Traumatic spondyloptosis of the thoracolumbar spine

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Object. Traumatic Grade V thoracolumbar spondylolisthesis, or traumatic spondyloptosis (severe translation injuries), are uncommon spinal injuries. To the best of the authors’ knowledge, this article represents the first reported case series of these unique spinal lesions.


Results. Five patients were identified (3 men and 2 women) with ages ranging from 17 to 44 years. All patients had sustained high-energy closed spinal injuries: 3 motor vehicle accidents, 1 injured in a building collapse, and 1 hurt by a fallen steel beam. Four patients, all with sagittal-plane spondyloptosis, had a complete neurological deficit (American Spinal Injury Association [ASIA] Grade A), and 1, with coronal-plane spondyloptosis, presented with an incomplete neurological deficit (ASIA Grade C). Four patients had sustained concurrent multisystem trauma. All patients underwent surgery: an isolated posterior fusion in 2 and combined posterior-anterior fusion in 3. Only the patient with an incomplete neurological deficit (coronal-plane spondyloptosis) recovered neurological function postoperatively.

Conclusions. Traumatic thoracolumbar junction spondyloptosis is rare. Surgical reconstruction and stabilization allow for early mobilization and rehabilitation. In the present series, a patient with coronal-plane spondyloptosis presented with preserved neurological function. This may be due to the result of differences in resultant neurological compression due to displacement mechanics compared with sagittally displaced injuries.

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Key Words • fracture • pedicle screw fixation • spinal cord injury • spondylolisthesis • spondyloptosis • thoracolumbar spine

Traumatic spondyloptosis, or Grade V spondylolisthesis, is defined as greater than 100% traumatic subluxation of one VB in the coronal or sagittal plane.1,10 It is a rare but severe injury of the vertebral column that results from high-energy trauma.5 The authors of previous reports have described injuries most often involving the lumbosacral junction or lower lumbar spine.1,6–8,10 Traumatic spondyloptosis of the thoracolumbar junction is exceedingly rare; only 1 case has been reported in the literature.12

The thoracolumbar junction is involved in 15% of all SCIs.11 Its location between the relatively stable thoracic spine and the more mobile lumbar spine may predispose it to certain types of traumatic injuries.12

In this report we present 5 cases of traumatic spondyloptosis involving the thoracolumbar junction. The patients presented to our institutions between 1999 and 2007. To our knowledge this is the first published case series of traumatic spondyloptosis involving the thoracic spine and thoracolumbar junction. We detail the clinical history, imaging findings, and surgical management of these injuries and compare them with reports of spondyloptosis involving other spinal levels.

Methods

We reviewed the database of a Level I SCI tertiary referral center and identified 4 patients. A fifth case was contributed by a colleague at the Louisiana State University Health Sciences Center. Clinical information was gathered from electronic records, radiology databases, operative notes, and office charts.
**Results**

Two women and 3 men, ranging in age from 17 to 44 years (mean 32.6 years), were included in the series (Table 1). Three patients were involved in high-speed MVAs, 1 sustained injury resulting from a building collapse, and 1 was struck by a falling steel beam.

Four of five patients sustained multisystem injuries including diaphragmatic rupture and splenic laceration. These four patients all suffered a penetrating chest injury resulting in hemo-, pneumo-, or hemopneumothorax. The fifth patient sustained only a superficial scalp laceration.

All five patients were found to have >100% spondylolisthesis of one VB over an adjacent VB within the thoracic spine or involving the thoracolumbar junction. All patients underwent plain radiography, CT, and MR imaging. Four patients had sagittal-plane spondylolisthesis; these four patients presented neurologically with ASIA Grade A paraplegia. One patient had coronal-plane spondylolisthesis; he presented neurologically with an ASIA Grade C injury. All five patients had a noticeable stepoff at the injured level on physical examination.

Two patients underwent single-stage posterior fusion and placement of pedicle screw/rod instrumentation. Three patients underwent a staged posterior then anterior fusion. All patients survived their injuries and were transferred to extended care rehabilitation facilities.

Follow-up data were obtained in 4 patients (follow-up duration: range 6 months–5 years, mean 2 years). Three patients with adequate follow-up who presented with ASIA Grade A paraplegia exhibited no improvement at follow-up. The patient with an ASIA Grade C injury exhibited improvement in lower-extremity strength and was independently ambulating at 6 months postoperatively. The fifth patient could not be located for follow-up.

**Illustrative Cases**

**Case 3**

**Examination.** This 21-year-old man presented after driving his motorcycle into a parked car at unknown speed. On arrival the patient had Grade 2/5 motor strength in the right proximal lower-extremity muscle groups and Grade 1/5 strength distally. His left leg had trace movement. Thoracolumbar CT scanning revealed complete right lateral (coronal) displacement of the L-2 VB with respect to L-1, with partial preservation of alignment of the posterior elements (Fig. 1). The patient also presented with a left pneumothorax, requiring insertion of a chest tube, as well as splenic and renal lacerations. The abdominal injuries necessitated emergency exploratory laparotomy and splenectomy for hemoperitoneum. This intervention was completed before the patient was transferred to our institution; his concomitant injuries were stabilized prior to open reduction and fixation of his spinal dislocation.

**Operation: Coronal Spondylolisthesis.** The patient underwent a staged spinal stabilization procedure, beginning with a posterior reduction and stabilization. Pedicle screws were placed bilaterally from T-10 to T-12 and at L-3 and L-4. A pedicle screw was placed on the left at the L-1 level and on the right at the L-2 level. Laminectomies for decompression were performed from L-1 to L-3. A short 2-rod construct was placed on one side of the spine. One rod connected to the spinal anchors from T-10 to L-1 and the other rod from L-2 to L-4.

By utilizing domino- or wedding-band connectors of the Monarch system (Depuy Spine), a distractor instrument straddling the rods and contacting adjacent dominoes on each rod (Fig. 2A–E) was used to separate physically both rods in a longitudinal manner; the result was to bring the spinal elements out to their length and achieve adequate temporary spinal alignment. This was confirmed fluoroscopically. Once alignment was confirmed, the contralateral rod was placed from T-10 to L-4 followed by removal of the 2 initially placed short rods, which were replaced with a single rod. Cross-linking of the 2 rods was then performed. The patient was returned to the operating room on another day when the staged anterior stabilization procedure was performed.

**Postoperative Course.** The patient was noted to have improved movement in both lower extremities after surgery. At the 6-month follow-up he was ambulating with crutches. At latest follow-up, plain radiography showed good alignment and progressive maturation of his fusion.

**TABLE 1**

Summary of data obtained in 5 patients with traumatic spondylolisthesis*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Mechanism of Injury</th>
<th>Associated Injuries</th>
<th>Spinal Level</th>
<th>ASIA Grade</th>
<th>Op</th>
<th>Complication</th>
<th>Postop Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38, F</td>
<td></td>
<td>unrestrained passenger in high-speed MVA</td>
<td>diaphragmatic rupture, rt hemothorax, lt radius-ulnar fracture</td>
<td>T10–12</td>
<td>A</td>
<td>pst T8–L1 fusion</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>43, F</td>
<td></td>
<td>steel beam fell on patient high-speed motorcycle MVA</td>
<td>splenic lac, liver lac, bilat HPTs, multiple rib fractures</td>
<td>T12</td>
<td>A</td>
<td>pst thoracic fusion</td>
<td>prolonged intubation</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>21, M</td>
<td></td>
<td>high-speed motorcycle MVA</td>
<td>lt pneumothorax, splenic lac, lt kidney lac, rt scapular fracture</td>
<td>L1–2</td>
<td>C</td>
<td>pst T10–L4 fusion, L1–3 laminectomy, partial L1–2 corpectomy</td>
<td>none</td>
<td>recovered ambulation</td>
</tr>
<tr>
<td>4</td>
<td>44, M</td>
<td></td>
<td>roof collapse</td>
<td>scalp lac</td>
<td>T12–L1</td>
<td>A</td>
<td>pst T10–L3 fusion, ant T11–L2 fusion, partial L-1 corpectomy</td>
<td>postop DVT</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>17, M</td>
<td></td>
<td>high-speed MVA, ejected from vehicle</td>
<td>severe pulmonary contusions, rt hemothorax, sternal fracture, rib fractures</td>
<td>T7–8</td>
<td>A</td>
<td>pst T3–11 fusion, ant T-7 corpectomy</td>
<td>prolonged intubation</td>
<td>none</td>
</tr>
</tbody>
</table>

* ant = anterior; DVT = deep vein thrombosis; HPT = hemopneumothorax; lac = laceration; pst = posterior.
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Case 4

Examination. This 44-year-old man, a construction worker, presented to the emergency department after a roof collapsed on him at a jobsite. Thoracic CT scanning revealed a sagittally displaced traumatic T12–L1 spondyloptosis, which resulted in an ~7-cm anterior displacement of the T12 VB relative to the L-1 VB. Spinal MR imaging revealed complete disruption of the thecal sac at the affected level (Fig. 3A and B). A significant scalp laceration was closed in the emergency department prior to treatment of the patient’s spondyloptosis. A preoperative CT angiogram was used to rule out intraabdominal vascular injury.

Operation: Sagittal Spondyloptosis. At the time of surgery the patient first underwent posterior reduction and pedicle screw/rod-augmented fusion from T-10 to L-3 on a Jackson table (Fig. 3C). Reduction of sagittal-plane deformity is similar to a coronal-plane deformity in that the principles of reduction involve initial lengthening of the spinal elements to regain alignment followed by definitive rod placement. This again involved the placement of a short 2-rod construct on one side of the spine. One rod connected to the spinal anchors from T-10 to T-12 and the other rod from L-2 to L-3.

By utilizing domino- or wedding-band connectors of the Monarch system (Depuy Spine), a distractor instrument straddling the rods and contacting adjacent dominoes on each rod was used to separate physically both rods in a longitudinal manner to bring the spinal elements out to length and achieve adequate temporary spinal alignment (Fig. 4). This was confirmed with fluoroscopy. Once alignment was confirmed, the contralateral rod was placed from T-10 to L-3 and followed by removal of the 2 initially placed short rods, which were replaced with a single rod. Cross-linking of the 2 rods was then performed. The patient returned to the operating room another day for a staged T11–L2 anterior stabilization procedure.

The patient was transferred to a rehabilitation facility after an uneventful postoperative course. He had not regained neurological function at the latest follow-up.

Discussion

Spondyloptosis is a highly unstable injury characterized by a complete fracture-dislocation of the spine. A high-energy force is required to create such injuries in the thoracic spine. According to the 3-column model of spinal trauma described by Denis, fracture-dislocation injuries are the most unstable fractures and have the highest association with SCI of all fracture types. The reported incidence of complete neurological paraplegia in patients with thoracic fracture-dislocation injuries is 80%.

The current series describes 5 patients with spondyloptosis of the thoracolumbar junction including the first such patient in whom an incomplete neurological injury was present. Three patients presented after MVAs, 1 patient after a steel beam fell on her, and 1 patient after a building collapsed at a construction site. These injuries are in accord
with previously reported mechanisms in that they were the result of large force vectors. Spondyloptosis has been described as an extreme fracture-dislocation injury.

Fracture-dislocation injuries, by definition, involve disruption of all spinal elements. Twenty percent of injuries described in Denis’s original series were fracture-dislocation injuries, and the majority occurred at the thoracolumbar junction. Fracture dislocations are further characterized into shear, flexion-rotation, or flexion-distraction classes. Patients with spondyloptosis have obvious disruption of all 3 columns of the spine. In the recently described TLICS (Thoracolumbar Injury Classification and Severity Score) system by Vaccaro et al., fracture-dislocations (severe translational injury with disruption of the posterior ligamentous complex with or without a neurological deficit) were again considered the most unstable of spinal injuries.

Within our case series a variable combination of mechanisms may have been involved in producing specific injuries. Case 1 in our series was found to have burst fractures of the T-10 and T-11 VBs in addition to complete S. Yadla et al.

Fig. 2. A Sawbones model of thoracolumbar coronal-plane traumatic spondyloptosis. Correction of this deformity requires distraction, reducing impacted VBs; translation, restoring normal coronal plane alignment; and rigid internal fixation, maintaining vertebral column correction and facilitating bony arthrodesis. Multiple fixation points are obtained above and below the site of injury. This specimen demonstrates fixation 3 points above and below the level of deformity. Longer constructs may be required in more severely impacted injuries. A: Two provisional rods are positioned, and wedding-band rod connectors serve as stops near the level of injury. B and C: A pedicle screw distractor is positioned; distraction between the wedding-band connectors restores normal spinal column height, facilitating correction of coronal deformity. D and E: Rod holders are used to correct coronal-plane translation. The 2 rods may be connected via the wedding bands, or a new rod may be positioned.
anterolisthesis of the T-11 VB on T-12. This suggests a combination of a flexion compression and shear injury. The mechanism of injury in Case 4 suggests a pure posteroanterior shear injury without a significant compression force because there was preservation of VB anatomy above and below the dislocation.

**Lumbosacral Spondylolisthesis**

Traumatic spondylolisthesis has been described most often as involving the lumbosacral junction and lumbar spine.\(^6\,8\,16\) Bellew and Bartholomew\(^1\) recently published a review of this injury in which they described 7 previously reported cases involving the lumbosacral junction and 7 cases involving the remainder of the lumbar spine superior to that level. In addition to those cases we have found only scattered case reports of spondylolisthesis involving the thoracic and cervical spine.\(^12\)

**Thoracic and Thoracolumbar Spondylolisthesis**

Only 1 previous report of traumatic thoracic spondylolisthesis has been described. Sekhon et al.\(^12\) recently reported on a 36-year-old man who presented after a large bale of hay had fallen onto his back and shoulders. The patient had a T-5 sensory level and lower-extremity paraplegia. He was found to have a T6–7 spondylolisthesis and multiple rib fractures. The patient underwent posterior decompression and fusion in which a pedicle screw/rod construct and iliac crest autograft were placed. At the 2-year follow-up the patient had no change in his neurological status and there was evidence of a solid fusion.

In the aforementioned article Sekhon et al.\(^12\) described the only previously published mention of a traumatic spondylolisthesis involving the thoracolumbar junction. A 22-year-old miner suffered a work-related hyperflexion injury resulting in a complete T-12 paraplegia. Aortic angiography excluded vascular injury. Plain radiography and CT imaging revealed a spondylolisthesis at the T12–L1 level. The injury was reduced intraoperatively with fluoroscopic guidance and stabilized with posterior pedicle screw and rod instrumentation. At the 4-month follow-up the patient remained paraplegic and used a wheelchair for mobility.

**Spondylolisthesis in the Coronal Plane**

The patient in Case 3 in our series was found to have intact VBs with complete lateral displacement of the L-1 VB in relationship to L-2. This suggests a shear-type mechanism with a coronally or laterally directed vector force. Incomplete neurological injury with traumatic spondylolisthesis has been well described at the lumbosacral junction and in the lumbar and cervical spine.\(^4\,8\,9\,12\,14\) We believe this is the first case of traumatic thoracolumbar spondylolisthesis to be reported without complete paraplegia. Our patient recovered further function and had regained ambulation at time of last follow-up.

Our patient’s injury is similar to that in the patient described by Gertzbein and Ofierski,\(^5\) who presented with T5–6 fracture-dislocation in the coronal plane. The patient was a 28-year-old who had been injured in a skydiving accident. He was neurologically intact on presentation and remained so 18 months later after treatment with a supportive brace. Imaging revealed intact alignment of the posterior elements, suggesting that the T5–7 VBs were sheared off their respective pedicles, sparing injury to the cord.

Lateral coronal-plane spondylolisthesis in the lumbar spine has also been recently described by Bellew and Bartholomew.\(^1\) Their patient initially presented with lower-extremity paraplegia but regained complete neurological function after delayed operative decompression. They postulated a posteroanterior shearing mechanism in the injury.

Spondylolisthesis in the coronal plane may be associated with incomplete SCI and improved capacity for recovery of function. A lateral shear force vector appears to have been operative in all 3 patients described above. In these injuries, the anterior vertebral column is sheared off of and dis-
placed from the posterior elements and spinal cord. This is in contrast to the other 4 cases in our series in which both the anterior and posterior vertebral elements sustained an en bloc shear force, leading to severe compression of the spinal cord.

**Surgical Technique**

The goal of surgery in the treatment of thoracolumbar spondylolisthesis is spinal stability with restoration and maintenance of normal spinal alignment. With complete neuro-
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logical spinal injuries, early stabilization allows for early mobilization and improved pulmonary toilet. In patients with an incomplete neurological injury, decompression and stabilization may contribute to earlier neurological recovery.

Operative techniques in this spinal injury must provide options for distraction of impacted VBs, restoration of sagittal and coronal malalignment, and maintenance of correction with stable segmental internal fixation. Vertebral body and laminar spreading instruments are extremely useful in vertebral element distraction and restoration of alignment.

Conclusions

This is the first published series of traumatic spondyloptosis at the thoracolumbar junction. The 4 patients with listhesis in the sagittal or anteroposterior plane incurred a complete neurological injury. The single patient with listhesis in the coronal plane suffered an incomplete injury. We have identified other cases in the literature of patients with spondyloptosis in the coronal plane with incomplete neurological injuries and reported improvement after decompression. Coronal spondyloptosis, through its mechanism of injury, may be associated with an incomplete rather than complete neurological injury and have the capacity for neurological recovery of function. Using modern spinal stabilization techniques, anatomical alignment may be reliably obtained in these injury types.

References


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