----|----------------|--------------|---------------------------|-------------------------------------|----------------------|
| 12    | Male| Axis fracture | Halo brace | Upper extremity weakness (right: 2/5, sensory deficits, respiratory insufficiency) | Complete recovery | 39 months |
| 16    | Male| Axis fracture | Halo brace | Upper extremity weakness (right: 3/5, left: 2/5) | Complete recovery | 24 months |
| 19    | Male| Axis fracture | Open reduction and internal fixation | Upper extremity weakness (right: 2/5, left: 2/5), lower extremity weakness (right: 4/5, left: 4/5), sensory deficits | Complete recovery | 14 months |
| 21    | Male| C2 and C3 fractures | Halo brace | Upper extremity weakness (left: 2/5) | Complete recovery | 8 months |
| 25    | Male| Axis fracture | Halo brace | Upper extremity weakness (right: 4/5, 2/5), sensory deficits | Complete recovery | 37 months |
| 26    | Female| Spinal cord injury without radiographic abnormality | Skull occipital mandibular immobilization brace | Upper extremity weakness (right: 3/5, left: 3/5) | Complete recovery | 18 months |
| 28    | Male| Gunshot injury of atlas | Open reduction and internal fixation | Upper extremity weakness (right: 0/5, left: 0/5), lower extremity weakness (4/5 in both extremities) | Complete recovery | 23 months |
| 43    | Male| Odontoideum with atlantoaxial instability and a 9 mm horizontal subluxation of C1 on C2 from the flexed to the extended position | Atlantoaxial arthrodesis | Hyperreflexia in all extremities with bilateral Hoffman’s sign and equivocal plantar responses. Several days of upper extremity weakness and clumsiness | Neurologically intact without hyperreflexia. Patient had stable C1–C2 bone fusion | 6 months |
| 62    | Male| Fracture of odontoid process and posterior ring of C1, burst fracture of the atlas and fracture through the base of the dens | Halo orthosis immobilization | 2/5 strength in left upper limb, 4/5 strength in other three limbs. Patchy diminished pinprick sensation and associated burning dysesthesias involving C4–C6 dermatomes. Deep tendon reflexes hypoactive (1/4 in upper extremities, 3/4 in lower extremities). Bladder dysfunction with urinary retention | Mild weakness (4/5) of the left arm, but otherwise completely recovered. No sensory symptoms. Mild hyperreflexia in all four extremities | 17 weeks |
| 62    | Male| Gunshot injury of odontoid | Philadelphia collar | Upper extremity weakness (right: 0/5, left: 0/5), respiratory insufficiency | Bilateral upper extremity spastic paresis (4/5), spastic gait | 58 months |
| 70    | Male| Atlas and axis fractures | Halo brace | Upper extremity weakness (right: 2/5, left: 2/5), lower extremity weakness (right: 3/5, left: 3/5), Sensory deficits. Cranial right XI nerve deficit. Urinary dysfunction | Mild upper extremity spastic paraparesis (5−/5), normal gait, diffuse hyperreflexia | 31 months |
| 72    | Female| Atlas and axis fractures | Open reduction and internal fixation | Upper extremity weakness (right: 0/5, left: 0/5) sensory deficits | Bilateral spasticity, upper extremity weakness (4/5) | 29 months |
| Dumitru and Lang 1986[6] | 39 | Male| Small hypodense fluid collection in the right frontoparietal region | Stabilization | Flaccid bilateral upper extremity paralysis. Flexor withdrawal response of lower extremities. Bulbocavernosus, cremasteric, corneal, and abdominal reflexes present. Trace patellar and Achilles reflex noted. No Hoffman’s sign and upon plantar reflex stimulation toes were downgoing. Impairment of IX–XII cranial nerves | Fair grade strength in upper extremities. Positive bilateral Hoffman’s signs, but toes still down going with plantar stimulation | 5 months |

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### Table 1: Contd...

| Study                              | Age | Sex | Type of injury                                                                 | Intervention                                      | Initial exam presentation                                                                 | Examination at the last follow-up                                                                 | Duration of follow-up |
|------------------------------------|-----|-----|--------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------|
| Erlich et al., 1989[9]             | 3   | Female | Undisplaced fracture of left lateral mass of C1 and Chiari malformation      | None                                             | Normal cranial nerves, flaccid plegia of both upper extremities, lack of reflexes in upper extremities | Great proximal recovery, child remains somewhat weak and clumsy distally. Return of motor stimuli to upper extremities and confirmed Chiari malformation | 5 months              |
| Georgiadis and Schulte-Mattler 2002[9] | 52  | Male  | Cortical atrophy without focal lesions                                       | None                                             | Upper extremity weakness (deltoid, triceps, biceps, brachioradialis muscles 3/5, hand flexion/extension, small finger muscles 0/5). More profound weakness on the right side. No sensory deficits | Full strength of both shoulder and arm muscles, mild weakness present in small finger muscles (3/5) | 1 year                |
| Gopalakrishnan et al., 2013[10]    | 63  | Male  | Giant fusi-saccular aneurysm                                                  | None                                             | Moderate spasticity and weakness predominantly in the right arm and the left leg. Pain and thermal sensation disturbances in the right arm, touch and vibration senses markedly diminished in the lower extremities. Deep tendon reflexes exaggerated in the right arm and the left leg. Pathological reflexes, positive in the right arm | Increased right upper limb weakness, lower limb remained the same | Not mentioned        |
| Inamasu et al., 2001[4]           | 85  | Male  | Type II odontoid fracture with posterior atlantoaxial dislocation             | Brooks method to correct instability (C1/ C2 fusion) | Elective paralysis of the arms, only trace movement of the shoulders and arms, movement of both legs was well preserved | Little functional recovery of muscle strength of upper extremity | 32 days               |
| Ladouceur et al., 1991[11]        | 88  | Female | Type III odontoid fracture                                                    | Cervical traction and halo vest                   | Bilateral flaccid paralysis in upper limbs, no weakness of lower limbs identified. No deep tendon reflexes in upper extremities, however, present and normal in lower extremities. Plantar reflexes flexor bilaterally | Drowsiness improved. No change in upper paralysis until she died of respiratory pneumonia 3 months later | 3 months              |
| Laubscher et al., 2012[12]        | 16  | Female | Undisplaced type II odontoid peg fracture                                     | Traction in Cone’s calipers for 6 weeks, then a Philadelphia collar for another 6 | Weakness in both arms (left weaker than right). The slight decrease in hip flexion on the right side. No sensory deficits. ASIA motor score=74 | Weakness improved. ASIA motor score=92 | 12 weeks              |
|                                   | 18  | Male  | Type III odontoid peg fracture (minimal displacement)                        | Traction in Cone’s calipers for 6 weeks, then a Philadelphia collar for another 6 | The weakness of upper limbs (right side weaker than left). Slight weakness in right leg. No sensory deficits. ASIA motor score=76 | Neurological deficit improved. ASIA motor score=90 | 12 weeks              |
|                                   | 26  | Male  | Subarachnoid hemorrhage, an interhemispheric subdural hematoma, and a right zygomatic arch fracture. Chiari 1 malformation and bulbous dens | Philadelphia collar                                | Decreased consciousness, no movement of upper limbs, movement of lower limbs on command. No obvious sensory deficits. ASIA motor score=68 | Full neurologic recovery after 3 months. After 5 days ASIA motor score=92 | 3 months              |

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Table 1: Contd...

| Study                  | Age | Sex  | Type of injury                                                                 | Intervention                                                                 | Initial exam presentation                                                                 | Examination at the last follow-up                                                                 | Duration of follow-up |
|------------------------|-----|------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------|
| Marano et al., 1986    | 62  | Male | Bullet wound in the C1 arch slightly to the right of midline                    | None                                                                         | Complete bilateral upper extremity paralysis, lower extremity strength normal. Reflexes 2/4 in both upper and lower extremities. After 48 h development of lower extremity weakness, hyperactive upper extremity reflex and Babinski’s reflexes in lower extremities | Spastic paraparesis in upper extremities and spastic gait, normal strength in all major muscle groups of lower extremities | 6 months             |
| Sweet et al., 2010     | 39  | Male | 21 mm of atlanto-occipital dislocation and ligamentous disruption              | Instrumented occiput-C4 fusion for stabilization                             | Bilateral abducens nerve palsies, flaccid paralysis of the bilateral upper extremities, antigravity strength in the bilateral lower extremities. Diffuse hyperreflexia and bilateral Babinski signs present. Lower extremity (3/5) upper extremity (1/5) | Significant bilateral lower extremity improvement (4+/5). Moderate improvement to upper extremities (3/5) | 2 months             |
| Yayama et al., 2006    | 49  | Female | Shifted odontoid process, compressing the spinal cord anteriorly            | Suboccipital craniotomy for posterior decompression and posterior fusion (of occiput and C3) | Marked spasticity in right arm/left leg. Unsteady ataxic gait. Muscle weakness in right arm/both legs. Pain and thermal sensation disturbances in the right arm and leg. Touch and vibration sensation diminished in all extremities except left leg. Exaggerated deep tendon in both arms, no pathological reflexes | Ambulatory, very occasional use of a cane and doing well. Sensory recovery was insignificant | 7 years after intervention |
|                        | 67  | Female | Displaced spinal cord from foramen magnum to C3 and healed odontoid base fracture | Lateral decompression and bone grafting                                       | Wasted left side of tongue/ deviation of the tongue to the left. Marked spasticity in the left arm and right leg. Pain and thermal sensation deficits more evident on the right arm/right leg. Deficits in touch and vibration in left arm and leg. Exaggerated Deep tendon reflex in the left arm and right leg. Positive pathological reflexes in the left arm and right leg. Reported difficulty in voluntary micturition | No neurological improvement | 2.3 years after intervention |
|                        | 67  | Female | Lesion suggestive of synovial hypertrophy                                     | Posterior atlantoaxial fusion                                                | Spasticity in right arm/left leg, muscle weakness in both legs (mainly left side), pain/temperature sensation diminished in left upper and lower extremities. Symmetric decreased sense of touch. Insignificantly positive deep tendon reflexes in the right arm/left leg. Hoffman and Wartenberg reflexes positive. Babinski’s and Chaddock’s reflexes positive on contralateral side | Bony union successful, patient attained almost full neurologic recovery | 6 months             |

ASIA - American Spinal Injury Association; SOMI - Sternal occipital mandibular immobilizer

syndrome of the subaxial cervical spine, in that it usually affects the upper more than the lower extremities; however, since it is localized to the upper cervical spine, it is also associated with various degrees of lower cranial nerve palsies and at times states of coma. Our review demonstrated that most cases are traumatic in nature with 78.4% of the cases reported. Overall, in the absence of coma, the outcome following this injury is favorable with 54% of patients achieving full recovery and 29.7% of patients achieving moderate recovery. Patients who were older than 60 years had a worse outcome than younger patients suffering from traumatic cruciate paralysis. While no concrete treatment recommendations
Figure 2: The patient was placed in crown halo traction and her fracture fragment was reduced as demonstrated by the lateral cervical spine X-ray (a). The patient then was placed in crown halo vest, and a magnetic resonance imaging of the cervical spine was done revealing reduction and realignment with decompression at the cervicomedullary junction as demonstrated with a sagittal T2-weighted sequence (b).

Table 2: Percentage of cases making a full recovery, moderate recovery, or insignificant recovery by cause of symptoms

|                  | Full recovery, % | Moderate recovery, % | Insignificant recovery, % | P     |
|------------------|------------------|----------------------|--------------------------|-------|
| Overall          | 54.0 (20/37)     | 29.7 (11/37)         | 13.5 (5/37)              | -     |
| Nontrauma causes | 50.0 (4/8)       | 25.0 (2/8)           | 25.0 (2/8)               | 0.50  |
| Trauma causes    | 55.2 (16/29)     | 34.4 (10/29)         | 10.3 (3/29)              |       |

Table 3: Percentage of trauma cases (29 patients) making a full recovery, moderate recovery, or insignificant recovery by age, gender, and type of correctional intervention

| Age     | Full recovery, % | Moderate recovery, % | Insignificant recovery, % | P     |
|---------|------------------|----------------------|--------------------------|-------|
| 0–20    | 100 (6/6)        | 0 (0/6)              | 0 (0/6)                  | 0.02* |
| 20–40   | 88.9 (8/9)       | 11.1 (1/9)           | 0 (0/9)                  | 0.02* |
| 40–60   | 40.0 (2/5)       | 60.0 (3/5)           | 0 (0/5)                  | 0.87* |
| 60+     | 0 (0/9)          | 66.6 (6/9)           | 33.3 (3/9)               | 1.5E-06* |
| Male    | 65.0 (13/20)     | 30.0 (6/20)          | 5.0 (1/20)               | 0.08  |
| Female  | 33.3 (3/9)       | 44.4 (4/9)           | 22.2 (2/9)               |       |
| Surgical | 33.3 (3/9)      | 44.9 (4/9)           | 22.2 (2/9)               | 0.08  |
| No surgical intervention | 65.0 (13/20) | 25.0 (5/20) | 5.0 (1/20) |       |

*P value for given age range tested against all remaining age groups combined,
**P value for combined ANOVA test between all grouped age ranges

Our study has a few limitations; the cohort size is small in size since our search focused only on papers that included cruciate paralysis as a keyword and hence some papers that may have included patients with cruciate paralysis secondary to atlantooccipital dissociation and combination atlas and axis fractures were not included. Moreover, patients who were in a comatose state were excluded as well since it would be hard to ascribe coma due to an intracranial or upper cervical spine injury.

Conclusion

While numerous cases of trauma-associated cruciate paralysis have been reported in the literature, there remain insignificant data to make any sound conclusion concerning whether or not surgical intervention is always the best method of treatment.

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Conflicts of interest
There are no conflicts of interest.

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