Traumatic Spondylolisthesis of the Fourth Lumbar Vertebra Without Neurologic Deficit or Fracture of the Posterior Elements

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Abstract

Acute traumatic spondylolisthesis in the lumbosacral spine is an uncommon injury. Traumatic dislocation of the fourth lumbar vertebra over the fifth lumbar vertebra (L4/L5) is extremely rare since few studies have been reported in the current literature. We report on a 53-year-old man, who had a motor vehicle accident and sustained an injury of the lumbar spine without neurological impairment. The radiographic evaluation disclosed an L4/L5 traumatic spondylolisthesis, classified as Meyerding grade III without any fracture of the posterior vertebral elements. To the best of our knowledge, this is the sixth case of L4 traumatic spondylolisthesis without concomitant fracture of the posterior vertebral elements and the third case without any neurological deficit among them. The patient underwent open reduction and posterior instrumentation. Intraoperatively, the posterior ligamentous complex, the capsules of the facet joints and also the disc were found torn, although facets, neural arch, and pedicles were intact. Following decompression and reduction of the spondylolisthesis without any neurologic complications, we performed pedicle screws and rods fixation from the third to the fifth lumbar vertebra (L3-L5). The patient had an uneventful recovery and returned to his previous activity three months after surgery. The four-year follow-up evaluation showed normal spinal alignment, successful pain-free fusion without neurologic complications. Flexion/distraction injury without simultaneous rotation at the L4/L5 segment during traffic accidents or the fall of a heavy object on the bent back accompanied with posterior ligament weakness is thought to be the probable mechanism for this type of injury. Concomitant neurologic impairment is associated with the majority of L4/L5 spondylolisthesis cases. Posterior decompression, reduction, and posterior instrumentation enhances bony fusion, improves the patient’s neurologic status and restores the sagittal alignment.

Introduction

Traumatic lumbar and lumbosacral spondylolisthesis is an uncommon injury. Especially, spondylolisthesis of the fourth lumbar vertebra (L4) is very rarely reported, while several cases with dislocation of the fifth lumbar vertebra (L5) over the first sacral vertebra (S1) have been described [1]. To our knowledge, there are only 16 studies with 18 patients reporting on L4 traumatic anterolisthesis, retrolisthesis, and spondyloptosis with or without concomitant fracture of the posterior vertebral elements [2-17]. Most of the patients in these reports were treated operatively with open reduction, intervertebral cages, pedicle screws, and rods fixation via the posterior approach. The purpose of this study is to report a rare case of L4 anterolisthesis without concomitant fracture of the posterior spinal elements, and also without neurologic impairment as well as to describe its operative treatment. We will also review all the published cases (according to our search on PubMed and Google Scholar) of L4 fracture-dislocation and pure dislocation, focusing on the mechanism of injuries, sagittal balance restoration, and neurological outcome following surgery.

Case Presentation

A 53-year-old man, with a body mass index (BMI) of 27.6 Kg/m2, was driving wearing his security belt with a velocity of about 70 Km/hour, when he lost control (with the same velocity) of his car and fell in a ditch from a height of about 1.5 meters. On admission, the patient was hemodynamically stable, while the physical examination disclosed swelling over the lower lumbar spine with severe pain on pressure without any neurologic impairment of the lower extremities. Plain roentgenograms in lying position revealed a traumatic dislocation of the fourth lumbar vertebra (L4), classified as Meyerding grade III spondylolisthesis (Figures 1, 2)
FIGURE 1: Preoperative supine lateral roentgenogram on admission of the lumbar spine showing Meyerding III anterolisthesis of L4. The black arrow shows the avulsion fracture of the anterior–superior vertebral corner.
FIGURE 2: Preoperative anteroposterior roentgenogram of the lumbar spine showing narrowing of the intervertebral space (black arrows).

A full-body computed tomography confirmed the anterior dislocation of L4 vertebra associated with an avulsion fracture of the anterior/superior corner of the fifth lumbar vertebra (L5), accompanied by fractures of the transverse processes of the second, the third, and the fourth lumbar vertebrae, without, however, any fracture of the facet joints and neural arches (Figures 3, 4)
FIGURE 3: Preoperative lateral supine CT scan with sagittal reconstruction showing the anterolisthesis of L4 and the avulsion L5 fracture (black arrow).
The patient underwent open posterior decompression, reduction, and pedicle screw fixation within 24 hours following admission. Continuous neuromonitoring was used. During exposure, the posterior spinal ligamentous complex and facet joint capsules were found completely torn accompanied by bilateral anterior facet dislocation and rupture of the intervertebral disc, without any fracture of the facets or neural arches of L4 and L5 vertebrae. Decompressive laminectomy was made to facilitate the reduction of L4 vertebra and inspection of nerve roots and dural sac during the reduction maneuvers. Reduction of the dislocation was achieved using flexion/distraction maneuvers (leverage of the L4 vertebra using a laminar spreader, Cobb elevators, and reduction pedicle screws through L4 pedicles) and it was temporarily secured with a unilateral longitudinal rod. An interbody expandable cage (transforaminal lumbar interbody fusion [TLIF]) was inserted in the L4/L5 intervertebral space after meticulous removal of the annulus fibrosus and the cartilage of the adjacent vertebral endplates. Autologous cortico-cancellous bone graft was impacted into the L4/L5 disc space. Finally, two lordotic contoured longitudinal rods were assembled with the screws and an autologous bone graft was placed posterolaterally to enhance fusion. The postoperative course was uneventful. The patient was mobilized on the first postoperative day with a brace and discharged on the third postoperative day. After a three-month follow-up, the patient was encouraged to progressively regain his previous activity as a pastry chef (Figures 5, 6).
FIGURE 5: Postoperative (three months follow-up) standing roentgenogram of the lumbar spine showing excellent sagittal balance and pedicle screw-rod fixation in situ.
FIGURE 6: Postoperative (three months follow up) standing anteroposterior roentgenogram of the lumbar spine. The black arrows show the level of the interbody fusion.

At the latest follow-up, four years postoperatively, the patient was symptom-free with normal spinal alignment and complete posterolateral spinal fusion (Figures 7, 8)
FIGURE 7: Postoperative lateral standing roentgenogram of the lumbar spine four years postoperatively. Note the completed fusion (white arrow) and excellent sagittal balance.
FIGURE 8: Postoperative anteroposterior standing lateral roentgenogram of the lumbar spine in the last evaluation, four years postoperatively.

Discussion

Acute traumatic spondylolisthesis in the lumbosacral spine is not common. The combination of hyperextension, hyperflexion, and rotation has been described [1] as a pathogenic mechanism. Moreover, L4/L5 traumatic dislocation is extremely rare, since only 16 studies in the literature have reported anterolisthesis, retrolisthesis, or even spondyloptosis of L4, with or without neurologic impairment [2-17]. Among the 18 patients reported, only five cases have been reported with L4-anterolisthesis Meyerding III with "locked" but not fractured facets [5,15-17]. Concomitant neurologic impairment was reported in the majority of the cases (11 out of 18 cases) [5,9-15,15-17] (Table 1).
| No | Authors                  | Year | Cases | Gender | Age | Neurologic impairment on admission | Type of Injury                                                                 | Posterior vertebral elements fracture | Trauma to Surgery time | Type of surgery | Open/MIS | Follow up | Neurologic impairment on Follow up |
|----|-------------------------|------|-------|--------|-----|-----------------------------------|--------------------------------------------------------------------------------|---------------------------------------|------------------------|-------------------|----------|-----------|----------------------------------|
| 1  | Abdel-Fattah et al. [9] | 2000 | 1     | Female | 16  | ASIA E                            | fracture retrolisthesis L4, fall from 3-m height                              | fracture/dislocation retrolisthesis L4, all posterior elements fractured        | Not available          | sacral rod and two Harrington rods | Revision surgery | 7 months | ASIA E               |
| 2  | Moti et al. [5]         | 2002 | 1     | Female | 32  | ASIA E                            | Traumatic bilateral locked facet at L4-5                                   | pure dislocation associated with locked facet at L4-5                         | 2 weeks                | L4-LS posterior pedicle screw plus PLIF | Open            | 18 months | ASIA E               |
| 3  | Song et al. [9]         | 2005 | 1     | Female | 34  | ASIA E                            | fracture dislocation L4, traffic                                            | LS facets fractures                                                             | 3 months               | Posterior L4-LS plus PLIF          | Open            | 12 months | ASIA E               |
| 4  | Ahmed et al. [9]        | 2005 | 1     | Female | 34  | Claudis Epiaire                    | traffic stacked/traction/dislocation retrolisthesis L4                      | LS facets fractures                                                             | 10 days                | Posterior, decompression, L4-LS PLIF titanium interbody cage, pedicle screws L3-L5 | Open            | 24 months | ASIA E               |
| 5  | Deniz et al. [5]        | 2008 | 1     | Male   | 44  | ASIA E                            | fracture dislocation L4, Mayerding I. Driver of a tractor that has crashed to a tree | L4 inferior facet fracture & bilateral facet dislocation                       | 4 months               | Posterior, decompression, L4-LS interbody cage, pedicle screws L3-L5 | Open            | 3 months | ASIA E               |
| 6a | Lim et al. [17]         | 2009 | 1     | Male   | 41  | Claudis Epiaire                    | a 600-kg container fell onto his back                                     | fracture of the anterior-superior corner of L5 associated with a Chance-type fracture-dislocation through the L4/5 disc space and bilateral prechondral facets with grade 3 spondylolisthesis of L4 on L5 | 4 hours                | Posterior decompression, L4-LS pedicle screws and TLIF | Open            | 1 year    | Almost full caudal function recovery |
| 6b | Lim et al. [17]         | 2009 | 1     | Male   | 56  | ASIA E                            | falling from a height of 3 metres                                         | comminuted fracture of L5 and grade-1 anterolisthesis of L4 on L5              | 24 hours               | Posterior decompression, L3-S1 pedicle screw fixation, L4-LS TLIF | Open            | 1 Year     | ASIA E               |
| 7a | Zhou et al. [3]         | 2010 | 1     | Male   | 19  | Claudis Epiaire                    | L4 spondylolisthesis, heavy object fell on his back                        | LS facets fractures                                                             | 10 days                | L4-L5 pedicle screws plus PLIF      | Open            | 78 months | Almost full caudal function recovery |
| 7b | Zhou et al. [3]         | 2010 | 1     | Male   | 13  | Claudis Epiaire                    | L4 spondylolisthesis, heavy object fell on his back                        | facets and lamina of LS fracture                                               | 5 days                 | L3-S1 pedicle screws               | Open            | 12 months | Drop foot only         |
| 8  | Chandrasekharan et al. [11] | 2011 | 1     | Male   | 10  | Claudis Epiaire                    | spondylolisthesis L4 over LS. He fell from a running truck                 | L3 and L4 facet fracture                                                        | Not available          | Pedicle screws L3-LS               | Open            | Not mentioned | MB improvement |
| 9  | Zanzar-Kilgusse et al. [10] | 2012 | 1     | Male   | 20  | Claudis Epiaire                    | traffic accident dislocation of L4-LS. Influence of alcohol was in a car that rolled over | L4 and LS facet fracture                                                      | 3 days                 | Traction, thee surgery L3-S1 pedicle screws | Open            | 12 months | ASIA D               |
| 10 | Tang et al. [12]        | 2012 | 1     | Female | 46  | Claudis Epiaire                    | incomplete cauda equina syndrome                                           | Traffic stuck on a car                                                         | 13 hours               | single stage combined anterior and posterior approach (anterior) | Open            | 24 months | ASIA D               |
To the best of our knowledge, our case is the sixth traumatic L4 anterolisthesis. Meyerding III reported, without associated fracture of the posterior vertebral elements (pedicles, facets, and neural arch), and the third case without neurological deficits caused by a trauma of moderate energy. According to the Denis classification, this is an unstable three-column injury, which requires surgical stabilization, as in all previously published cases. In our case, the probable mechanism for L4 olisthesis is a severe flexion-distraction injury in the lumbar spine with the safety belt acting as the fulcrum for the bending force applied to the spine. There was initially rupture of the posterior ligamentous complex (supraspinous, interspinous, ligamentum flavum, posterior longitudinal ligament, facet joint capsule, and intervertebral disc) and subsequently dislocation of the facet joints without fracture. All these were intraoperatively certified. Facet joints and their well-developed capsules play a crucial role in the stability of the lumbar spine [18]. Usually, a flexion-rotation injury is required to provoke dislocation of these structures [18]. In biomechanical studies, it has been reported that when vertebral displacement in the lumbar spine is observed, facet fracture is suspected, which permits abnormal axial rotation and subsequent dislocation [18]. However, in five previous cases [5,15-17] and in our case, no fracture was associated with the L4-L5 anterolisthesis. Among these five previously reported cases, only two patients were without neurologic deficits on admission [5,17]. So, our case is the third one which is associated with traumatic L4/L5 spondylolisthesis without fracture of the posterior elements and also without neurological impairment. Sullivan and Farfan [19] showed in a biomechanical study that axial rotation > 30° of the lumbar spine caused the failure of the neural arc, progressing from facet joint dislocation to fracture of the articular process. Thirteen out of 18 previously published cases with L4 spondylolisthesis were associated with facet fracture, while in our case and those of Mori et al. [5], Im et al. [15], N’Dri-Oka et al. [16], and Lim et al. [17], there was no facet fracture, but locking facets and pure dislocation. Apparently, the rupture of the facet joint capsule has occurred without simultaneous spinal rotation, resulting thus in a pure anterolisthesis. Aside from the mechanical forces that act in the lower lumbar spine, weakness of the posterior ligament complex has been suggested as a predisposing factor for lumbar fracture-dislocation in 21% of subjects aged > 20 years [20]. Patients’ age averaged 31.9±14.52 years in the published papers, but there were four patients with ages lower than 20 years [5,8,11] (Table 1). Eleven out of the 18 patients were admitted with neurologic impairment [5,6,9,15-17]. Neurologic injury was more common in patients with L4 retrolisthesis. However, all patients who had on admission neurological deficits showed worth noting improvement in the final observation (Table 1). Successful pedicle screw fixation was applied in all the patients, except in two cases with L4-L5 spondylolisthesis [8,13]. The insertion of an intervertebral cage in 12 out of 18 cases [5,5,6,9,12-14,16,17] resulted in solid fusion and reportedly restoration of sagittal balance.

**Conclusions**

| Case | Year | Age | Sex | Mechanism | Level | Fracture | Decompression | Fusion | Surgery | Follow-up | Notes |
|------|------|-----|-----|-----------|-------|----------|--------------|--------|---------|-----------|-------|
| 11   | 2012 | 37  | Male| Spondylolisthesis | L4    | Facet fracture | Yes | Open | L4-L5 pedicle screw plus PLIF | 6 months | ASIA E |
| 12   | 2014 | 34  | Male| L4 spondylolisthesis | L4-L5 | Facet fracture | No | Open | L4-L5 pedicle screws | 2 months | ASIA D |
| 13   | 2016 | 36  | Male| Traction | L4    | Fracture | Yes | Open | L3-L5 fusion pedicle screws | 3 months | ASIA E |
| 14   | 2016 | 33  | Male| Traffic accident | L4    | Fracture | No | Open | Decompression, L4-L5 pedicle screws plus TLIF | 16 months | ASIA D |
| 15   | 2016 | 34  | Female| Locked facet dislocation, traffic | L5    | Fracture | Yes | Open | L4-L5 pedicle screw plus PLIF | 12 months | ASIA E |
| 16   | 2019 | 60  | Male| Grade 3 traumatic spondylolisthesis of L4 | L3 & L4 | Fracture | Yes | Open | 2 stage anterior & posterior surgery/ 11 days interval plus PEEK vs oblique lumbar interbody approach/ L2-S1 | 24 months | ASIA D |

### TABLE 1: Cumulative data on 16 published cases with traumatic olisthesis of L4. Case 2, 6a, 6b, 11, and 14 concern those without facet fracture, similar to our case.
In conclusion in our case, high-energy trauma resulted in disruption of the already weakened posterior ligamentous complex, anterior sliding of the L4 vertebra body, and a subsequent three-column injury, according to Denis classification. Open decompression, reduction with internal segmental pedicle screw fixation, and fusion is the most accepted treatment resulting in excellent short- and long-term clinical and radiological results and neurologic recovery of the patients. Clinicians and spine surgeons should be aware that traumatic lumbar spondylolisthesis can take place even with the absence of neurologic impairment and/or without any fracture of the posterior vertebral elements.

Additional Information

Disclosures

Human subjects: Consent was obtained by all participants in this study. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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