Lower Cervical Posterior Element Fractures in the National Football League: A Report of 2 Cases and a Review of the Literature

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BACKGROUND AND IMPORTANCE: Injuries in professional football players are common because of the nature of the collisions and the frequency of axial loading to the cervical spine. These injuries should be thoroughly evaluated because they can put the player at risk of future injury and even paralysis. The focus of this report is to present 2 cases of this injury and review the current body of literature.

CLINICAL PRESENTATION: We present 2 cases of professional football players who experienced injuries to the lower posterior elements of their cervical spine simultaneously on a kickoff during a game. Both players described transient symptoms consistent with a "stinger," which is commonly encountered. Workup revealed fractures of the lower cervical spine in both patients. One patient was able to be managed conservatively and returned to football the following season. The second patient had an unstable fracture that ultimately required operative intervention, and the patient retired from professional football.

CONCLUSION: Cervical spine injuries in football players need to be adequately evaluated, and in many cases can be career threatening. We recommend that players with persistent pain after a transient neurapraxia undergo radiography and computed tomography of the cervical spine to evaluate for a fracture.

KEY WORDS: Lower cervical fractures, Professional football

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Injuries to the cervical spine in contact sports require careful attention because of the risk of neurological compromise and permanent damage. Football players are at increased risk of cervical spine injuries because of the high energy of collisions and the frequency of axial loading to the cervical spine. The range of cervical injuries is wide, from mild cervical strains and "stingers" to catastrophic injuries resulting in quadriparesis.

The National Football Head and Neck Injury Registry, established in 1975, has collected data on cervical spine injuries at the high school, college, and professional levels.[1-3] Players with a fracture, subluxation, dislocation, neurological injury, or the need for hospitalization for more than 72 hours or who died were entered into the database. Although the number of catastrophic injuries has decreased over time, the number of cervical spine fractures, dislocations, and subluxations has increased considerably.[3,4]

Transverse process fractures of the cervical spine have often been considered rare and inconsequential. However, it was previously demonstrated that transverse process fractures are common and present in one fourth of all patients with a cervical fracture.[5] Furthermore, 10% of patients had either cervical radiculopathy or brachial plexus palsy. A majority of these fractures extended into the foramen transversarium and caused dissection or occlusion of the vertebral artery. Vertebral artery injury is common in patients with cervical spine trauma occasionally resulting in devastating neurological consequences.[6] Facet fractures, especially unilateral, can be difficult to diagnose with plain radiographs. These injuries can present as persistent axial neck pain, and instability can develop despite immobilization in a halo vest.

We describe 2 lower cervical spine posterior element fractures occurring secondary to axial loading in National Football League (NFL) players

who were engaged in the same play. Both players describe symptoms consistent with a stinger immediately after the injury. To our knowledge, this injury has not yet been described in the literature in this patient population.

CASE 1

In case 1, the player was a 23-year-old, 6-foot 5-inch, 270-pound defensive end in his third NFL season. He had no history of cervical spine problems. On a kickoff in the second quarter of a regular season game, he was the lead blocker. As he hit the wedge, he lowered his head and collided with another player (patient 2). Immediately after the hit, he experienced severe pain in his right shoulder with a transient period of numbness and tingling extending into his hand. He also experienced a brief period that he describes as "blacking out." He was taken out of the game and evaluated. On physical examination immediately after the injury, he had asymmetry of his trapezius, with tenderness and spasm in the right. There was pain with range of motion in his neck. He had pain and difficulty with shoulder abduction and elevation. There was no motor weakness or sensory loss. He had no difficulties with vision, hearing, or balance. He was taken for radiographs in the stadium, which were negative for fracture or subluxation. He was given pain medication, a sling, and a soft neck brace.

The following day he was seen in a hospital setting. He localized his pain to the right side of the base of his neck and described no neurological symptoms. A secondary examination localized tenderness to his right lower cervical spine. He had no weakness in his shoulder girdle and no neurological findings. He continued to have difficulty with shoulder elevation secondary to pain.

Magnetic resonance (MR) imaging was performed that demonstrated fluid within the interscalene musculature on the right side, suggesting a partial tear (Figure 1). There was no evidence of nerve compression or nerve root avulsion. MR imaging was unable to determine whether there were any subtle fractures, so a computed tomography (CT) scan of the neck was performed. CT demonstrated a fracture of the transverse process of C7, extending into the foramen transversarium (Figures 2 and 3). Magnetic resonance angiography was performed, showing no evidence of vertebral artery occlusion or intimal tear (Figure 4). The athlete was placed in a soft collar and treated symptomatically. He was placed on the injured reserve list after diagnosis of the fracture. His injury healed uneventfully, and he regained full range of motion of his cervical spine without any neurological sequelae. He was medically cleared and returned to professional football the following year but was cut from a second team before the season ended. He subsequently retired from football.

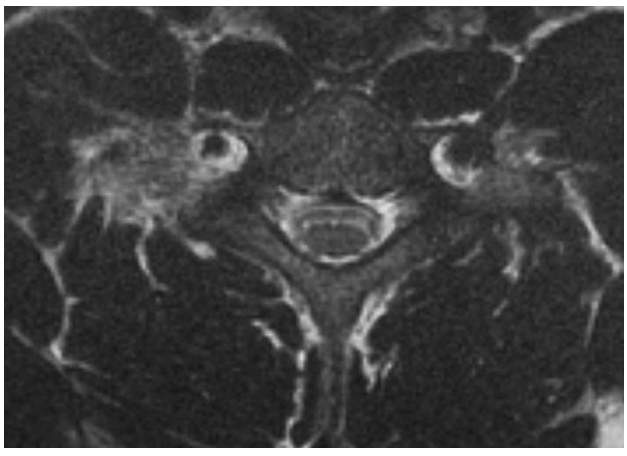

FIGURE 1. *Axial T2-weighted magnetic resonance imaging at the C7 level depicting edema around the transverse process on the right.*

CASE 2

In case 2, the player was a 24-year-old, 6-foot 2-inch, 311-pound guard in his second NFL season. After the collision, he experienced pain in his left upper extremity, consistent with a stinger. He reported numbness in his left upper extremity but was able to leave the field under his own power. On the sidelines, he began to develop increased muscle spasm on the left side, particularly in the trapezius muscle. The numbness improved; however, he continued to have moderate cervical pain that radiated to his posterior thoracic region. He had no pain laterally to the shoulder.

A physical examination revealed decreased neck range of motion secondary to pain and tenderness in the mid-posterior cervical region. The patient had trace reflexes of the biceps, triceps, and brachioradialis. They were symmetrical in the contralateral upper extremity and decreased compared with the lower extremity. There was no clonus or other long-tract signs. Upper extremity strength was 5/5 in all major muscle groups and symmetrical bilaterally. Sensation was intact to light touch in all extremities.

Radiography and a CT scan of the cervical spine were performed, and a fracture was identified. Specifically, the patient had a facet fracture of C6-7 on the left side that involved the posterior half of the C6 facet. At this point, an Aspen collar was placed. The left C6-7 facet joint had, in fact, jumped with widening of the fracture through the facet joint (Figures 5 and 6). The left inferior facet of C6 was located anterior to the left superior facet of C7. MR angiography results were negative for damage to the vertebral artery or intimal tear.

The findings detailed were consistent with a unilateral C6-7 fracture dislocation, an unstable cervical injury. A consultation by several orthopedic spine surgeons was obtained, and surgery was recommended to reduce the dislocation and fuse the C6-7 level. A standard posterior cervical approach was used and posterior cervical arthrodesis at C6-7 was performed. The facet joints were decorticated with a Midas rex. Under fluoroscopic guidance, a lateral mass screw at the C6 level and a pedicle screw at the C7 level were placed on the right side. A rod was used to connect

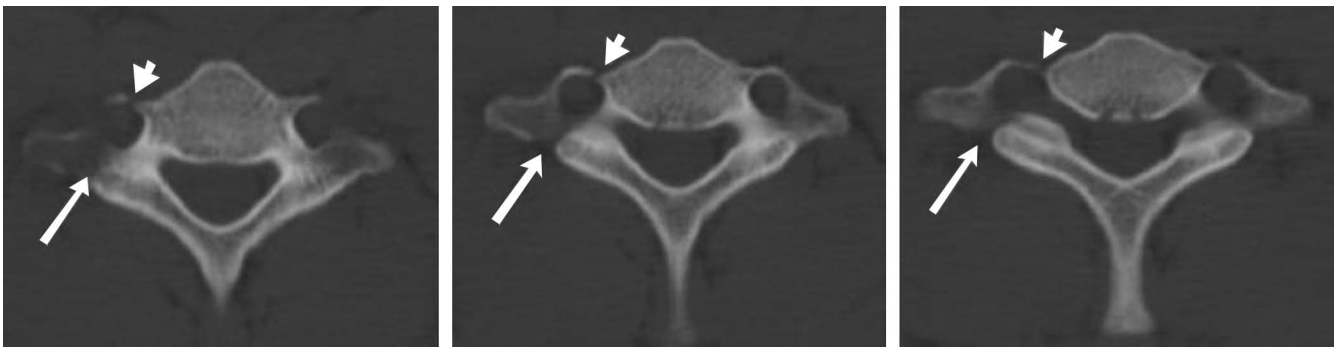

FIGURE 2. *Fine computed tomography sequential axial cuts through C7 demonstrate the minimally displaced fracture through the transverse process on the right (arrow), extending into the foramen transversarium (arrowhead).*

these 2 screws. This area was then packed with cancellous bone graft. On the left side, 2 cerclage wires were used in the spinous processes at the aforementioned levels. These were used to secure 2 full-thickness, contoured allograft struts to the posterior cervical spine (Figures 7 and 8).

The patient was placed in a collar. His postoperative course was uneventful. He had no neurological sequelae. Postoperatively, he regained his range of motion. One year postoperatively he underwent another CT scan that revealed a solid fusion mass at the C6-7 level. His return to play was not advised because of the cervical spine injury. The concomitant injury to the C6-7 facet placed him at an increased risk of further injury, particularly if he were to sustain another axial load to his cervical spine. Per the medical recommendation, the patient retired from professional football.

DISCUSSION

An estimated 1.2 million athletes play high school football annually, with an additional 200 000 college and professional players. Cervical spine injuries are common, occurring in 10% to 15% of athletes at each level.[2,7] These injuries are usually self-limited, although some studies have found that football players with a previous neck injury have persistent abnormalities on radiographs.[7] Cervical spine fractures represent a small percentage of these injuries, but can lead to a grave prognosis. Because of the proximity of critical surrounding structures including the vertebral arteries and the spinal cord, even small fractures in the contact athlete must be managed carefully.

The transverse processes in the lower cervical spine originate from the pedicle and extend laterally, with the foramen transversarium located between the pedicle and transverse process, slightly on the anterior side. The transverse process has 3 parts: the posterior tubercle, costotransverse bar, and anterior tubercle. The transverse processes increase in size inferiorly, with C7 significantly larger than the more cephalad processes. The vertebral arteries branch from the subclavian artery in the neck and enter the foramen transversarium at C6 in a majority of cases. However, 1% of patients will have the artery enter at the C7 foramen transversarium.[8] The artery proceeds cephalad through the foramen tranversarium to the atlas, where it forms the posterior aspect of the circle of Willis. Symptoms of vertebral artery occlusion include a severe occipital headache, posterior neck pain, and neurological symptoms attributable to dysfunction of the lateral medulla (Wallenberg syndrome). These symptoms include ipsilateral facial pain and numbness (most common), dysarthria, hoarseness, ipsilateral limb or trunk numbness, vertigo, nausea, vomiting, diplopia, and disequilibrium. Vertebral artery injury is relatively common in cervical trauma, identified in 46% of patients with mid-cervical spine fracture or subluxations in 1 study.[9]

Injuries to the transverse processes are often considered insignificant findings. Most of these injuries are from high-energy

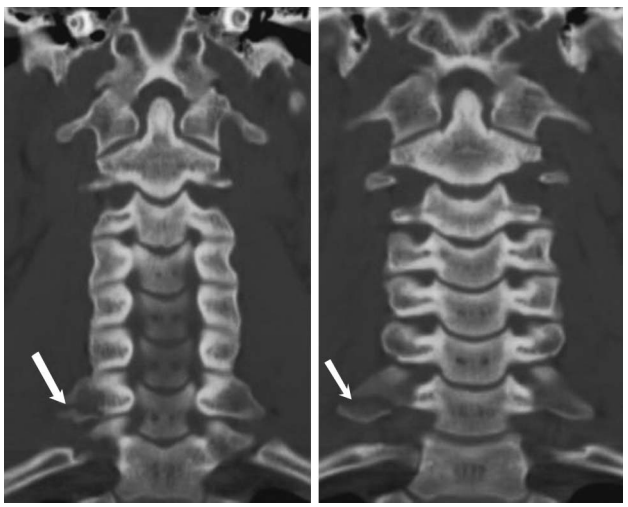

FIGURE 3. *Sequential coronal reconstructions of a computed tomography scan clearly demonstrating right C7 transverse process fracture (arrow).*

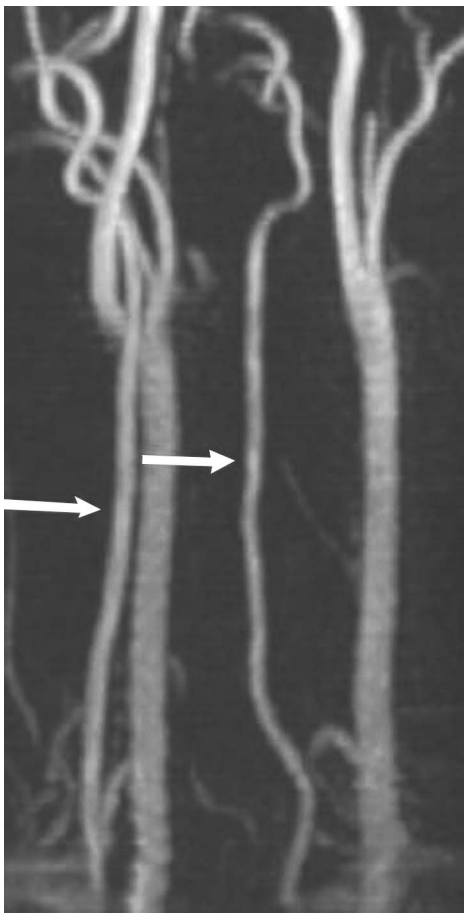

FIGURE 4. *Magnetic resonance angiography demonstrating patent vertebral arteries (arrows) after C7 transverse process fracture.*

FIGURE 5. *Sagittal computed tomography of a coronal fracture of the C6 facet (arrow points to fracture).*

blunt force trauma such as motor vehicle accidents. Tewes et al[10] reported on 29 lumbar transverse process fractures in NFL players. Seventeen of 29 occurred by direct impact, and another 8 were secondary to an unspecified impact. The average time lost was 3.5 weeks, and only 1 player had an associated injury, a kidney contusion that resolved. No players had nerve root symptoms. However, cervical transverse process fractures may not be as benign. Woodring et al[5] reviewed 216 patients with cervical fractures and found that 24% had transverse process fractures. Ten percent of these patients had cervical radiculopathy or brachial plexus palsies. CT scans demonstrated that 78% of the transverse process fractures extended into the transverse foramen. Most importantly, dissection or occlusion of the vertebral artery was demonstrated in 7 of 8 patients (88%) who underwent angiography, with 2 patients having vertebrobasilar artery strokes. Although fractures of the foramen transversarium in themselves are not predictive of vertebral artery injury, comminuted fractures of the foramen transversarium do have a high incidence of vertebral artery injury.[9] Thus, although lumbar transverse process fractures may indeed be benign, cervical transverse process fractures must be treated with caution, and associated injury to the vertebral artery should be ruled out with either CT or MR angiography.

Similar to transverse process fractures, facet fracture in the subaxial cervical spine can be difficult to diagnose by radiographs and can represent more unstable injury than appreciated. The mechanism of injury is one of hyperextension and rotation of the cervical spine, with injury to the ligamentous structures as well.[11] Numerous studies have reported on the difficulty of plain radiographs in the diagnosis of cervical spine facet fractures.[12,13] CT with multiplanar reconstructions best establishes the diagnosis and fracture pattern.[11] MR imaging is beneficial in identifying the ligamentous injury as well as any disc herniations and can be predictive of instability.[11,14]

The initial management of unilateral facet fractures is usually in a halo vest or hard collar. However, patients with subluxation on the initial studies treated in a halo vest have been shown to have a high failure rate. Halliday et al[14] demonstrated that the subluxations seen in their study usually occurred during a trial of nonoperative management, not at the original time of injury.

FIGURE 6. *Computed tomography 3-dimensional reconstruction of a C6 facet fracture with dislocation of the C6-7 facet joint (arrow).*

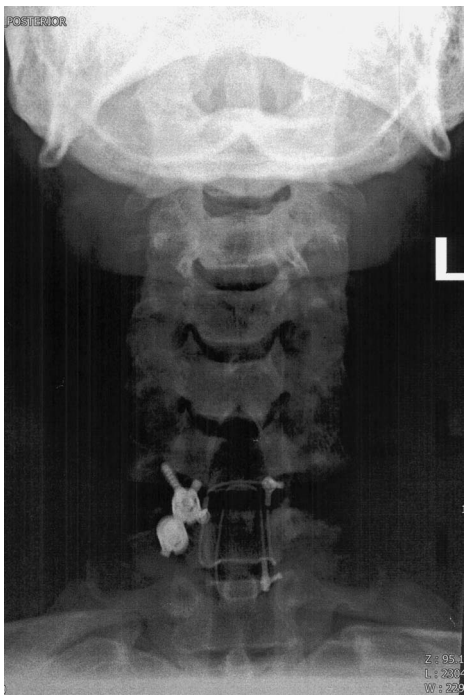

FIGURE 7. *Anteroposterior radiograph of the cervical spine postoperatively with hardware in place.*

They determined that injury of 3 of the cervical ligaments (facet region, interspinous ligament, anterior longitudinal ligament, or posterior longitudinal ligament) represented an unstable injury, and operative management may be indicated. Willis et al[9] demonstrated vertebral artery injury in 46% of patients with a mid-cervical spine facet fracture with subluxation. Thus, athletes with persistent neck pain or any neurological symptoms after a contact injury must be evaluated carefully for posterior column injuries to the cervical spine because these injuries may lead to significant morbidity if not treated appropriately.

Neurapraxia of the brachial plexus, termed stingers or burners, are an extremely common football injury.[15] Athletes describe a feeling of stinging or burning in the shoulder, often extending down 1 hand. Symptoms of unilateral muscle paresis are common as well. Bilateral symptoms are more concerning because they suggest cervical cord injury. The mechanism of injury is usually a compression or traction injuries to the upper roots of the brachial plexus. With the traction injury, the upper roots are tensioned when a sudden downward force is applied to the shoulder girdle. Contralateral tilting of the head will increase the tension on the nerve roots, and head rotation toward the affected arm will narrow the foramen. Compression injuries have been found to be more common in football.[16] Associated injuries, especially in the athlete, are rare, because stingers are often considered transient episodes with return to play once the symptoms resolve. To our knowledge, there have been no reports of transverse process fractures and

FIGURE 8. *Lateral postoperative radiography confirming alignment of the cervical spine.*

brachial plexopathies, especially in football players. These cases suggest that it may be more common than previously appreciated, and because of the risk of injury to the vertebral artery, further imaging may be warranted in selected symptomatic athletes with brachial plexopathy and pain.

These cases also highlight the difficulty of imaging lower cervical spine trauma with conventional radiographs. In both cases, plain radiographs obtained at the stadium did not clearly demonstrate a fracture. Radiographs of the cervical spine to evaluate for fractures have long been the standard initial study, but considerable controversy exists on how best to evaluate patients with possible cervical spine injury. Besman et al[17] examined 936 trauma patients, 58 of whom had cervical spine injuries. They found that 3 views of the cervical spine yielded a sensitivity of 90.3% and a specificity of 96%. There were 3 false negatives in the study. They concluded that plain radiographs of the cervical spine were a highly sensitive and specific study for cervical spine fractures. In contrast, Gale et al[18] found that only 31% of cervical spine fractures seen on CT were detected on plain radiographs, suggesting that CT is much more accurate, if not more specific, than conventional radiographs in detecting cervical spine fractures.

Another recent study compared the accuracy of CT of the cervical spine with that of conventional radiographs in the trauma setting to detect fractures.[19] CT had a sensitivity of 98% and specificity of 99%, and there were no missed fractures. A lateral cervical spine radiograph alone only had a sensitivity of 53%. Finally, a meta-analysis was performed that concluded that although CT outperform plain radiography as a screening for patients at high risk of cervical spine injury, there is not sufficient evidence that CT should supplant conventional radiography in less injured patients.[20]

CONCLUSION

Fractures of the posterior column of the subaxial cervical spine are likely more common than previously reported. We report 2 cases of lower cervical posterior column fractures that occurred on a single play in the NFL. Both players described transient symptoms consistent with a stinger, an injury that is often considered benign and self-limited. In athletes with significant pain and cervical tenderness after an episode of brachial neurapraxia, a fracture of the posterior cervical spine should be considered.

It is our recommendation that players with persistent pain after a transient neurapraxia undergo radiography and CT of the cervical spine to evaluate for a fracture. If a transverse process or facet fracture is detected, MR or CT angiography should be performed to rule out injury to the vertebral artery because this injury can have grave consequences. Athletes with facet fractures should be followed closed in the postinjury period for the development of instability because this would warrant operative management.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, and devices described in this article.

REFERENCES

1. Torg JS, Quedenfeld TC, Burstein A, Spealman A, Nichols C III. National football head and neck injury registry: report on cervical quadriplegia, 1971 to 1975. *Am J Sports Med*. 1979;7(2):127-132.
2. Torg JS, Truex R Jr, Quedenfeld TC, Burstein A, Spealman A, Nichols C III. The National Football Head and Neck Injury Registry. Report and conclusions 1978. *JAMA*. 1979;241(14):1477-1479.
3. Torg JS, Vegso JJ, Sennett B. The National Football Head and Neck Injury Registry: 14-year report on cervical quadriplegia (1971-1984). *Clin Sports Med*. 1987;6(1):61-72.
4. Cantu RC, Mueller FO. Catastrophic football injuries: 1977-1998. *Neurosurgery*. 2000;47(3):673-675; discussion 675-677.
5. Woodring JH, Lee C, Duncan V. Transverse process fractures of the cervical vertebrae: are they insignificant? *J Trauma*. 1993;34(6):797-802.
6. Schwarz N, Buchinger W, Gaudernak T, Russe F, Zechner W. Injuries to the cervical spine causing vertebral artery trauma: case reports. *J Trauma*. 1991;31(1):127-133.
7. Albright JP, Moses JM, Feldick HG, Dolan KD, Burmeister LF. Nonfatal cervical spine injuries in interscholastic football. *JAMA*. 1976;236(11):1243-1245.
8. Bruneau M, Cornelius JF, Marneffe V, Triffaux M, George B. Anatomical variations of the V2 segment of the vertebral artery. *Neurosurgery*. 2006;59(1 Suppl 1):ONS20-ONS24; discussion ONS20-ONS24.
9. Willis BK, Greiner F, Orrison WW, Benzel EC. The incidence of vertebral artery injury after midcervical spine fracture or subluxation. *Neurosurgery*. 1994; 34(3):435-441; discussion 441-442.
10. Tewes DP, Fischer DA, Quick DC, Zamberletti F, Powell J. Lumbar transverse process fractures in professional football players. *Am J Sports Med*. 1995;23(4):507-509.
11. Harris JH, Mirvis SE. *The Radiology of Acute Cervical Spine Trauma*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins; 1996.
12. Smith GR, Beckly DE, Abel MS. Articular mass fracture: a neglected cause of post-traumatic neck pain? *Clin Radiol*. 1976;27(3):335-340.
13. Woodring JH, Lee C. Limitations of cervical radiography in the evaluation of acute cervical trauma. *J Trauma*. 1993;34(1):32-39.
14. Halliday AL, Henderson BR, Hart BL, Benzel EC. The management of unilateral lateral mass/facet fractures of the subaxial cervical spine: the use of magnetic resonance imaging to predict instability. *Spine (Phila Pa 1976)*. 1997; 22(22):2614-2621.
15. Robertson WC Jr, Eichman PL, Clancy WG. Upper trunk brachial plexopathy in football players. *JAMA*. 1979;241(14):1480-1482.
16. Markey KL, Di Benedetto M, Curl WW. Upper trunk brachial plexopathy. The stinger syndrome. *Am J Sports Med*. 1993;21(5):650-655.
17. Besman A, Kaban J, Jacobs L, Jacobs LM. False-negative plain cervical spine x-rays in blunt trauma. *Am Surg*. 2003;69(11):1010-1014.
18. Gale SC, Gracias VH, Reilly PM, Schwab CW. The inefficiency of plain radiography to evaluate the cervical spine after blunt trauma. *J Trauma*. 2005; 59(5):1121-1125.
19. Brohi K, Healy M, Fotheringham T, et al. Helical computed tomographic scanning for the evaluation of the cervical spine in the unconscious, intubated trauma patient. *J Trauma*. 2005;58(5):897-901.
20. Holmes JF, Akkinepalli R. Computed tomography versus plain radiography to screen for cervical spine injury: a meta-analysis. *J Trauma*. 2005;58(5):902-905.

COMMENTS

In this article, the authors present a report of 2 professional football players who experienced lower cervical posterior element fractures during play. Both exhibited transient neurological symptoms. Both patients underwent computed tomography scanning for persistent pain. One fracture was not shown on plain radiographs, whereas the other required surgical treatment. Both patients experienced an excellent

neurological outcome. The authors appropriately recommend an aggressive radiographic workup in this scenario.

Anyone acquainted with professional sports, particularly professional football, is familiar with the trend toward bigger, faster, and stronger athletes. Although equipment and the rules of play have been continually updated to lessen the incidence of catastrophic injury, the bar is set ever higher. It is therefore not surprising that these types of injuries still occur. As illustrated by the cases in this report, a high index of suspicion in the setting of persistent symptoms is prudent and may prevent tragedy.

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The authors summarize the cases of 2 professional athletes who experienced persistent symptoms after transient neurapraxia. They bring attention to 2 points that should be kept in mind in the management of athletes subjected to "stingers." (1) In the athletes with persistent symptoms, plain radiographs and even magnetic resonance imaging may be inadequate to demonstrate skeletal abnormalities. Computed tomography with reconstruction techniques is the gold standard. (2) There are increasing reports in the medical literature of the occurrence of vertebral artery dissection. This is more common with fractures that may extend into the transverse foramen but, as we recently reported, can occur from forceful turning of the head, even in golf.[1]

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1. Maroon JC, Gardner P, Abla AA, El-Kadi H, Bost J. "Golfer's stroke": golf-induced stroke from vertebral artery dissection. *Surg Neurol.* 2007;67:163-168.