Enhance your diagnostic skills with this "test yourself" column, which features a radiograph and challenges you to make a diagnosis.

The case:

A 28-year-old man presented to a level 1 trauma center with significant cervical spine pain after sliding into third base during a softball game. He struck his head on the thigh of the defensive player and had immediate pain in his neck and arm. He reported no loss of consciousness, no transient tetraplegia/paraplegia, and no loss of bowel and bladder control. After initial imaging, enhanced computed tomography scans were obtained.

Figure: Axial (A) and sagittal 2-dimensional reconstruction (B) computed tomography scans.

Your diagnosis?

For answer, see next page.

Section Editors: Terrence C. Demos, MD & Laurie M. Lomasney, MD

Diagnosis:
Pedicolaminar Fracture-Dislocation

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Answer to Radiologic Case Study
Case facts appear on previous page.

Pedicolaminar fracture-dislocation is an uncommon injury to the cervical spine.[1,2] This fracture pattern is the result of a hyperextension-rotational force, and the predominant force is rotational.[3] In this injury pattern, there are ipsilateral pedicular and laminar fractures with injury to the facet capsule.[4-6] This produces a free-floating lateral mass, which is an unstable injury. This creates cervical instability at the fracture-separation level as the fracture essentially negates stability contribution from the adjacent facet joint and lateral mass itself. In addition, rotational movement can create instability at more than one level.[7] Neurologic compromise can occur as a result of foraminal injury to the nerve root. A classification system dedicated to lateral mass fracture subtypes was created by Kotani et al[8] and is based on morphology: separation, comminution, split type, and traumatic spondylolysis. Pedicolaminar fracture-dislocations typically require surgical reduction and stabilization. They are challenging to surgically manage, as immobilization of 2 motion segments is required.[9]

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Diagnostic Imaging and Assessment

The American College of Radiology Appropriateness Criteria (ACR-AC) can be used to guide imaging decisions in an acute care setting.[10] These guidelines were developed using expert opinion and clinical data from more than 72,000 patients to provide recommendations on the most appropriate and cost-effective imaging modality for patients with suspected acute cervical spine injury.[11] The ACR recommends no further imaging for stable, alert patients meeting all of the low-risk clinical criteria put forth by either the National Emergency X-Radiography Utilization Study Group or the Canadian C-Spine Rule study group, given the high negative predictive value of these criteria for clinically important injury, the cost of imaging, and the potential for harmful radiation exposure (**Tables 1-2**).[11-13] For patients not meeting these low-risk criteria, the ACR recommends computed tomography (CT) of the cervical spine without contrast, with sagittal and coronal reconstructions.[11] Lateral radiographs are only indicated if CT reconstruction is inadequate.[11] For patients with myelopathic signs or suspected ligamentous injury, magnetic resonance imaging of the cervical spine without contrast is recommended in addition to noncontrast CT, given its superiority in characterizing intramedullary hemorrhage, spinal cord edema, or ligament rupture.[11] If arterial injury is suspected, computed tomography angiogram with contrast (**Figure 1**) or magnetic resonance angiogram with contrast is mandated, in addition to the aforementioned noncontrast CT.[11] Cervical flexion-extension radiographs are not recommended in the acute setting, due to the high prevalence of muscle spasm, which limits cervical range of

motion and thus diminishes the diagnostic yield.[14]

Computed tomography imaging provides better visualization of the fracture and its association with neural elements.[15] The fracture pattern is seen on radiograph as horizontalization of the lateral mass with a mean angulation and mean translation of 4.6 mm and 6.9°, respectively.[6] On CT axial images, a floating lateral mass fracture is characterized by ipsilateral laminar and pedicular fractures. Should the fracture extend into the foramina transversarium, the possibility of vertebral artery injury may occur and CT angiography or magnetic resonance angiography is indicated. Kotani et al[8] found that a lateral mass fracture-dislocation showed high rates of anterior translation ($P<.05$). Kyphosis and segmental translation can occur along with these injury patterns.

The CT scan of this patient showed fractures through the right C5 lamina, pedicle, and posterolateral margin of the body, resulting in a free-floating articular mass. The unilateral interfacetal dislocation resulted in an intact but deviated right vertebral artery. The patient had subjective pain, numbness, and tingling in his right arm and was objectively weak in his right deltoid and biceps with 4±5 strength.

Management

Patients with a neurologic deficit who are not cognitively impaired can undergo closed reduction of unilateral and bilateral facet dislocations. It is performed with tongs, skeletal traction, and mild sedation. Spinal cord function must be monitored. Cotler et al[16] described the closed reduction of cervical spine dislocations with traction up to 100 pounds without any worsening neurological deficits in awake, mildly sedated patients. They recommended avoiding the forced flexion during reduction especially in bilateral facet dislocations, because of severe canal compromise in that position based on cadaver studies. Magnetic resonance imaging should be performed after reduction to evaluate the disko-ligamentous complex.

Operative stabilization techniques vary in the literature. Cervical facet fracture and dislocation stabilization includes posterior spinous process wiring, lateral mass screw-plate fixation, and cervical pedicle screw fixation.[17-21] Surgical options include a stand-alone anterior approach, a stand-alone posterior approach, or a staged anterior/posterior/anterior approach. Lifeso and Colucci,[1] in a dual retrospective and prospective study, found a 45% failure rate with posterior fusion alone (n=32), due to failure of reduction or late kyphosis secondary to anterior disk collapse, and a 100% success rate with early anterior cervical diskectomy and fusion (n=18). Unilateral lateral mass fracture-dislocations typically fail nonsurgical treatment and early single-level anterior arthodesis has a favorable outcome.[22] A survey analysis of the Spine Trauma Study Group showed extreme variations in the choice of approach for unilateral or bilateral facet injury treatment.[23]

Table 1

National Emergency X-Radiography Utilization Study Group Low-Risk Criteria[a]

No posterior midline cervical spine tenderness
No evidence of mental status change or intoxication
Glasgow Coma Scale score of 15
No focal neurologic deficit (on motor or sensory examination)
No distracting injuries

[a]*Data from Hoffman et al.*[12]

Table 2

Canadian C-Spine Low-Risk Criteria[a]

Age <65 years
Glasgow Coma Scale score of 15
No dangerous mechanism of injury (fall from >3 feet, motor vehicle collision >100 km/h, motor vehicle collision with rollover or ejection, diving injury)
No paraesthesias in extremities
Patient is ambulatory with no posterior midline cervical tenderness, or pain onset was delayed after initial injury
Able to actively rotate neck 45° to both the right and the left

[a]*Data from Stiell et al.*[13]

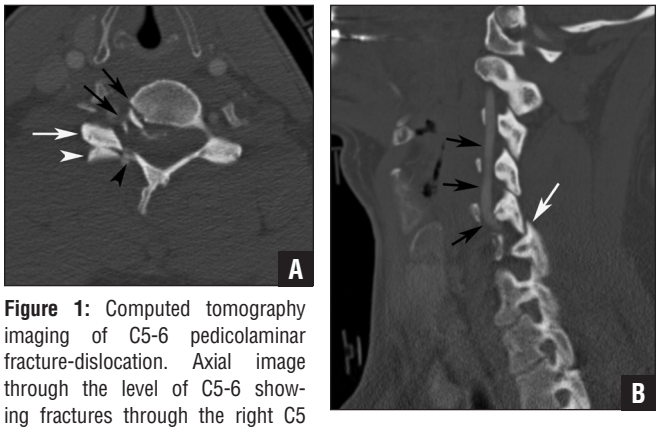

Figure 1: Computed tomography imaging of C5-6 pedicolaminar fracture-dislocation. Axial image through the level of C5-6 showing fractures through the right C5 lamina (black arrowhead), pedicle, and posterolateral margin of the body (black arrows), resulting in a free-floating articular mass. Note the reversed relationship of the inferior C5 (white arrow) and superior C6 (white arrowhead) articular facets due to interfacetal dislocation (A). Sagittal 2-dimensional reconstruction through the right-sided facet joints showing the unilateral interfacetal dislocation (white arrow) and intact but deviated right vertebral artery (black arrows) (B).

In the current case, following physical examination

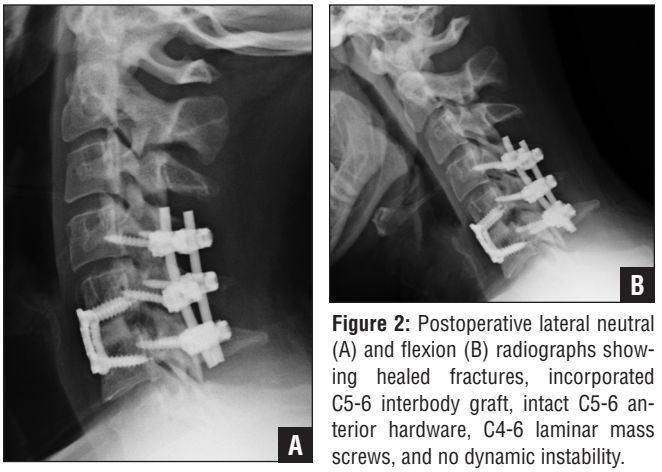

Figure 2: Postoperative lateral neutral (A) and flexion (B) radiographs showing healed fractures, incorporated C5-6 interbody graft, intact C5-6 anterior hardware, C4-6 laminar mass screws, and no dynamic instability.

and radiographic assessment, surgical intervention was chosen. This spinal injury was approached anteriorly, then posteriorly, and finally by anterior fixation. Surgery was performed under spinal cord monitoring. Initially, in 15 pounds of Gardner-Wells traction, diskectomy with corticocancellous allograft interbody placed at C5-6 was performed. The anterior wound was provisionally closed and the patient was placed in the prone position. The posterior approach involved reduction of the right C5 lateral mass and placement of lateral mass screws at C4, C5, and C6 bilaterally. The facet joints of C4-5 and C5-6 were decorticated and filled with allograft. This was followed by wound closure. Next, the patient was returned to the supine position and the anterior incision was reopened for anterior cervical plate placement, bridging the C5-6 disk space. The patient was then extubated and placed in a rigid cervical collar.

The patient returned to the clinic 2 weeks after surgery for a wound check and radiographs. He reported continued dysesthesias in the right arm and was objectively weak in the right upper extremity. The patient had minimal swallowing difficulty and was allowed to remove his collar when in a controlled environment. At the 6-month follow-up, the patient had full strength without dysphagia or dysesthesias in his right upper extremity. Radiographs showed healed fractures, incorporated C5-6 interbody graft, intact hardware, and no dynamic instability (**Figure 2**).

Conclusion

Cervical pedicolaminar fracture-dislocation is an uncommon injury resulting from hyperextension-rotational forces. The CT scan of this patient showed fractures through the right C5 lamina, pedicle, and posterolateral margin of the body (resulting in a free-floating articular mass) as well as unilateral interfacetal dislocation. Contrast administration proved helpful in this preoperative CT, as it demonstrated a deviated right vertebral artery without occlusion and intimal dissection.

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