Case Report

Traumatic high-grade spondylolisthesis at C7-T1 with no neurological deficits: Case series, literature review, and biomechanical implications

ABSTRACT

Traumatic high-grade spondylolisthesis in subaxial cervical spine is frequently associated with acute spinal cord injury and quadriparesis. There have been rare cases where such pathology demonstrates minimal to no neurological deficits. Assessment of the underlying biomechanics may provide insight into the mechanism of injury and associated neurological preservation. Patient 1 is a 63-year-old female presenting after a motor vehicle collision with significant right arm pain without neurological deficits. Imaging demonstrated C7/T1 spondyloptosis, associated with a locked facet on the left at C6/7 and a locked facet on the right at C7/T1, with a fracture of the left C7 pedicle and right C7 lamina. Patient 2 is a 60-year-old male presenting after a bicycle collision with transient bilateral upper extremity paresthesias without neurological deficits. Imaging demonstrated C7/T1 spondyloptosis, with fractures of bilateral C7 pedicles, C7/T1 facets, and C7 lamina. Patient 3 is a 36-year-old male presenting after a motor vehicle collision with diffuse tingling sensation throughout all extremities. His neurological examination was nonfocal. Imaging demonstrated a grade 4 spondylolithesis at C7/T1, associated with bilateral C7/T1 locked facets. From literature, most cases were noted to be dislocations resulting from fractures of the posterior elements. A minority of cases has been found to involve facet dislocations without fractures. Further biomechanical studies are needed to understand the underlying mechanisms.

Key words: C7-T1 junction; high grade; spondylolisthesis; trauma.

Introduction

Cervical fractures have been classically the subject of review regarding traumatic spinal cord injuries. There is a paucity of literature regarding traumatic high-grade spondylolisthesis in the cervical spine. These injuries usually cause profound spinal cord compression and neurological deficits. Nonetheless, there have been rare instances where such pathology exhibits minimal neurological compromise. We report a series of three patients that remained neurologically intact, postulating the underlying biomechanical implications.

Materials and Methods

An extensive literature search through PubMed through all English articles with key words "cervical spondylolisthesis" was conducted; those with traumatic high-grade spondylolisthesis (grade 3–5) with minimal deficits (at worse ASIA E or Frankel E) were reviewed; those cases are summarized in Table 1. Moreover, 3 cases from our institution were discussed (patient 2 was previously published in Surgical Neurology International, and is briefly presented here).

Ha Son Nguyen, Hesham Soliman, Shekar Kurpad

Department of Neurosurgery, Medical College of Wisconsin, Milwaukee, Wisconsin, USA

Address for correspondence: Dr. Ha Son Nguyen, Department of Neurosurgery, Medical College of Wisconsin, 9200 W Wisconsin Ave., Milwaukee, Wisconsin 53122, USA.
E-mail: hsnguyen@mcw.edu

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Table 1: Review of literature

Literature	Age	Gender	Level	Mechanism	Fracture pattern	Dislocation grade
Acikbas and Gurkanlar[1]	42	Male	C7/T1	MVA	C6, C7, T1 lamina fractures; C6, C7, T1 lateral mass fractures	5
Amin and Saifuddin[2]	32	Female	C7/T1	Traffic accident	Bilateral C7 pars, ruptured C7-T1 disc	3
Dahdaleh *et al*.[3]	51	Male	C7/T1	MVA	Bilateral locked facets, bilateral facet fractures	5
Gasco *et al*.[4]	45	Male	C4/C5	MVA	Bilateral locked facets	5
Menku *et al*.[5]	35	Male	C6/C7	Traffic accident	Bilateral pedicle, bilateral jumped facets	5
Munakomi *et al*.[6]	56	Female	C7/T1	Fall from tree	Bilateral locked facets	5
Ramieri *et al*.[7]	55	Female	C6/C7	MVA	C6 bilateral pedicle fractures	5
	38	Male	C7/T1	***	C7 bilateral pedicle fractures	4
Sribnick *et al*.[8]	76	Female	C5/C6	MVA	Bilateral facet dislocations	4
Srivastava *et al*.[9]	35	Male	C3/C4	Fall	C3 bilateral pedicle fractures, C2 bilateral pedicle fractures, C1 posterior arch fracture	5
Tumialán *et al*.[10]	48	Male	C7/T1	MVA	C6 facet fracture, C7 lamina fracture	5
Wang *et al*.[11]	33	Male	C3/C4	Diving accident	Bilateral jumped facet	3
Current cases	63	Female	C7/T1	MVA	Locked facet on the left at C6–C7 and a locked facet of C7-T1 on the right, with fracture of the left C7 pedicle and right C7 lamina	5
	60	Male	C7/T1	Bike versus stationary semi-truck	Fractures of bilateral C7 pedicles, bilateral C7/T1 facets, and bilateral C7 lamina	5
	36	Male	C7/T1	MVA	Bilateral C7/T1 locked facets	4

***Some form of trauma, but unclear mechanism, MVA - Motor vehicle accident

Case Reports

Patient 1

A 63-year-old female presented after a motor vehicle collision (a single car roll-over where she was a restrained driver). She complained of significant right arm pain but remained neurologically nonfocal. CT of the cervical spine demonstrated C7/T1 spondyloptosis, associated with a locked facet on the left at C6/7 and a locked facet of C7/T1 on the right, with fracture of the left C7 pedicle and right C7 lamina [Figure 1a]. A magnetic resonance imaging (MRI) of the cervical spine demonstrated significant deformity of the spinal canal and deformity of the spinal cord, with minimal cord edema [Figure 1b]. She was placed in cervical traction to 16 pound resulting in an improvement of her pain. Lateral X-rays revealed marginal reduction. Patient then underwent an anterior C7/T1 discectomy, C7/T1 fixation, with partial reduction of the deformity. A posterior cervical approach ensued with C7 laminectomy, right C6 facet removal, and right C7 facet partial removal, followed by complete reduction of deformity. Postoperatively, she woke up well with baseline motor and sensory examination in her extremities. Her remaining hospital course was complicated by a subsegmental pulmonary embolus. She was discharged uneventfully home after clearing therapies. Postoperative flexion/extension films at 3 months demonstrated maturation of fusion and no instability [Figure 2].

Patient 2

A 60-year-old male presented after a bicycle collision with a semi-truck. He noted transient bilateral upper extremity paresthesias. Imaging demonstrated C7/T1 spondyloptosis, with fractures of bilateral C7 pedicles, C7/T1 facets, and C7 lamina [Figure 3a and b]. He was placed in traction to 10 pounds, but the reduction was challenging to visualize with lateral X-rays. Afterward, the patient was placed in a halo. Subsequently, he received a posterior decompression (C6 to T1 laminectomies), reduction through bilateral C7 facetectomies, and C4-T2 instrumentation. An anterior C7/T1 fixation was later performed as a second stage without any intraoperative changes to neuromonitoring. Postoperatively, he exhibited hoarseness secondary to left vocal cord paralysis, a likely retraction injury to the recurrent laryngeal nerve. He was discharged home uneventfully after clearing therapies. Postoperative flexion/extension films at 6 months demonstrated maturation of fusion and no instability [Figure 4]. This patient was recently published as a case report and briefly presented here.[12]

Patient 3

A 36-year-old male was an unrestrained driver involved in a motor vehicle collision. He complained of a diffuse tingling sensation throughout all four extremities. His neurological examination was nonfocal. CT cervical spine demonstrated a grade 4 spondylolisthesis at C7/T1, associated with bilateral C7/T1 locked facets [Figure 5a]. MRI cervical spine demonstrated narrowing of the spinal canal with equivocal cord edema and disruption of the anterior longitudinal ligament/ligamentum flavum/interspinous ligaments; posterior longitudinal ligament appeared intact [Figure 5b]. The patient was placed in traction up to 50 pounds. The reduction was difficult to assess with

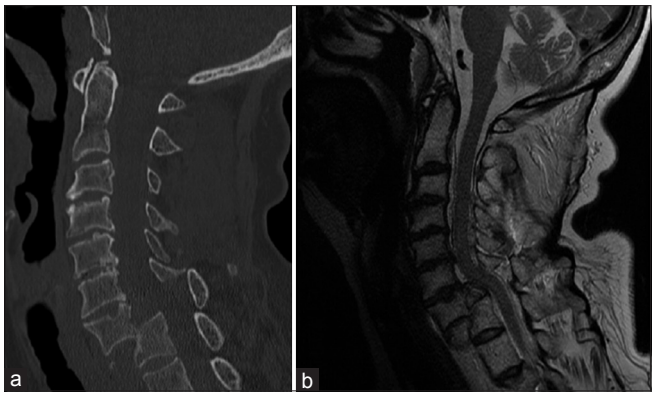

Figure 1: Patient 1 – (a) Computed tomography C spine, (b) magnetic resoance imaging C spine

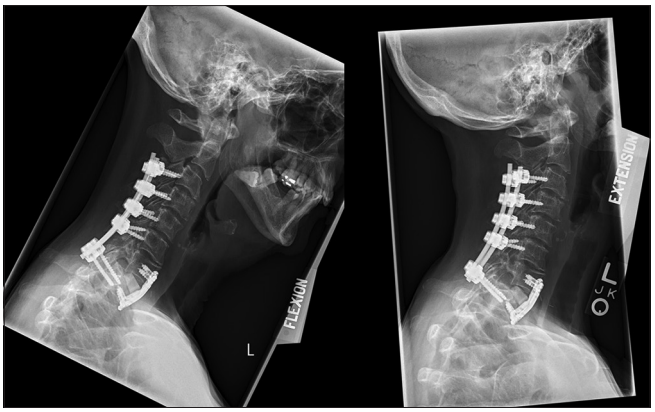

Figure 2: Patient 1 – Flexion/extension films at 3 months

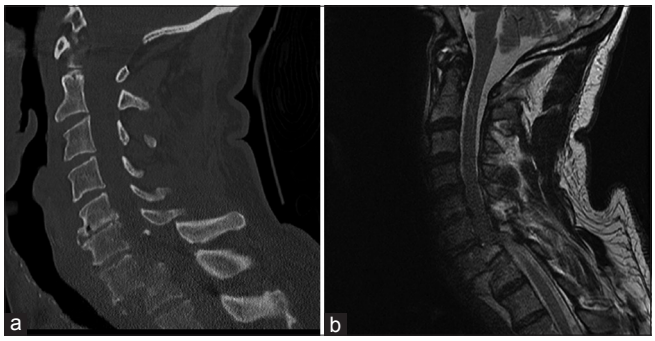

Figure 3: Patient 2 – (a) Computed tomography C spine, (b) magnetic resoance imaging C spine (patient 2 was previously published in Surgical Neurology International, and is briefly presented here)

Figure 4: Patient 2 – Flexion/extension films at 6 months (patient 2 was previously published in Surgical Neurology International, and is briefly presented here)

plain films. Subsequently, he underwent a posterior cervical approach for reduction of bilateral C7-T1 locked facets, with C7 laminectomy, T1 superior laminotomy, and C5-T2 fixation. Intraoperative monitoring was employed, without intraoperative changes. Postoperatively, he was found to be at his baseline motor and sensory exam. His remaining hospital course was uneventful, followed by discharge to home after clearing therapies. Postoperative flexion/extension films at 6 months demonstrated maturation of fusion and no instability [Figure 6].

Discussion

Traumatic spondylolisthesis in the cervical spine is commonly associated with a fracture of the C2 pars, (AKA a hangman fracture) a topic that has been heavily described in the literature.[13] On the other hand, instances associated with the subaxial cervical spine, especially high-grade translation (grades 3–5), have seldom been discussed. Such traumatic cases are well known to exhibit immense spinal cord compression leading to acute spinal cord injury and quadriparesis.[8,14,15] Seldom, patients exhibit minimal (at worse ASIA E or Frankel E) to no neurological compromise. Including our 3 cases, there have been 15 cases of cervical spine traumatic high-grade spondylolisthesis with minimal neurological deficits, including 10 cases of cervical spondyloptosis. C7/T1 was the most frequently affected level. The average age was 48-year-old; there were 11 males and 4 females. The predominant mechanism of injury was related to motor vehicle accidents.

Our first two patients sustained fractures of the posterior arch. This is a common feature among the majority of previously reported cases, largely the presence of bilateral pedicle fractures, facet fractures, and/or laminar factures.[1-3,5,7,9,10] Theoretically, this fracture pattern permits natural decompression at the level of the dislocation due to broadening of the spinal canal.[1-3,5,7,9,10] Merianos *et al*.[16] observed this pattern when they evaluated the features of 17 cervical fracture dislocations. To curtail neurological injury, decompression likely occurred before vertebral translation.

Allen *et al*.[17] developed a mechanistic classification of cervical injuries based on applied forces, which were divided into six groups: Compressive flexion, vertical compression, distractive flexion, compressive extension, distractive extension, and lateral flexion. Within each group, there is a

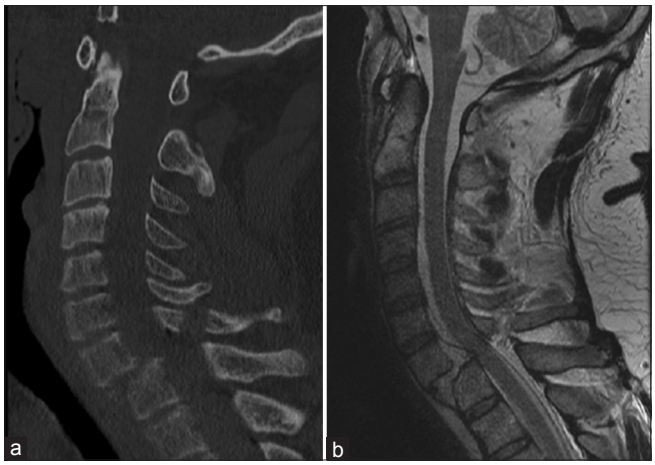

Figure 5: Patient 3 – (a) Computed tomography C spine, (b) magnetic resoance imaging C spine

scale of stages varying from mild to severe. These injuries are consistent with compressive extension, where high-grade translation corresponds with the most severe stage within that category, stage 5. The principle features of this injury are bilateral fractures within the posterior elements and anterior translation of the fractured vertebra relative to the caudal level; the posterior portion of the arch of the fractured level does not translate while the anterior portion of the arch translates with the body.[17]

The cerviothoracic junction (CTJ) fractures account for the majority of the cases (9 patients). The CTJ is the transitional area between the mobile, lordotic cervical spine and the rigid, kyphotic thoracic spine. Consequently, the CTJ experiences distinctive biomechanical forces that are not directed elsewhere along the vertebral spinal column. Perhaps the prevalence of these cases at the CTJ is partly explained by the rigidity of the thoracic spine compared to the cervical spine; this provides a relatively higher force against the C7 posterior elements during a compressive extension mechanism, compared to other levels of the subaxial cervical spine. A similar comparison would be the prevalence of L5 spondylolysis compared to other lumbar levels, where the sacrum applies the rigidity.

Surprisingly, Gasco *et al*.[4] reported a case of spondyloptosis without fractures of the posterior elements who presented 8 months after a motor vehicle collision. However, there was no documentation of the extent of structural injury right after the accident. Perhaps the initial injury was less severe, and the listhesis slowly evolved where the spinal cord was able to adapt. Several cases of cervical spondyloptosis have been reported associated with syndromes (Klippel fiel,[18] neurofibromatosis,[19] Larsen's syndrome[20]), congenital anomalies (absent posterior elements[21]), or pathological

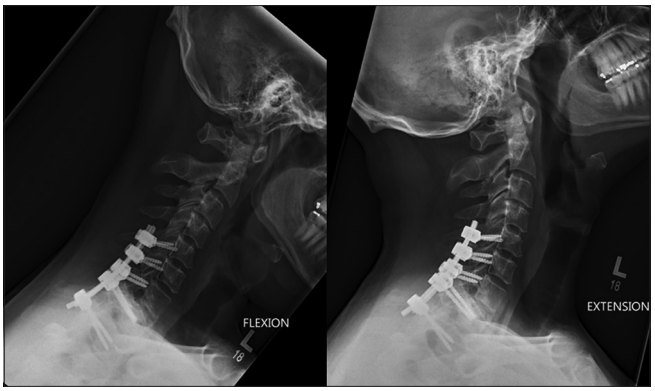

Figure 6: Patient 3 – Flexion/extension films at 6 months

lesions (aneurysmal bone cyst[22]). No cases have occurred where the diagnosis of spondyloptosis was made immediately after a trauma without associated fractures of the neither posterior elements nor neurological compromise.

The third patient exhibited C7/T1 locked facets, grade 4 translation, without fractures through the C7 neural arch or through bilateral C7/T1 articular processes. There has been some mention of high-grade spondylolisthesis associated with bilateral facet dislocations without neurological compromise; however, fracture patterns were not emphasized, and whether other posterior elements were injured remains unclear.[8,11,23,24] Prior biomechanical study suggests that unilateral facet dislocation can precede bilateral dislocation;[25] this mechanism sensibly reduces the likelihood for neurological compromise compared to simultaneous bilateral dislocation.

Conclusion

From the literature, the majority of cases involve fractures of the posterior elements; however, some instances only involve facet dislocations without fractures. Further biomechanical studies are needed to understand the underlying mechanisms.

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Conflicts of interest

There are no conflicts of interest.

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