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Technical Report

Lag screw fixation of remote bilateral pedicle fractures of the fourth and fifth lumbar vertebrae after a single gunshot wound: a case report and technical pearl

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Abstract

BACKGROUND CONTEXT: Of the injuries involving the lumbar spine, pedicle fractures are among the least common; those involving bilateral pedicles are rare.
PURPOSE: The aims of the study were to provide the first documentation of bilateral pedicle fractures at two consecutive levels after a gunshot, to review the mechanism of injury, and to evaluate a nonfusion treatment option for pedicle fractures.
STUDY DESIGN: This is a technical note and case report.
OUTCOME MEASURE: The outcome measures were lumbar range of motion, return of motor and sensory functions, and return to normal activities.
METHODS: A 20-year-old male sustained bilateral pedicle fractures at L4 and L5 with a massive dural tear, progressive neurologic deficits, and urinary incontinence. He underwent repair of the dural tear and lag screw fixation of the pedicle fractures without fusion.
RESULTS: The patient had full range of motion of his lumbar spine, full strength in his lower extremities, and bladder control.
CONCLUSIONS: This is the first report of bilateral multilevel lumbar pedicle fractures after a single penetrating gunshot wound. The case documents this injury pattern after a gunshot, reviews the mechanism of injury, and presents the successful application of a nonfusion treatment option.

Keywords: Pedicle; Fracture; Spine; Screw; Lumbar

Introduction

The lower lumbar spine is usually well protected from traumatic injury by its strong muscular and ligamentous attachments to the pelvis and axial skeleton. Injuries to this area, therefore, are infrequent and involve the transfer of high amounts of energy. Of the injuries involving the lumbar spine, pedicle fractures are among the least common; those involving bilateral pedicles are rare. One report described multilevel bilateral pedicle fractures in the cervical spine, secondary to a blunt trauma [1]. A second case involved multilevel bilateral pedicle fractures in the lumbar spine because of a high-energy shear injury [2]. To our knowledge, there are no previous reports of bilateral multilevel pedicle fractures in the lumbar spine, secondary to gunshot or other penetrating trauma. We believe that reporting this case is important to provide the first documentation of this injury pattern after a gunshot, to review the mechanism of injury, and to evaluate a nonfusion treatment option for pedicle fractures. Our patient was informed that the data concerning his case would be submitted for publication.

Preoperative assessment

A 20-year-old male was presented to the trauma bay at our hospital after sustaining a gunshot wound, with a chief

FDA device/drug status: approved (Pedicle Screw).

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complaint on presentation of low back pain. Primary survey revealed that the patient was stable from a cardiopulmonary standpoint with a Glasgow Coma Score of 15. On secondary survey, a single bullet wound was discovered in the left lumbosacral region, just proximal and lateral to the gluteal fold. There was no midline bony tenderness or step-off in the lumbar spine. The patient's initial motor examination was deemed Grade 4+ of 5 strength (according to the classification of the American Spinal Injury Association) in all lower-extremity motor groups [3]. Sensation was intact to light touch in all dermatomal distributions, including the perianal and genital regions; normal rectal sphincter tone was present.

Computerized tomography (CT) scan of the lumbar spine showed a bullet lodged within the L4 inferior end plate and disc space of L4–L5 (Fig. 1). The posterior margin of the L5 vertebral body was comminuted with retropulsion of bone and bullet fragments into the central canal from L3 to S1 (Fig. 2). Bony and metallic fragments were also noted to compromise the right L5 lateral recess and neural foramen. A spinous process fracture was noted at the L5 level along with bilateral fractures of the L4 and L5 pedicles and transverse processes. Sagittal plane alignment was maintained with no evidence of anterolisthesis.

The patient was taken to the surgical intensive care unit for frequent neurovascular checks and was maintained on strict logroll precautions. Within the first 24 hours after his injury, the motor and sensory examination of his lower extremities remained unchanged; however, the patient began to complain of progressive numbness in the anal and genital regions. Clinically he demonstrated decreased sensation to light touch and pinprick in the distribution of S1. Given the presence of bullet fragments and fractures in the setting of progressive saddle anesthesia, the decision was made to obtain a CT myelogram to assess both the neural and bony elements. The CT myelogram revealed contrast within the epidural, subdural, and subarachnoid spaces along with details about the previously mentioned fractures. Given concerns of progressive neurologic deficit, the presence of a massive dural tear, and dissociation of the anterior and posterior columns because of the bilateral pedicle fractures, the decision was made to proceed with immediate surgical decompression and fixation of the pedicle fractures.

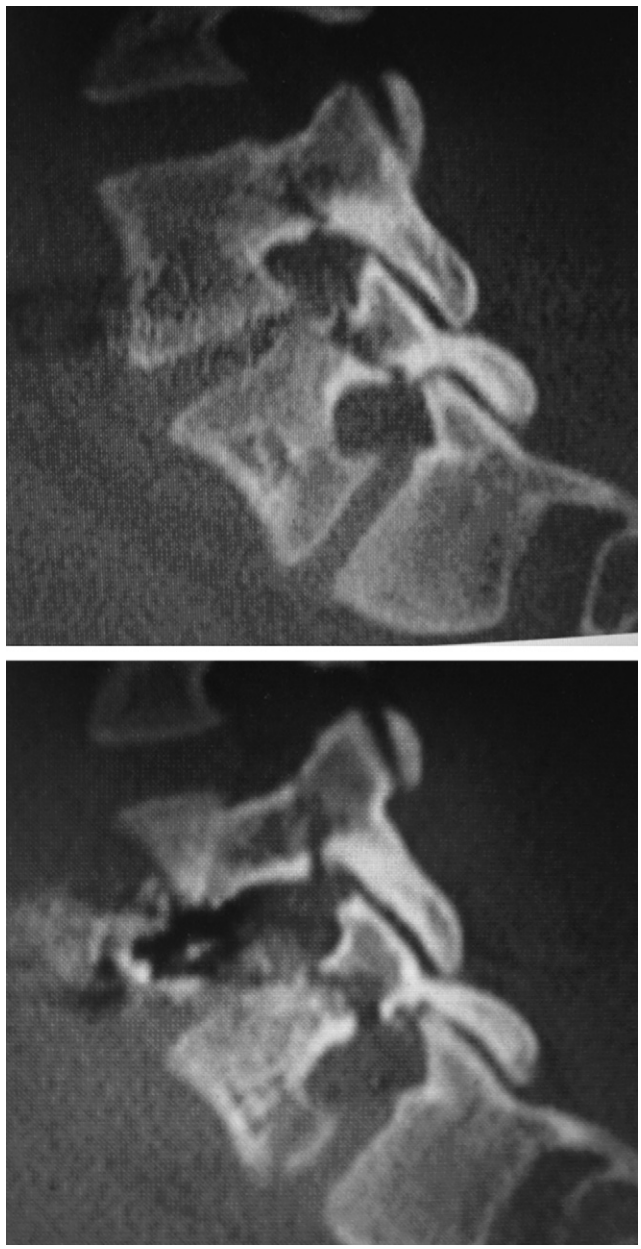

Fig. 1. (Top) A sagittal reconstruction of the lumbar CT scan demonstrating the disrupted left L4 and L5 pedicles. (Bottom) A sagittal reconstruction of the lumbar CT scan demonstrating a right L4 inferior end plate fracture and right L4 and L5 pedicle fractures. CT, computerized tomography.

Technique

After adequate general endotracheal anesthesia, the patient was placed prone on a Jackson Spinal Table (OSI, Union City, CA, USA), and his lumbar spine was exposed. The laminas of L4 and L5 were removed to allow complete decompression and access to the dural tear and bullet. The nerve roots were shredded at the left L5 and S1 levels. A massive dural tear approximately 5 cm in length was also noted extending through the anterior aspect of the dura. The anterior dural repair was accomplished with a DuraGen Dural Graft Matrix (Integra LifeSciences Corporation, Plainsboro, NJ, USA), and the posterior aspect of the tear was repaired primarily with a running 5-0 prolene suture. Monoaxial dual-opening screws (6.2×45 mm) (Synthes Spine, Westchester, PA, USA) were next placed through the L4 and L5 pedicles bilaterally with fluoroscopic confirmation of their positions. The entire length of the pedicle was tapped to 5.2 mm, after which the near cortex only was tapped to 6.2 mm. A 6.2-mm screw was then placed,

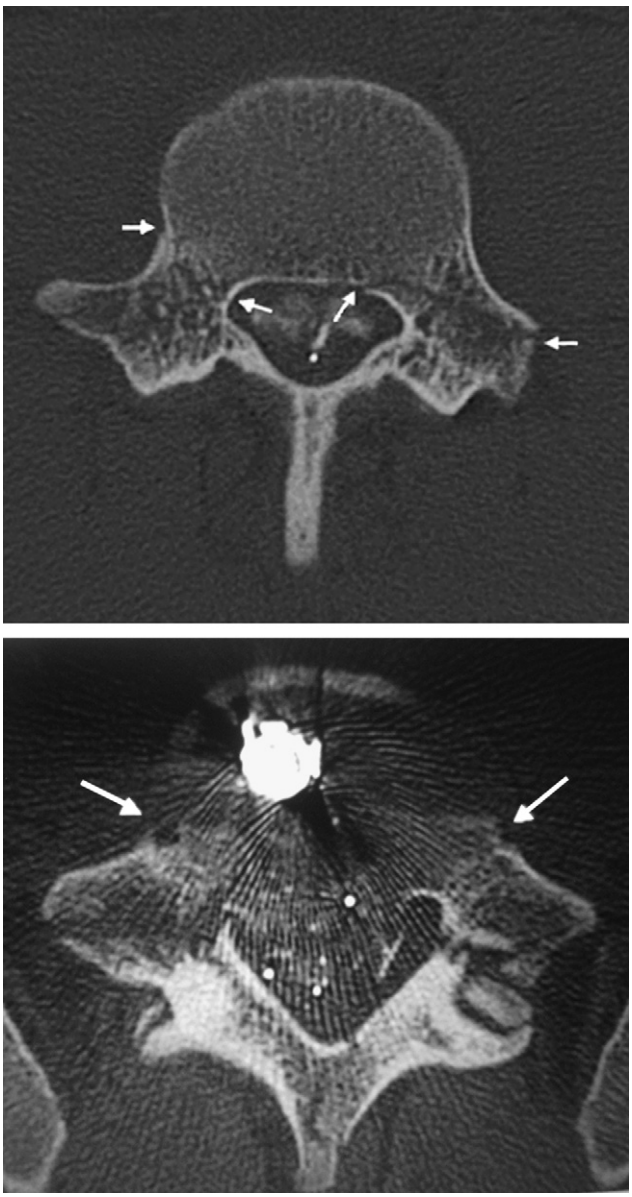

Fig. 2. (Top) An axial CT image demonstrating bilateral pedicle fractures at the L4 level, extending into the left transverse process (small arrows). (Bottom) An axial CT image demonstrating bilateral pedicle fractures at the L5 level (small arrows) with an additional fracture through the right L5 transverse process. The bullet is lodged within the L5 vertebral body, and retropulsed bony fragments are visible within the spinal canal. CT, computerized tomography.

creating a lag across the fracture sites at L4 and L5. Both the L4 and L5 pars interarticularis were explored and confirmed to be intact. There was no evidence of any direct injury to the pedicles.

After fixation of the pedicle fractures, the bullet fragments were carefully removed from the L4 body, spinal canal, and L4–L5 disc space. The dural was gently retracted medially, and Pennfield probes were used to dislodge the bullet under fluoroscopic guidance. Once directly visualized, a Kocher clamp was used to extract the bullet.

Postoperative assessment

After surgery, the patient's postoperative hospital course was uncomplicated. He did not initially experience any resolution of his genital numbness, and remained incontinent of urine, under the care of an urologist. He was maintained in a thoracolumbosacral orthosis for the management of his vertebral body fracture and was discharged 2 weeks after surgery.

At the most recent follow-up, 16 months after the initial injury, the patient had regained sensation in the anal and genital regions with complete resolution of his urinary incontinence. He had returned to his preinjury level of activity and complained only of intermittent Grade 1 of 10 (visual analog scale) low back pain after prolonged sitting. On physical examination, he had asymmetry of the calves with the left slightly more developed than the right, suggestive of atrophy. He had difficulty in toe walking but, otherwise, had no neurologic deficit. Range of motion of the lumbar spine was 90 degrees of flexion to 15 degrees of extension without pain (Fig. 3). Lumbar spine films and CT scan (Fig. 4, top and bottom) performed at this most

Fig. 3. Photograph of the patient at 16 months postoperatively, demonstrating his range of motion (flexion of 85 degrees).

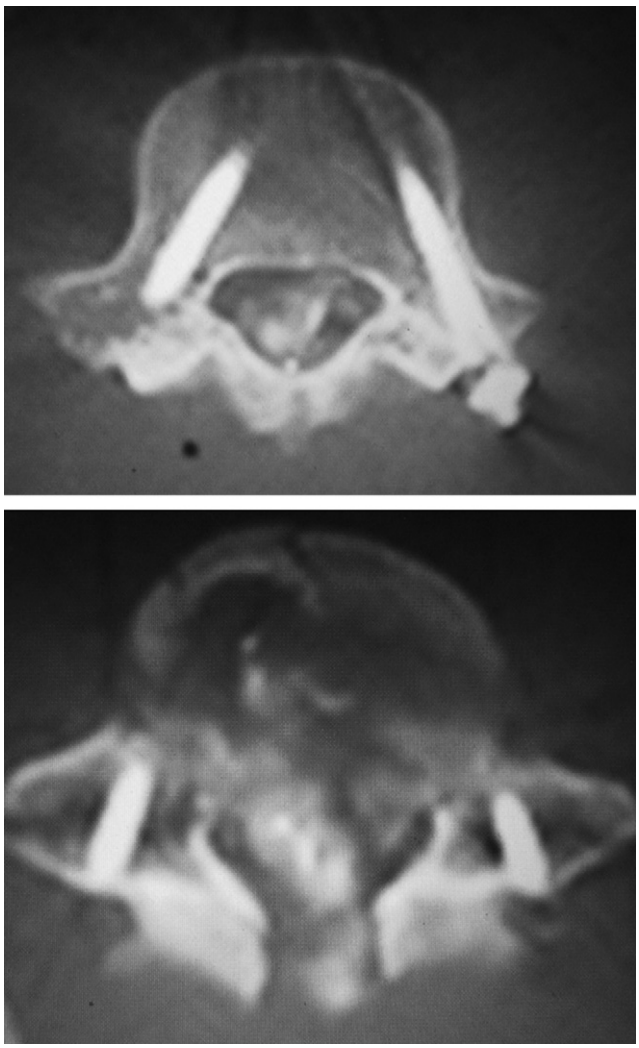

Fig. 4. (Top) Postoperative CT scan showing position of the L4 pedicle screws. (Bottom) Postoperative CT scan showing position of the L5 pedicle screws, decompression of the spinal canal, and removal of the bullet fragments. CT, computerized tomography.

recent visit revealed healed pedicle and vertebral body fractures, normal sagittal alignment on flexion and extension radiographs without listhesis, and well-positioned pedicle screw instrumentation (Fig. 5).

Fig. 5. Sixteen-month postoperative lateral radiograph showing well-positioned instrumentation. There are healed fractures of the L4 and L5 pedicles, along with the L4 and L5 vertebral bodies.

Discussion

The intrinsic strength of the pedicle within the neural arch is based on its relatively short moment arm from the vertebral body [4]. The pedicle, therefore, has a greater ability to resist cyclic shear forces than a structure such as the pars interarticularis [5,6]. To our knowledge, this is the first report of bilateral multilevel lumbar pedicle fractures as a result of a gunshot or other penetrating trauma. The rarity of this injury is likely because of the unusually high–energy mechanism that might be required to produce such a fracture pattern. Previous reports of bilateral pedicle fractures have been stress fractures in young athletes, fractures secondary to total disc replacement, and fractures secondary to posterior instrumentation with fusion [7–10]. One case each of a cervical and lumbar pedicle fracture have also been reported, both secondary to a shear mechanism or blunt trauma [1,2]. In our case, a bullet that lodged within the end plate provided sufficient energy to remotely fracture these relatively strong bony elements, at multiple levels, without any direct impact.

We reviewed the principles of ballistic trauma in an effort to understand the likely mechanism of this patient's unusual fracture pattern. Low-velocity bullet wounds (less than 1,000–2,000 ft/s) are those generally seen in civilian trauma. High-velocity wounds involve significantly more soft-tissue damage and are usually caused by military or hunting weapons [11]. We recognized, however, that although civilian handguns are technically of low velocity, penetrating bullet even from a low-velocity gunshot that delivers all of its energy at the time of impact makes this a high-energy mechanism. However, a penetrating injury that passes through a structure delivers significantly less energy within the body itself. It has been proposed that the terms low and high velocity are somewhat misleading and that a better designation might be low or high *energy* based on the amount of damage to the tissue [12]. Kinetic energy (KE) is directly related to velocity based on the formula $KE = \frac{1}{2} mass \times velocity^2$. The concept of the ''wounding capacity'' of a bullet, however, takes into account more than just the velocity; it is based on the efficiency of energy transfer at the time of impact. An inefficient energy transfer by a high-velocity bullet might cause only minimal tissue damage, whereas the complete release of energy by a low-velocity bullet could cause massive injury [11]. A

penetrating bullet, even from a low-velocity shotgun, delivers all of its contained KE at the time of impact, thus making this a high-energy mechanism. A penetrating bullet injury delivers significantly less KE within the body [11]. In our patient, the bullet was impacted within the L5 vertebral body and L4 inferior end plate; yet he sustained bilateral L4 and L5 pedicle fractures. Once the bullet was lodged within the vertebra, its entire KE was dissipated away from the point of impact, likely causing the associated fractures.

There is sparse, if any, evidence to support the choice of management in traumatic bilateral multilevel pedicle fractures. Without the progressive neurologic deficits in this patient and with the bullet in the disc space, we would have opted to treat this patient in a lumbosacral orthosis with a thigh extension and follow his lead levels clinically [13]. However, with the progressive cauda equine syndrome and bilateral pedicle fractures, the literature suggests several surgical options. These include posterior instrumentation with fusion, combination anterior and posterior fusion, and curettage with bone grafting of the pedicles with the use of posterior lag screws. Fusion, especially combined anterior and posterior fusion, has been suggested because it decreases shear forces across the intervertebral disc that may contribute to delayed healing of the pedicles [7]. In this case, the surgeon (KRC) chose a posterior lag screw method that was technically simple [14] and avoided segmental fusion in this young patient. The lag screw technique has long been used in fracture fixation of the extremities and has even been proposed for the treatment of stress fractures in the spine. The option of fusion, if necessary in the future for this patient, was maintained and can be accomplished with simply placement of two contoured rods.

The bullet was fairly easily retrieved in this case, prompting removal; the decision to remove the bullet was also based on the concern for plumbism in this young patient. Elevated blood levels of lead have been reported in a retrospective series of patients with retained bullet fragments within the intervertebral disc space. The authors of this study concluded that bullets within the disc can be retained, but serum levels should be monitored over the long term [13].

In conclusion, this report of bilateral multilevel lumbar pedicle fractures documents a rare injury pattern after a single penetrating gunshot wound. The case provides an example of the importance of the initial neurologic examination and serial neurologic examinations in the first 24 hours in a trauma patient. This report also documents this injury pattern after a gunshot, reviews the mechanism of injury, and presents the successful application of a nonfusion treatment option to surgeons who may encounter similar injuries in their practices.

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