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CASE REPORT

Traumatic L4–5 bilateral locked facet joints

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Abstract
Introduction Traumatic bilateral locked facet joints occur with extreme rarity in the lumbar spine. A careful review of the literature revealed only three case reports.
Clinical Presentation We present the case of a 36 year-old male who suffered bilateral L4–5 facet fracture dislocations following a motor vehicle collision. The dislocation was associated with disruption of the posterior elements and a Grade II anterolisthesis of L4 on L5 as well as an epidural hematoma resulting in severe canal narrowing, with the patient remaining neurologically intact on presentation. The patient underwent open reduction with L3 to S1 pedicle screw fixation and arthrodesis to treat this highly unstable injury.
Conclusion The existing literature and a biomechanics review of the lumbar spine are described in the context of the presented case in addition to a proposed mechanism for such dislocations.

Keywords Bilateral locked facet joints · Pedicle screw fixation · Spinal biomechanics

Introduction

Traumatic jumped facets in the lower lumbar spine are rarely encountered. To date, three cases of bilateral locked facets at the L4–5 level have been reported [1–3]. We describe a case of a young male presenting with bilateral L4–5 jumped facets after a motor vehicle collision and provide details regarding the history, radiological findings, and treatment course. We additionally discuss previous case reports and compare their findings and management strategies employed, as well as the unique biomechanical characteristics of the lower lumbar spine as they pertain to these injuries.

Methods

PubMed was searched using the search terms "(L4–5 OR L4–L5) and dislocation"; "(L4–5 OR L4–L5) and locked facets"; "(L4–5 OR L4–L5) and jumped facets"; "(L4–5 OR L4–L5) and traumatic spondylolisthesis". The cases with bilateral locked facets at the L4–5 level were selected. The three cases found in the PubMed English literature are summarized in Table 1 [1–3].

Clinical presentation

A 36-year-old male was the restrained passenger in a head-on motor vehicle collision. Upon arrival, he was neurologically intact with full strength in his lower extremities, intact sensation to pinprick and light touch, normal rectal tone, and normal deep tendon reflexes.

A computed tomography (CT) scan of the lumbar spine revealed bilateral jumped facets at L4–5 with a small fracture of the right L5 superior articular process resulting in a Grade-II anterolisthesis of L4 on L5 and severe canal narrowing. Also noted were fractures through the right transverse processes from L1 through L5, a fracture of the anterior superior L5 vertebral body, and a displaced fracture through the spinous process of L4. Magnetic resonance

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Table 1 Existing case reports

Author (year)	Description of dislocation	Patient characteristics	Mechanism of injury	Neurological examination	Treatment	Outcome
Mori et al. [2]	L4–5 locked facets without fx. Associated L4, L5 TP fx. Grade 2 spondylolisthesis	32 y/o F, no other injuries, very thin (44 kg)	MVA head on collision; wearing seatbelt low (with shoulder harness under axilla)	Intact	Delayed diagnosis and treatment Reduction with resection of L5 superior facets, L4–5 posterior interbody fusion and L4–5 pedicle screw fixation	Resolution of pain Neurologically intact at 6 months
Song and Lee [3]	L4–5 locked facets with small L5 body fx. Associated L2 body and L5 TP fx. Grade 2 spondylolisthesis	47 y/o F, no other injuries	MVA head on collision, correctly wearing seatbelt	Intact	Reduction with resection of L5 superior facets, L4–5 posterior interbody fusion and L4–5 pedicle screw fixation	Resolution of pain Neurologically intact at 10 months
Deniz et al. [1]	L4–5 jumped facets with small L4 inferior facet fx. Grade 2 spondylolisthesis	44 y/o M, no other injuries	Fall of tractor after crashing into tree	Bilateral Numbness and weakness, decreased patellar reflexes	Delayed treatment because patient was refusing surgery Reduction with resection of L5 superior facets, L4–5 posterior interbody fusion and L3–5 pedicle screw fixation	Resolution of pain Neurologically intact at 3 months

TP transverse process(es), *y/o* year old, *fx* fracture, *MVA* motor vehicle accident

imaging (MRI) further identified rupture of the L4–5 disc with disruption of the anterior and posterior longitudinal ligaments as well as the interspinous and supraspinous ligaments from L3 to S1. Additionally, there was an epidural hematoma contributing to canal and foraminal stenosis at L4–5 (Fig. 1).

The patient was taken to the operating room the following morning. A large paraspinous muscle hematoma with posterior tension band disruption was encountered. A complete L4 and superior L5 laminectomy were performed and the epidural hematoma was evacuated. The pars and superior L5 facets were removed with a high-speed drill bilaterally until the L4 inferior facets disengaged, easily resulting in listhesis reduction and spinal realignment. Of note, the reduction and re-alignment after disengagement of the L4 Inferior facers was immediate and full, requiring no further manipulations such as a cantilever technique. Segmental pedicle screw fixation with posterolateral arthrodesis was performed from L3 to S1 with morselized bone autograft plus allograft.

After a protracted course involving the treatment of other injuries including right ulnar and radial fractures, rib fractures and a pneumothorax, the patient was discharged home without neurological deficit. The patient reported near complete relief of back pain at 3 months follow-up. Of note, the patient did not sustain any internal abdominal organ injuries.

Discussion

Bilateral jumped facets, a relatively common injury pattern in the cervical spine, remain a rare entity in the lower lumbar region. The majority of previous reports with bilateral lower lumbar jumped facet joints involve the lumbosacral junction [4–7]. A PubMed search revealed only three reports of bilateral traumatic locked facets at the L4–5 level (Table 1) [1–3].

Biomechanical considerations

Consideration of lumbar spine biomechanics provides insights into the pathophysiology of dislocations in this region. Sagittal plane range of motion (ROM) increases from the L1–2 level to a maximum at the L4–5 level (average 16°) and then decreases at the L5–S1 level to approximately 14° [8]. The majority of the ROM at the L4–5 level occurs in flexion (14° of the 16°), whereas at the L5–S1 level only 10° of the 14° occurs in flexion [8]. Thus, the L4–5 level is more capable of flexion than the L5–S1 level, but near incapable of extension. Consequently, hyperflexion or flexion–distraction injuries force the L5–S1 joints beyond their physiologic range of motion prior to the

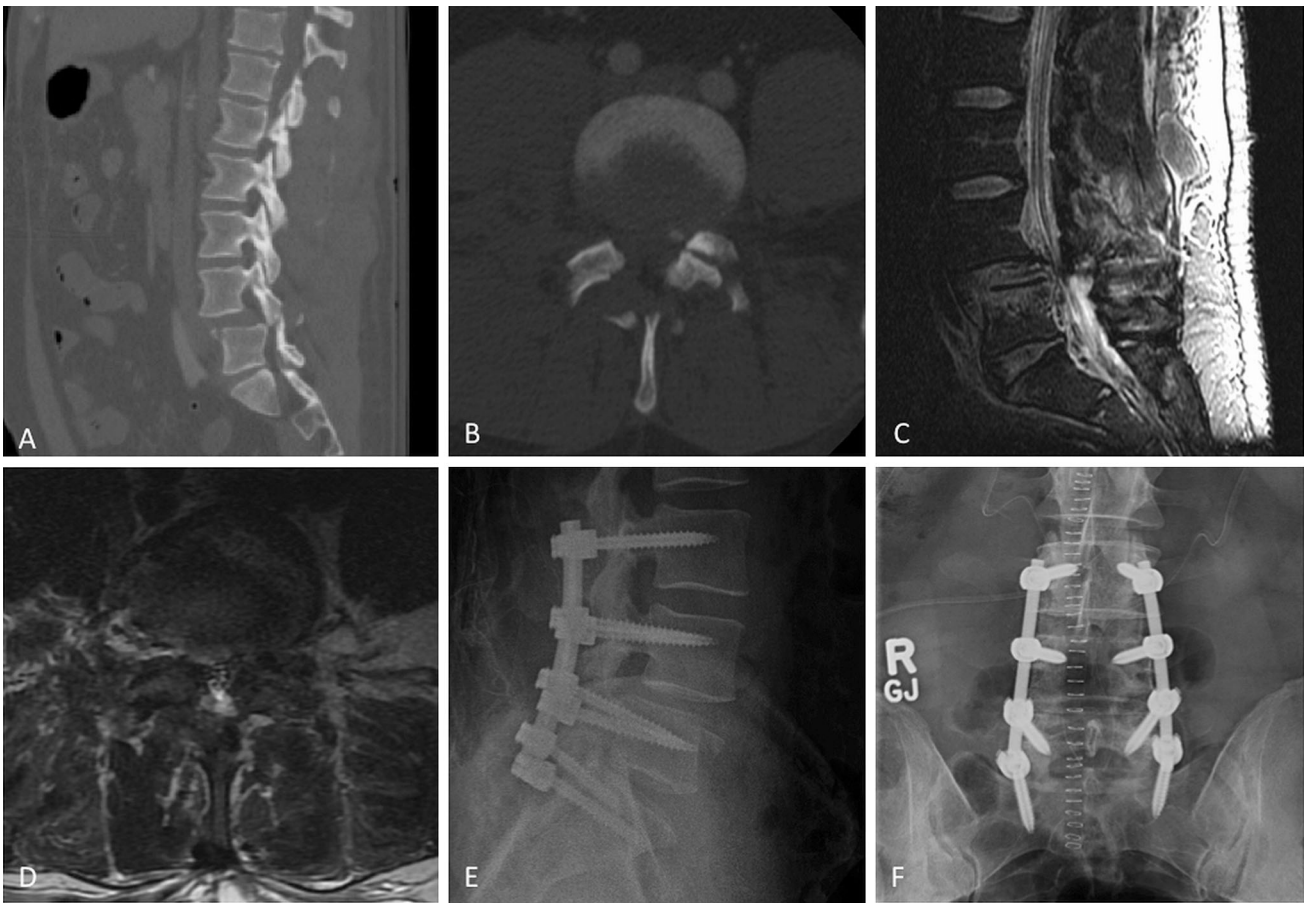

Fig. 1 **a**, **b** Computed tomography (CT) scan of the lumbar spine showing the locked L4–5 facet joint complex resulting in a Grade 2 anterolisthesis of L4 on L5. There is an associated fracture of the right L5 superior articular facet process. **c**, **d** Magnetic resonance (MR) images reveal rupture of the L4–5 disc, and disruption of the anterior and posterior longitudinal ligaments, as well as the ligamentum flavum, interspinous and supraspinous ligaments. An epidural hematoma results in severe canal stenosis at L4–5. **e**, **f** Antero-posterior and lateral X-rays following open reduction and L3–S1 pedicle screw fixation reveal reduction of the dislocation and adequate spinal realignment

L4–5 joints. Additionally, the L5–S1 facet joints are oriented more in the coronal plane, as opposed to the more sagittally oriented L4–5 joints [8]. Therefore, hyperflexion or flexion–distraction injuries may lead to L5–S1 dislocations, whereas the L4–5 joints tolerate the same forces within their natural range of motion. This is a plausible explanation for the higher frequency of L5–S1 dislocations in the literature despite the more robust ligamentous support of the lumbosacral joints.

Three of the four patients (index case included) with L4–5 locked facets involved head-on motor vehicle collisions in restrained occupants occurring in combination with extensive adjacent injuries including transverse or spinous process fractures [2, 3]. These supplementary fractures suggest high impact forces and failure of the supporting muscles and ligaments [9–12]. One case reported a thin (44 kg) 32-year-old female restrained rear-seat passenger [2]. The authors hypothesized that two factors facilitated this rare dislocation: (a) the patient's thin body habitus with limited paraspinal muscle mass and (b) erroneous use of the seatbelt, as the patient positioned her shoulder harness under her axilla enabling the seatbelt to act as a fulcrum at the L4–5 joint. Neither our patient nor the patients in the other reports possessed a small body habitus or wore their seatbelts improperly [1, 3].

During head-on collisions, it is possible that the waist harness of the seatbelt splints the L5–S1 joint, and the shoulder harness acts as a fulcrum around the thoracic cage so the forward momentum of the body forces the lower lumbar spine anteriorly and rostrally. As the pelvis is stabilized to the seat by the waist harness, the net effect of extension–distraction forces on the L4–5 facet complex effectively pulls the L4 inferior facets over the L5 superior facets resulting in dislocation. The stronger ligamentous support of the L5–S1 articular complex as well as the ability for greater extension allows tolerance to these extension–distraction forces [8]. The larger radius from the fulcrum in the thoracic spine and the rapid transition to the

stronger ligaments in the lumbosacral region may render the L4–5 level more susceptible to this type of injury (Fig. 2). The magnitude of the forces applied is indirectly implied from the presence of multiple transverse process fractures and the extensive posterior element ligamentous injury evident on imaging and confirmed intra-operatively. It is noteworthy that the strong ligaments in the lumbosacral region are more robust than the bony articular facets resulting in the more common fracture dislocations. Conversely, the dislocation in this case was associated with only a minimal fracture of the right superior L5 facet suggesting the extreme forces applied. These unusual forces may be an explanation for the extensive posterior ligamentous injury seen on imaging and confirmed intra-operatively.

Treatment options

In two reports, complete L4 and superior L5 laminectomies resulted in successful decompression of the central canal, and resection of the L5 superior articular processes enabled reduction of the dislocation [1–3]. In these cases, pedicle screw and rod instrumentation was placed only at the L4–5 level [2, 3], with the third case extending the hardware rostral to L3. Treatment each time included interbody arthrodesis [1–3]. The rationale to perform interbody arthrodesis or fusion extension may involve the extent of discectomy due to disc fragmentation and/or herniation in the setting of a compromised posterior column and/or anticipation of inadequate stabilization due to poor bone quality or vertebral body fractures limiting screw purchase.

In our case, extensive damage to the posterior tension band manifested by a large paraspinal muscle hematoma spanning from L3 to the sacrum and gross incompetency in the ligamentous structure prompted instrumentation extension from L3 to S1. Although our fixation is wider than previously described, this was felt to be necessary given the degree of ligamentous injury. An interbody fusion was not performed in our case as L4–5 disc disruption was limited and the posterior annulus was relatively preserved. No canal compromise was seen by either the disc or disc fragments forcing us to open the annulus and perform a radical discectomy. Additionally, our patient had large pedicles and good bone quality providing excellent pedicle screw purchase, which in association with the longer construct was deemed adequate stabilization for

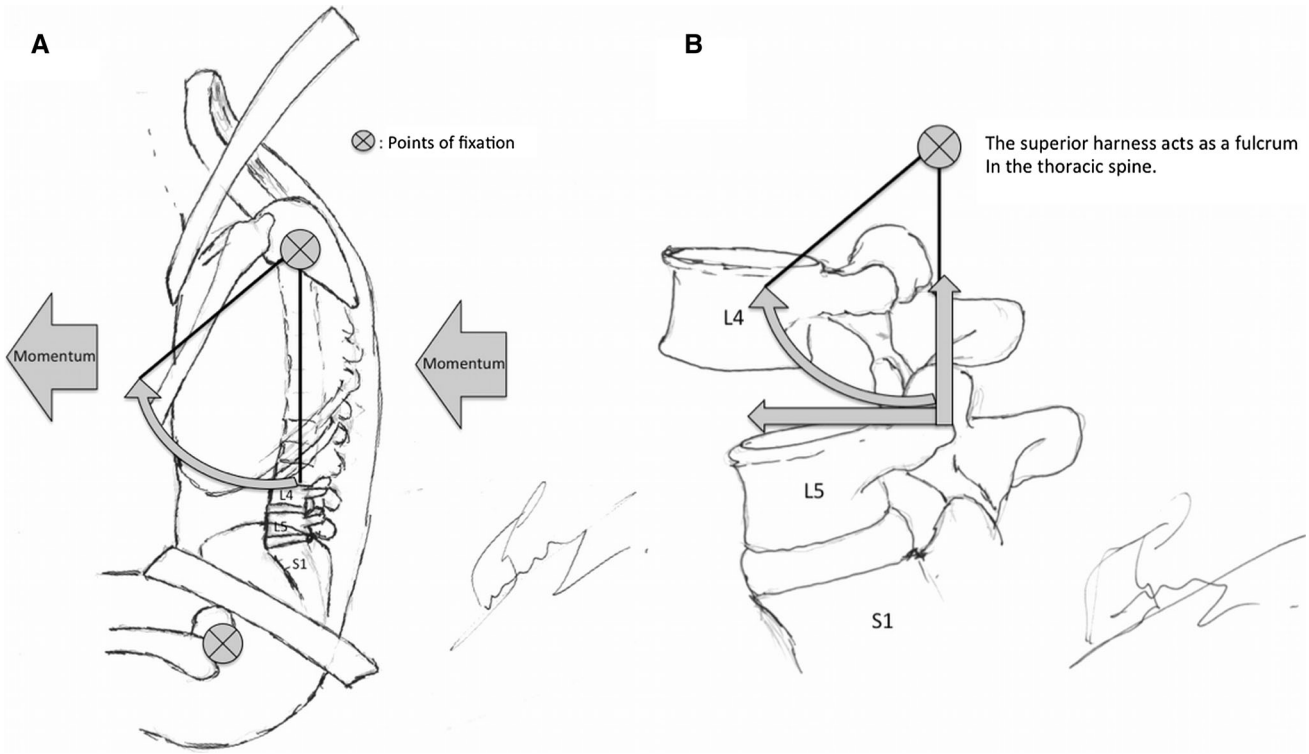

Fig. 2 Proposed pathophysiology of L4–5 jumped facets during head-on motor vehicle collisions in restrained occupants. **a** During the collision, the shoulder harness may act as a fulcrum in the thoracic spine transforming the momentum of the body into anterior and rostral forces on the lower lumbar spine. The pelvis is splinted to the seat by the waist harness. **b** The net effect is extension–distraction forces on the L4–5 articulating facet complexes resulting in dislocation. The L5–S1 complex is more tolerant to these forces due to their stronger ligamentous support and ability to accommodate greater extension. The larger radius from the fulcrum in the thoracic spine and the rapid transition to the stronger ligaments in the lumbosacral region may render the L4–5 level more susceptible to this type of injury

fusion support. Thus, although an interbody fusion was an option, we elected to forego it.

Outcomes

Given the wide central canal in the lower lumbar spine, it is not surprising that extensive neurological deficits were not associated with these injuries at the time of presentation [1–3]. Deniz et al. noted their patient had numbness and weakness in bilateral lower extremities, although the exact distribution is not described [1]. After treatment, all patients were back to their neurologic baselines and reportedly symptom free.

Conclusion

Isolated bilateral traumatic L4–5 jumped facets are extremely rare injuries caused by high-force, high-velocity impact. The use of a seatbelt in head-on motor vehicle collisions may alter the biomechanics of the lumbar spine, leading to extension–distraction forces exerted on the L4–5 facet joints resulting in their dislocation. None of the reported cases resulted in any permanent neurologic deficits and all were safely reduced and fixated with varying level constructs. The extent of instrumentation and arthrodesis may be influenced by the damage to the posterior tension band. Dislocation reduction is safely achieved by removal of the superior L5 articular facet with limited lateral osteotomies. The addition of an interbody arthrodesis has been associated with good results, although not always necessary if adequate stabilization can be achieved without it and if disruption of the posterior annulus is not present.

Compliance with ethical standards

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Conflict of interest The authors have no personal or institutional interest with regards to the authorship and/or publication of this manuscript.

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