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Case Report

Optimizing the distal anchorage in stabilization for the traumatic adjacent lumbar vertebra fracture in an adolescent idiopathic scoliosis patient who had posterior spinal fusion: a novel surgical technique

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ABSTRACT

The incidence of traumatic spine fractures (TSF) is increasing worldwide, with a reported annual incidence of up to 32.8 per 100 000 persons. However, there are only a few cases of spine fractures reported in adolescent idiopathic scoliosis (AIS) patients after posterior spinal fusion (PSF) in the literature. Fractures adjacent to fusion blocks that extend into the lower lumbar spine pose a unique challenge as stabilization of such fractures might require an extension of instrumentation to L5 or the pelvis. We report a novel surgical technique where bilateral pedicle and cortical screws at L4 and supplementary rods that connect the cortical screws to the main rods via dominos were implemented for optimizing the distal anchorage for TSF stabilization following an L3 Chance fracture in an AIS patient who had undergone T4-L2 posterior spinal fusion.

Introduction

The incidence of traumatic spine fractures (TSF) is increasing worldwide, with a reported annual incidence of up to 32.8 per 100 000 people.[1,2] Traumatic spine fractures are primarily caused by high-energy trauma such as motor vehicle accidents (MVA), falls from height, and sports injuries.[3] To date, there are only a few cases of spine fractures reported in adolescent idiopathic scoliosis (AIS) patients after posterior spinal fusion (PSF) in English literature.[4,5] Fractures adjacent to fusion blocks that extend into the lower lumbar spine pose a unique challenge as stabilization of such fractures might require an extension of instrumentation to L5 or the pelvis. We would like to report a novel surgical technique for optimizing the distal anchorage for TSF stabilization following an L3 Chance fracture in an AIS patient who had undergone T4-L2 posterior spinal fusion.

Case Presentation

A 21-year-old girl with an AIS Lenke 1AN curve had undergone PSF T4-L2 four years before the accident. She was involved in an MVA where her car collided with the rear of a lorry. She complained of low back pain associated with persistent abdominal pain. Computed tomography (CT) scan confirmed the diagnosis of L3 Chance fracture (AO:B2) (Figure 1A). There was no neurological deficit. She underwent an exploratory laparotomy on post-trauma day 3 due to small bowel perforation, and a small bowel resection with primary anastomosis was subsequently performed. On day 8 post-trauma, she underwent revision PSF surgery to L4.

Surgical Technique

To avoid extension of fusion to L5 vertebra, we employed several surgical strategies to ensure adequate anchorage distal to the fracture (Figure 1B and C):

1. Bilateral pedicle and cortical screws at L4 vertebra. We moved the starting point of the L4 pedicle 2-3 mm more laterally than the conventional entry to allow space for the cortical screw trajectory, which had a medial starting point.
2. Intermediate screws were inserted at L3 vertebra. The trajectories of the bilateral L3 pedicle screws were directed inferiorly to ensure that they provide anchorage distal to the fracture.
3. Use of supplementary rods that connect the cortical screws to the main rods via side-to-side domino.
4. The transition of the connectors was moved proximally to the thoracolumbar region. To avoid additional stress to the fracture site and the distal anchorage, the connectors between the fusion block and the new instrumentation at L4 were moved to the thoracolumbar region.

Her revision surgery and postoperative recovery were uneventful. She was discharged on post-trauma day 12. At 9 months follow-up, her radiographs showed fracture union with no implant loosening (Figure 1D). The lumbar lordosis was 40°. Her pelvic incidence was 42° (Figure 1D). Informed consent was obtained from the patient for the use of radiographs and intraoperative photos.

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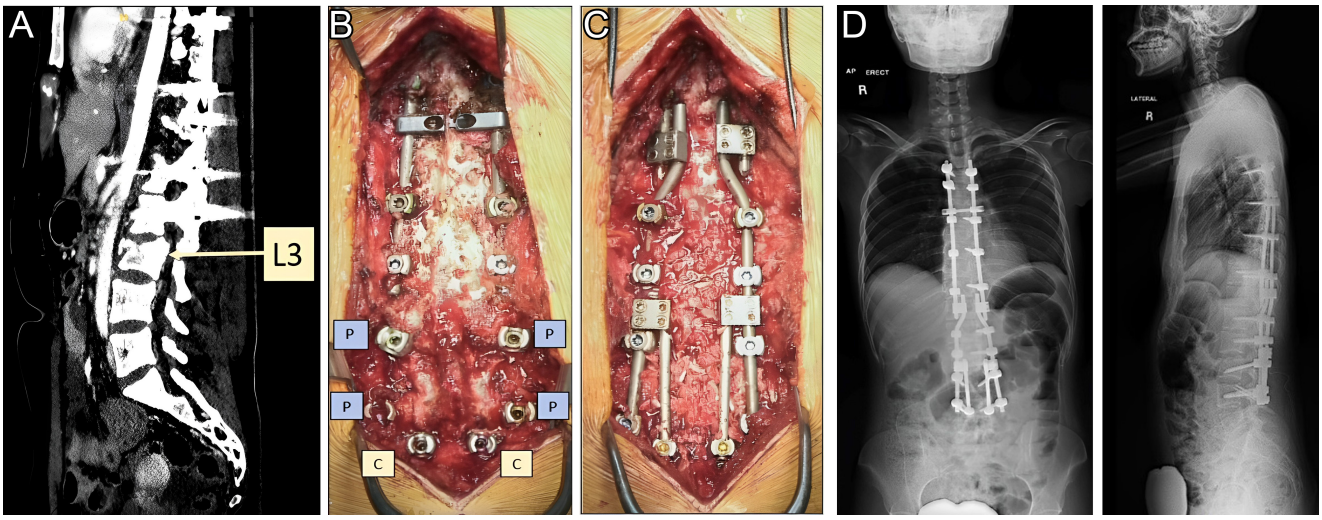

Figure 1. (A-D) Pre-operative CT scan, intra-operative images and post-operative radiographs. (A) Sagittal CT scan shows a fracture at the level of the L3 vertebra. (B) Intraoperative photo shows the insertion of pedicle screws (labeled as P in the blue box) at L3 and L4 and two cortical screws (labeled as C in the yellow box) at L4 vertebra, while (C) intra-operative photo shows the final construct with bone graft in situ. (D) Anteroposterior and lateral radiograph of the patient (with cortical and pedicle screws within the same L4 vertebra) at final follow-up with good coronal and sagittal alignment.

Discussion

Spine fractures among AIS patients who have undergone PSF are rare, with a reported incidence of 1.2%-2.5%.[6] Only two cases of unstable traumatic adjacent vertebra fractures were reported out of 1501 AIS patients who underwent PSF in our center between January 2013 and December 2022. Hence, we report that the 10-year incidence of unstable traumatic adjacent vertebra fracture among AIS patients who had undergone PSF surgery in our center is 0.13%.

Our patient presented with a single-level Chance fracture, which is frequently seen in MVAs due to the spine being subjected to significant flexion and distraction forces over the seatbelt.[7] As was the case with our patient, it is important to look for any concurrent intraabdominal hollow-organ injuries, which have been reported in up to 51.3% of pediatric Chance fractures.[8]

Our case had a fracture at the adjacent segment distal to the lowest instrumented vertebra of the index surgery. In comparison to the normal spine, the surgically fused spine is more rigid with a long lever arm acting at the transition between the fusion block and the mobile spine. As a result, the stress will be transferred mainly to the proximal and distal adjacent non-fused segments during the trauma. Due to the stress and hypermobility of the unfused segment compared to the fused segment, the junction, i.e., the adjacent vertebra, is predisposed to injury.[9]

Previous studies have reported that a longer spinal fusion, particularly those extending beyond L4, was associated with reduced lumbar mobility, higher pain scores, and poorer health-related quality of life.[10] Therefore, one of the main goals for the revision surgery was to preserve motion segments by minimizing the number of fusion levels. For our patient, we decided to fuse only one vertebra below the level of fracture to maintain maximal lumbar range of motion and flexibility. However, this may lead to a high rate of implant failure, pseudoarthrosis, and poor postoperative alignment, as previously reported in patients with thoracolumbar fractures who underwent short-segment fixation.[11,12]

To prevent the complications mentioned, two key surgical strategies were undertaken. Firstly, it was important to strengthen the base of the construct by using multipoint anchors as well as supplementary rods.[13] In our case, two cortical screws were first instrumented medial to the pedicle screws at the lowest instrumented vertebra (L4). The cortical screws were connected to the main rods by using domino connectors placed at the L2/L3 levels via supplementary rods. Secondly, to reduce the stress over the fracture site, the rod-to-rod connectors were placed more proximally over the fusion block and not at the fracture site.

Literature on fractures occurring after pedicle screw instrumentation in AIS patients is scarce. Calderaro et al.[4] in 2019 described a case of a 16-year-old girl who experienced a low-energy fall from a flight of stairs 40 days after her T2-L1 PSF surgery for AIS. The patient sustained a nondisplaced fracture at the L1 vertebral body, leading to post-traumatic kyphoscoliosis of the thoracolumbar spine. She underwent revision PSF surgery to L4 at 10 months post trauma. Two Ponte osteotomies at T12-L1 and L1-L2 were performed during the revision surgery for correction of her kyphosis. She recovered well with good clinical outcomes.

Rocos et al.[5] in 2021 reported on a case of LIV fracture occurring in an AIS patient after PSF without any known trauma or antecedent events. At 6 months post-PSF, the patient sustained an L1 Chance fracture causing kyphosis between T12 and L2. She subsequently underwent revision surgery to L3 with good postoperative recovery outcomes. The authors postulated that the cause of the fracture was likely due to the insertion of oversized pedicle screws, which may have led to intraoperative or delayed fracture. Hence, an accurate

HIGHLIGHTS

- Unstable traumatic adjacent vertebra fractures among AIS patients who have undergone scoliosis surgery are rare.
- A short-fusion strategy was described, whereby only one level below the fractured vertebra was fused during revision surgery to maintain maximal lumbar range of motion and flexibility.
- The final construct was strengthened by using multipoint anchors, i.e., two pedicle and two cortical screws in the lowest instrumented vertebra with supplementary rods.
- To reduce the stress over the fracture site, the rod-to-rod connectors were placed more proximally over the fusion block and not at the fracture site.

assessment of the pedicle type and size in each case is essential to prevent any implant-related complications.

Conclusion

In conclusion, unstable traumatic adjacent vertebra fractures among AIS patients who have undergone scoliosis surgery are rare. However, a high index of suspicion should be maintained, especially in patients who sustained high-energy trauma. We reported a novel revision surgical strategy with multipoint anchors (i.e., bilateral pedicle and cortical screws) within a single vertebra and the use of supplementary rods to avoid extension of fusion to L5 with good clinical outcomes.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Informed Consent: Informed consent was obtained from the patient who agreed to take part in the study.

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