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Case Report

A Novel Case of Multi-Level Lumbar Spine Injury

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Abstract

Background: Fractures involving several posterior arch elements of lumbar vertebrae are rare and usually associated with high-energy axial loading (e.g., burst fracture) or hyperflexion and distraction (e.g., Chance fracture) resulting in displacement and neurological sequelae. This report explains the mechanical and biomechanical factors and treatment options for a novel fracture pattern involving multi-level posterior arch vertebral fractures and imparts optimism for timely recovery and return to play in high-level athletes.
Case Report: We report a case of a 21-year-old male elite football player with an acute, traumatic two-level lumbar pedicle, pars, and lamina fractures without failure of the vertebral body nor neurological complications. Treatment was conservative with relative rest, movement restrictions, non-narcotic analgesics, and a bone growth stimulator. After four months, the patient was pain-free with corresponding radiographic evidence of healing. He returned to training with special attention given to core strength and lumbopelvic mobility. A computed tomography (CT) scan 2.5 years after the injury showed no evidence of pars, lamina, or pedicle fractures. To date, this patient has played in the National Football League (NFL) as a starter for three years without any complaint of low back pain.
Conclusion: This unique fracture pattern could represent a harbinger to a more severe injury. We discuss mechanical and biomechanical factors, management, and return to play expectations for a collision sport athlete with this particular spine injury.

Keywords: Lumbar Vertebrae; Vertebral Body; Spondylolysis; Return to Sport; Low Back Pain

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Background

Despite the integrity of lumbar vertebrae with normal bone density, these robust structures are still susceptible to injuries involving the posterior arch, usually when influenced by compression forces or excessive flexion coupled with distraction. Hyperextension mechanism fractures usually involve the pars interarticularis with more complex fractures being rare in the young athlete with a mobile spine, and more likely to occur in someone with ankylosing spondylitis.

During trauma resulting in a flexion-distraction mechanism, a Chance fracture involving the posterior elements (pedicle, lamina, spinous process) and posterior aspect of the vertebral body can occur at the thoracolumbar junction. Instability is complicated by disruption of the posterior ligamentous complex. There are reports of thoracolumbar distraction injuries resulting from heavy squats (1).

A burst fracture occurs under high-energy axial loading, resulting in varying degrees of compression of the vertebral body. This is often associated with a complete or incomplete lamina fracture, and/or a pedicle fracture. Burst fractures can occur at any lumbar spine level. Acute lumbar burst fractures have been reported in power lifters (2). Chance and burst fractures usually result in neurological sequelae and often require surgical stabilization or decompression. By comparison, a pars interarticularis injury usually occurs in the lower lumbar spine. These injuries are acquired through repetitive micro-trauma during hyperextension or acute high-energy trauma. If unilateral, the likelihood of healing is much higher (3).

An excessive load event coupled with axial rotation in an individual with normal bone density and excellent core strength may result in pars and lamina fractures without failure of the vertebral body. The same trauma may be catastrophic in a less durable individual, resulting in spinal canal retropulsion.

Albeit extremely rare, there appear to be injury patterns that may represent a level of posterior arch disruption that occurs just prior to failure of the vertebral body and compromise of the vertebral canal. One such case report defined a non-traumatic lumbar pars defect with a contralateral pedicle and lamina fracture in the same vertebra (4). We report the first case of a traumatic two-level injury involving a pars fracture and contralateral lamina fracture in L4 and an adjacent pedicle fracture in L5, in an elite athlete injured during heavy squatting.

This is an excellent opportunity to expand our understanding of the causal biomechanical factors that predispose to posterior arch lumbar spine injury and to educate athletes, optimize movement efficiency, and prevent more ominous outcomes.

Case Report

A 21-year-old male American college football player (defensive lineman) was seen for low back pain. Two months earlier, he developed severe, new-onset low back pain during the concentric phase of an unassisted overhead deep squat with greater than 600 lbs. Radiographs were negative. Despite the injury, he continued to play at a very high level of performance and did not miss any games. He reported some mild temporary relief with oral methylprednisolone during the season and an unspecified corticosteroid injection into the spine at the end of the season. The pain, however,

never resolved. He reaggravated the injury one week prior to our visit while pushing a blocking sled (hyperextension mechanism). The pain escalated and negatively impacted his ability to do sport-related activities and training. At no point did he experience any weakness, numbness, tingling, or pain in the lower extremities.

On examination, there was an area of tenderness with deep palpation localized to the left lower back region at the level of L4 and lateral to the midline. Bilateral lumbar paraspinal muscle tightness was noted. Single leg (left) hyperextension maneuver (Michelis test) was positive. Sacroiliac, hip, and neurological examinations were normal. Lower extremity strength was preserved. Gait and stance were stable, and there was no antalgia during ambulation.

Motion analysis of the lumbar spine and pelvis was performed using wearable biometric sensors (DorsaVi, East Melbourne, Victoria, Australia), including two wireless motion sensors equipped with a triaxial accelerometer, a triaxial gyroscope, and a magnetometer, and two wireless surface electromyography (EMG) sensors.

In a neutral standing position, the patient had a low (i.e., flattened) lumbar lordosis. Not surprisingly, lumbar spine range of motion (ROM) was noticeably impaired. Lumbar flexion was restricted due to trunk immobility rather than pelvic immobility. EMG activity was aberrant as indicated by a poor flexion relaxation response of the erector spinae muscles during flexion. Lumbar extension ROM was also reduced due to trunk immobility, and surface EMG indicated highly overactive paraspinal muscles during lumbar extension. Lateral movement was highly restricted during side-bending to the left compared to normal side-bending range to the right. Pelvic tilt was restricted anteriorly but remained normal posteriorly.

Radiographs of the lumbar spine did not show any signs of osseous pathology. Because there was a high level of clinical suspicion for a pars defect, a computed tomography (CT) scan with three-dimensional (3D) reconstruction was performed and multiple levels of injury were identified. These included an incomplete right L4 lamina fracture without displacement (Figures 1 and 2), incomplete left L4 pars fracture without displacement, and an incomplete right L5 pedicle fracture without displacement (Figures 3 and 4).

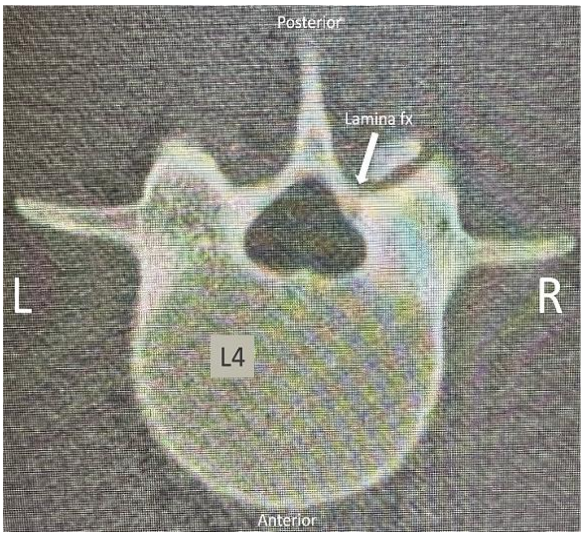

Figure 1. Axial view of L4. Right lamina fracture (arrow)

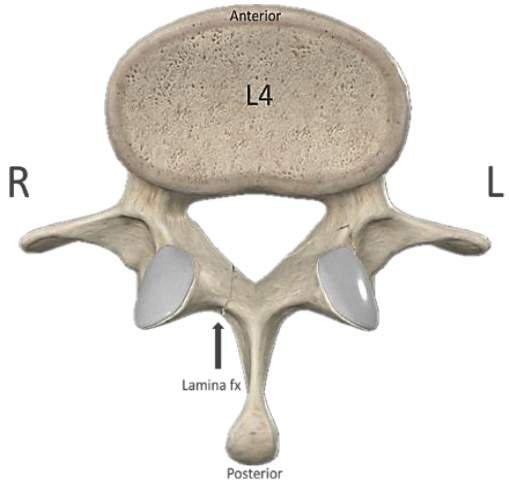

Figure 2. Inferior view of L4 reconstruction. Right lamina fracture (arrow)

Treatment was conservative. Relative rest was strictly enforced. He was restricted from loaded squats, high-impact exercises (e.g., plyometrics or running), or maneuvers requiring lumbar spine extension (e.g., pushing a sled or live blocking drills).

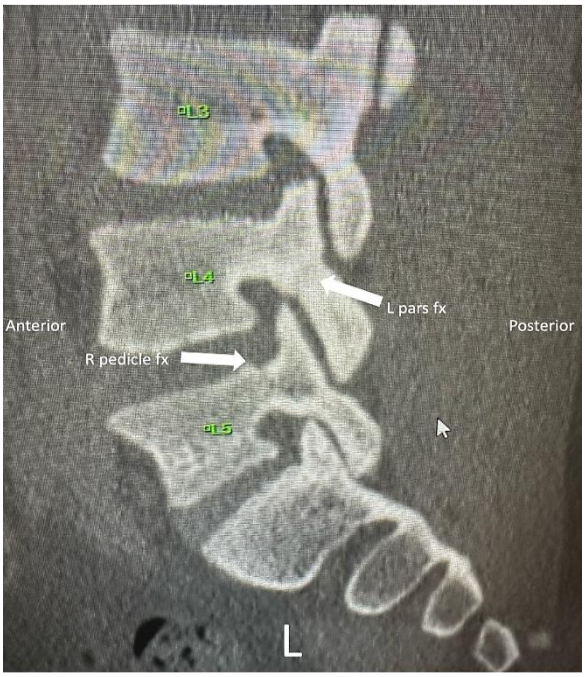

Figure 3. Left sagittal view of L3-L5. Left L4 pars fracture and right L5 pedicle fracture (arrows)

He was allowed to do supervised strength training (i.e., low-weight, high-rep) with rigid lumbar brace support. Aerobic conditioning was done primarily while seated on a stationary bike. Weight management was prioritized, since weight gain would be counter-productive to our return to play goals. He used non-narcotic analgesia and non-steroidal anti-inflammatory drugs (NSAIDs) sparingly. He wore a bone growth stimulator (Orthofix, Lewisville, Texas, USA) using pulsed electromagnetic fields (PEMF) for two hours per day for three months in hopes of augmenting bone healing.

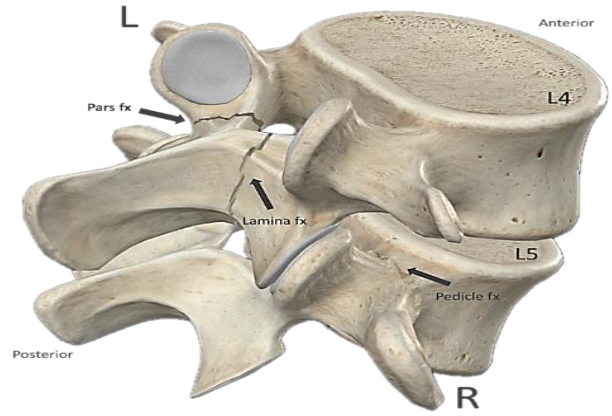

Figure 4. Right oblique view of L4 and L5 reconstruction. Right L4 lamina fracture and left L4 pars fractures. Right L5 pedicle fracture (arrows)

He was monitored daily by his trainer and physical therapist, and was evaluated clinically by the physician on a weekly basis. He had serial CT scans of the lumbar spine at 4-6-week intervals for four months.

After four months of conservatism, the patient was pain-free with corresponding radiographic evidence of healing (left L4 pars fracture was absent, and the right L4 lamina and right L5 pedicle fractures were more subtle). He was cleared to return to training and sport-related activity with restrictions. The only exception was that compound exercises, such as heavy loaded squats, were strongly discouraged, and he was reeducated on proficient squat mechanics. Special attention was then given to core strength and lumbo-pelvic mobility. He was encouraged to play at a lower body weight and to embrace a functional training program rather than rely on heavy strength training.

A CT scan performed 2.5 years after the injury did not show any evidence of the pars, lamina, or pedicle fractures (all imaging was interpreted by the same radiologist for continuity). This confirmed our original suspicion that these had indeed been acute injuries.

To date, this patient has played in the National Football League (NFL) as a starter for three years without any complaint of low back pain.

Discussion

Fractures involving the neural arch of the lumbar vertebrae may be influenced by the degree of force, mechanism of injury, morphometric characteristics and fatigue strength of the different neural arch structures, as well as facet width and orientation.

The pars interarticularis is the most commonly injured neural arch structure. When injured, structural change in the pars appears to alter load distribution and load transfer characteristics. According to multi-scale finite element modeling and adaptive remodeling studies, these new loading patterns can increase vulnerability of contralateral neural arch structures (5). This phenomenon would explain why unilateral pars injuries are often accompanied by contralateral pedicle fractures. Bilateral pars injuries with bilateral pedicle injuries are less common but do occur.

Not surprisingly, isolated pedicle fractures in an unaltered vertebra (i.e., in the absence of a same level pars defect or surgical instrumentation) are rare due to the short moment arm and durability of the pedicle. It has been suggested that such injury could be due to rotational instability (6). Lamina fractures (laminolysis or retroisthmic cleft) are uncommon because the lower edge of the lamina has good mechanical properties and a high modulus of elasticity (7).

There are only a few reports of a pedicle fracture with contralateral lamina fracture, and pars defects with contralateral lamina fractures (8, 9). Two types of lamina fractures have been described: the intralaminar type is considered a stress fracture due to repetitive extension loading, and the hemilaminar type with contralateral spondylolysis is due to loading with axial rotation onto the contralateral pedicle and pars interarticularis, which increases laminar stress (10).

Multiple posterior arch fractures involving pars, pedicle, and lamina are extremely rare. Xie et al. reported multiple posterior arch fractures in a 48-year-old man with chronic low back pain and left leg radiculopathy. This was the first report of a unilateral pars defect (left), and contralateral pedicle and lamina defects within the same vertebrae. This was accompanied by disc herniations at L3/L4 and L4/L5 with entrapment of L4 nerve roots, bilaterally. These injuries were successfully treated surgically (4).

Our case is the first known fracture pattern involving the pars (left L4) and lamina (right L4) at one level and an isolated pedicle fracture at an adjacent level (right L5). Making this even more unusual was that it did not result in damage to the vertebral body nor were there neurological consequences, which is usually the case when these three neural arch elements are damaged during trauma.

Limitations of this study include a lack of generalizability to the broader population, given the unique case of a professional athlete with a rare injury pattern, and an inability to establish causality since the order of occurrence of the three injuries reported is speculative. However, prior case reports and biomechanical studies lead us to conclude that this unique two-level pattern appears to represent a traumatic injury from a single event (i.e., loaded squat), rather than repetitive stress (9, 10). The mechanism was likely a combination of axial loading, a slight rotational component, and hyperextension during the ascending squat. The L4 injuries in our patient are consistent with the hemi-laminar-type laminolysis with contralateral spondylolysis described by Miyagi (9). The sagittal fracture line at the lamina suggests that there was axial loading combined with axial rotation (10). The left L4 pars appears to have been subsequently reaggravated through a hyper-extension mechanism during football activities and was the predominant source of our athlete's pain.

Conclusion

When posterior arch fractures occur due to trauma, the injuries are usually much more severe and require surgical intervention. Multi-level injury is much more likely to result in poor prognosis and a need for surgical intervention compared to single-level injury. The presence of these traumatic posterior arch injuries in the absence of vertebral body or neurological involvement suggests that this could be a precursor to a more severe injury, such as a burst fracture. This case supports optimism for timely recovery and return to play in multi-level neural arch fractures.

It is reassuring that this multi-level injury was able to heal with conservative measures and did not have a negative impact on this athlete's promising career. Perhaps most importantly, this provided an opportunity

to reinforce proper squat mechanics and explore equally effective and safer alternative exercises.

Conflict of Interest

The authors declare no conflict of interest in this study.

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