AJNR

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AJNR Am J Neuroradiol 1986, 7 (1) 135-140
http://www.ajnr.org/content/7/1/135

Hyperextension Dislocation of the Cervical Spine

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The purpose of this report is to describe hyperextension dislocation of the cervical spine and to illustrate its often subtle radiographic features. An analysis of the lateral cervical spine radiographs in 20 patients with hyperextension dislocation of the cervical spine revealed the combination of diffuse prevertebral soft-tissue widening together with *normally* aligned cervical vertebrae in all patients with this injury. In six (30%) of 20 patients, this combination of findings was the only radiographic sign. The precise level of dislocation was indicated by a thin, transversely oriented avulsion fracture fragment arising from the anterior aspect of the inferior end-plate of the dislocated vertebra in 13 (65%) of 20 patients, by a vacuum defect in the intervertebral disk subjacent to the dislocated vertebra in three (15%), by a widened intervertebral disk space in three (15%), and by comminuted fracture of the spinous process in one (5%). Clinically, all 20 patients had facial trauma and all had some manifestation of the acute central cervical spinal cord syndrome.

Hyperextension dislocation is a specific type of acute cervical spine injury that is frequently not recognized radiographically. The radiographic signs have been described as diverse [1–3] and subtle [4–6]. The diagnosis is usually established by the presence of an acute central cervical spinal cord syndrome in a patient who has sustained facial or craniofacial trauma and in whom the cervical vertebrae are normally aligned in the lateral projection [3, 5, 7, 8].

While many authors have described various radiographic signs of hyperextension "injuries" [2, 8–15], a review of the literature revealed no single comprehensive description of the radiographic signs of the specific injury, hyperextension dislocation.

The purpose of our report, therefore, is to present the results of an analysis of the lateral cervical radiographs in 20 patients with hyperextension dislocation and to describe the pathologic features of this injury on the basis of autopsy and experimental studies reported in the literature.

Materials and Methods

The initial lateral radiographs of the cervical spine in 20 patients with the diagnosis of hyperextension dislocation seen at the Hermann Hospital since 1980 were analyzed for the presence of signs ascribed to hyperextension dislocation, namely, the alignment of the cervical vertebrae, prevertebral soft-tissue swelling, avulsion fracture of the anterior aspect of the inferior end-plate of the dislocated vertebra, widened intervertebral disk space, vacuum disk, and fracture of the lamina or spinous process. The diagnosis of hyperextension dislocation was based on historic, clinical, and radiographic findings.

The lateral cervical spine radiographs included in this study were obtained with a horizontal beam and target-film distance (TFD) of 40–72 inches (1.0–1.8 m). Because the TFD was not recorded for each examination, the shortest TFD was assumed in all patients to allow for the maximum magnification effect on the prevertebral soft tissues and to provide a basis for comparison with the normal prevertebral soft-tissue width of 5 mm at 60 inches (1.5 m), as

This article appears in the January/February 1986 issue of *AJNR* and the April 1986 issue of *AJR*.

Received December 3, 1984; accepted after revision June 20, 1985.

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***AJNR* 7:135–140, January/February 1986**
0195-6108/86/0701-0135

established by Weir [11]. The magnification factor at 40 inches (1.0 m) is 1.4. Therefore, in adults, a prevertebral soft-tissue width of 7 mm on a lateral cervical spine radiograph obtained at a TFD of 40 inches (1.0 m) is equivalent to a 5-mm width obtained with a TFD of 60 inches (1.5 m).

The clinical data pertaining to each patient were reviewed for age, gender, etiology of trauma, neurologic findings, and associated injuries. Fifteen of the patients were male and five were female. They were 7–60 years old (mean, 31). All patients, except one who sustained multiple trauma in a construction accident, were injured in high-velocity impact accidents.

Results

Review of the radiographs of the 20 patients in this study revealed several radiographic signs that reflect the various pathologic components of the injury. The constant finding in all 20 patients was the combination of diffuse prevertebral soft-tissue swelling and normally aligned cervical vertebrae. The actual prevertebral soft tissues in all patients included in this study at the anterior inferior margin of C3 measured 9–19 mm (mean, 13.5 mm).

The second most common finding, present in 13 (65%) of the patients, was a thin fracture fragment with a horizontal dimension greater than its vertical dimension that arose from the anterior aspect of the inferior end-plate of the involved vertebra. Increased height of the involved disk space and vacuum disk were each present in three (15%) of the patients. Each is evidence of disruption of the intervertebral disk [9, 16]. A fracture of the spinous process was present in one (5%) of the patients. Transverse fractures of the vertebral bodies have been described in association with hyperextension injury [5], but none was present in our series.

All patients had signs and symptoms of acute central cervical spinal cord syndrome. At the time of admission, eight patients had flaccid paralysis of the upper extremities only, and one had progressive sensory loss in the upper extremities. All patients had evidence of facial trauma. Two had fractures of the mandible, one had a craniofacial fracture, and one had a depressed fracture of the frontal bone.

Discussion

Hyperextension dislocation of the cervical spine was first defined pathologically by Taylor and Blackwood [8] in 1948. Their patient had an acute injury of the cervical spine "in which damage to the cervical part of the spinal cord appears without radiographic evidence of vertebral injury or displacement." Autopsy of this patient "revealed that the anterior longitudinal ligament was ruptured between the sixth and seventh cervical vertebrae, the column had been torn through by detachment of the intervertebral disc from the lower surface of the sixth vertebral body. The upper segment of the column, carrying with it the intact posterior longitudinal ligament, could be displaced backwards on the lower segment with great ease, the disk remaining attached to the upper surface of the seventh vertebra and the posterior longitudinal ligament being lifted from its posterior surface." In discussing this patient, Taylor and Blackwood stated that "a backward thrust applied through the head does cause dorsal dislocation or fracture at the lower levels of the cervical spine" and that injury causing the syndrome of a paraplegic patient with normally aligned, intact cervical vertebrae is "extension dislocation with immediate spontaneous reduction."

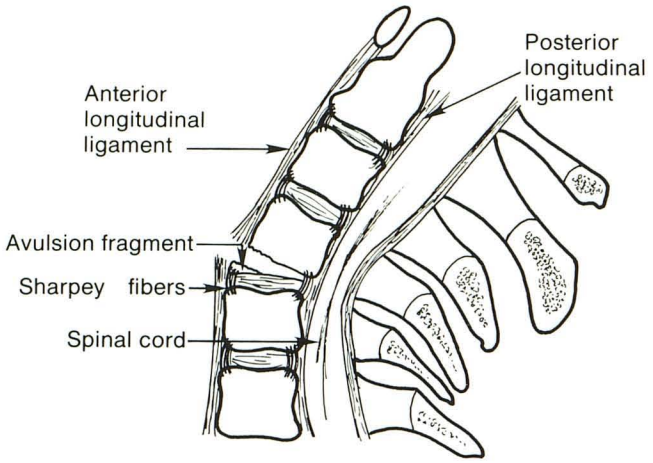


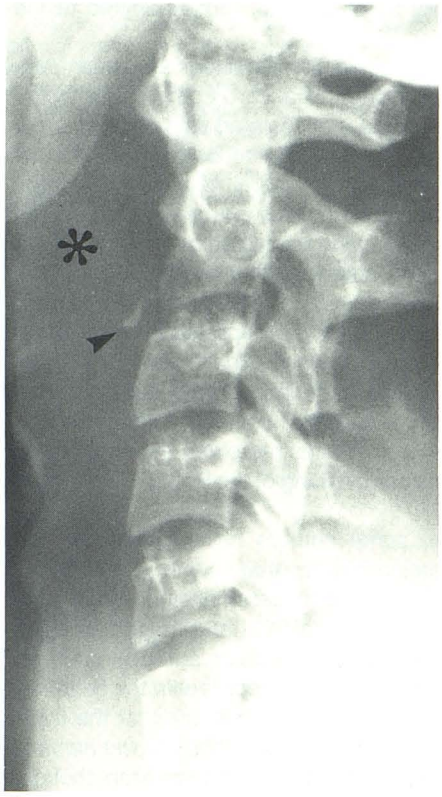
Fig. 1.—Schematic representation of pathophysiology of cervical spine and soft tissues during hyperextension dislocation.

The pathology of hyperextension dislocation described by Taylor and Blackwood [8] and subsequently by Marar [5] has been produced in anesthetized monkeys [17–19].

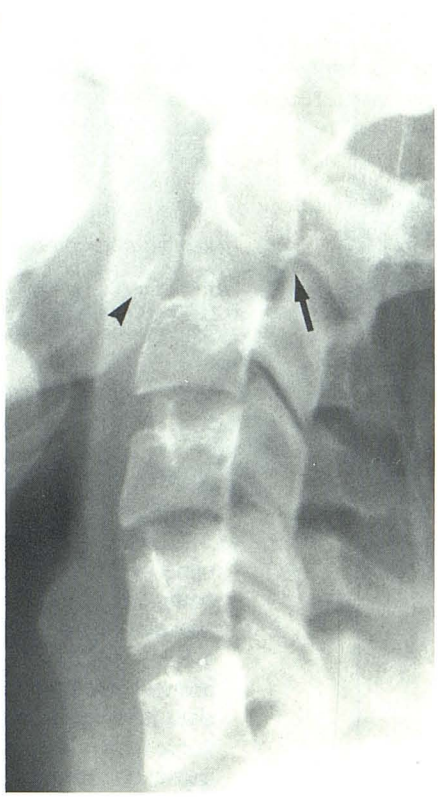
Hyperextension dislocation of the cervical spine is usually the result of a high-velocity, abrupt-deceleration motor-vehicle accident, although any circumstance that delivers a posteriorly directed major force to the face may cause the dislocation.

The true incidence of hyperextension dislocation is not known, partially at least because its radiographic signs have been neither generally recognized nor appreciated. The fact that our series of 20 patients with hyperextension dislocation is the largest in the English literature suggests that hyperextension dislocation is an uncommon, although important, injury.

The pathologic lesion of hyperextension dislocation consists of rupture of the anterior longitudinal ligament and either avulsion of the involved vertebra from the subjacent disk or horizontal rupture of the disk. Continued posterior excursion of the involved vertebra strips the posterior longitudinal ligament from the subjacent vertebral body, allowing the dislocating vertebra to impinge on the ventral surface of the spinal cord. Simultaneously, kyphotic angulation occurs posteriorly at the level of dislocation, causing the ligamentum flavum and dura to impinge on the posterior aspect of the cord. Anteroposterior compression of the spinal cord (fig. 1) results in the "acute central cervical spinal cord syndrome" characterized by sensory changes below the level of dislocation and motor impairment that is disproportionately greater in the upper than in the lower extremities. Bladder dysfunction, resulting in urinary retention, may be present. Depending on the type and degree of central cord damage, tetraplegia may be permanent or death may occur [3, 20]. There is little correlation between radiologic and neurologic findings [16]. The extent of neuro-



A



B

Fig. 2.—Diffuse widening of prevertebral soft tissues (*asterisk*). **A**, Secondary to hemorrhage and edema resulting from rupture of anterior longitudinal ligament. Avulsion fracture (*arrowhead*) from anterior aspect of inferior end-plate identifies dislocated vertebra and serves as confirmatory evidence of hyperextension dislocation. **B**, 1 month after injury. Prevertebral soft-tissue swelling is diminished but still present. Slight posterior displacement of C2 (*arrow*) results from ligamentous instability. Avulsion fracture (*arrowhead*).

Fig. 3.—Acute avulsion fracture from anterior aspect of inferior end-plate (*arrowhead*) of dislocated vertebra. This fracture occurs at site of attachment of Sharpey fibers and indicates level of dislocation. Calcification in anulus fibrosus (*arrow*) is secondary to degenerative disease.

logic recovery seems to be related to the extent and nature of the cord damage [3, 5, 20].

Rupture of the anterior longitudinal ligament, which may occur with a force of as little as 340 psi (24 kg/cm^2) [21], is manifested radiographically by diffuse widening of the prevertebral soft tissues and blurring of the air–soft tissue interface secondary to hemorrhage and edema associated with the ligamentous tear (fig. 2) [2]. Weir [11] established that the normal width of the prevertebral soft tissues at the level of the anterior inferior border of C3 in adults is 2.6–4.8 mm with a TFD of 1.5 m. At this TFD, a prevertebral soft-tissue shadow exceeding 5 mm at this level is abnormal.

The shortest TFD used in obtaining lateral cervical spine radiographs of the patients in our series was 40 inches (1.0 m), which resulted in a maximum magnification factor of 1.4 and a normal prevertebral thickness of 7 mm as measured at C3. The prevertebral soft-tissue shadow at this level in all 20 patients was 9–19 mm. Further, in 50% of the patients, the width of the prevertebral soft tissues was more than double the accepted upper limit of normal (7 mm).

In all patients with hyperextension dislocation, except two adolescents, the prevertebral soft-tissue swelling involved the entire cervical region, extending even to the nasopharynx and the clivus. In the two adolescents, in whom the inferior ring apophysis of the dislocated vertebra was avulsed, the soft-tissue swelling extended only a distance of about four cervical segments. Avulsion of the apophysis, limited soft-tissue swelling, and minimal neurologic findings all suggest that these injuries were less severe than those in the adults with diffuse prevertebral soft-tissue swelling.

The avulsion fracture fragment seen in two-thirds of the patients with hyperextension dislocation is characteristic of this injury. The separate fragment, with a horizontal dimension greater than its height, arises from the anterior aspect of the inferior end-plate of the involved vertebra (fig. 3). The fragment is avulsed by the intact Sharpey fibers (fig. 4) [22, 23], and its presence confirms the diagnosis and indicates the level of dislocation.

The fracture fragment caused by hyperextension dislocation must be distinguished from that of the extension teardrop fracture because of the significant clinical difference between these two injuries. The avulsion fracture of hyperextension dislocation (fig. 5A) is characterized by its location and by the fact that its horizontal dimension is greater than its height.

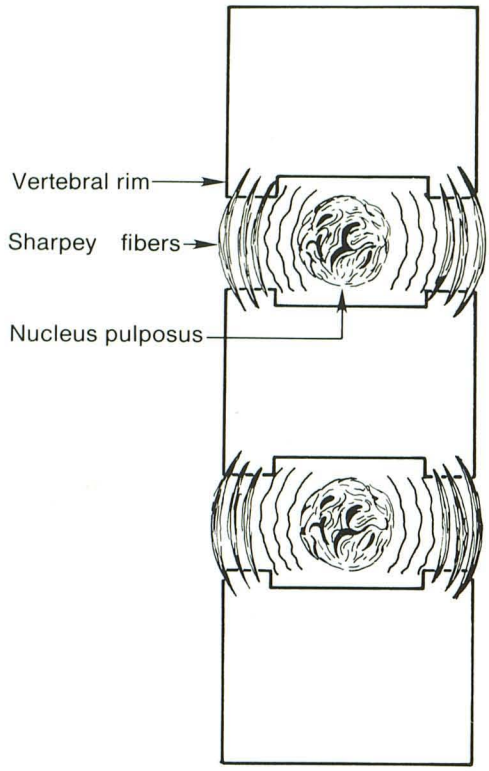


Fig. 4.—Schematic representation of attachment of intervertebral disk to vertebral rim by fibrous extensions of anulus fibrosus (Sharpey fibers). Fibers are attached initially to cartilaginous ring apophysis and gradually become embedded in ossifying vertebral rim during skeletal maturation. (Modified from [22].)

Conversely, the height of the extension teardrop fragment (fig. 5B) equals or exceeds its horizontal dimension.

Widening of the intervertebral disk space (fig. 6) may become radiographically evident only when the cervical spine is examined in extension. Cintron et al. [9] emphasized that a widened disk space may indicate "a potentially unstable lesion."

The vacuum defect is a horizontal, oval lucency within the intervertebral disk space (fig. 7). This "lucent cleft" was first reported as a sign of cervical disk injury or disease by Reymond et al. [10], who postulated that the lucency represented gas, probably nitrogen, diffused into the joint space by the negative pressure associated with avulsion of the inferior end-plate of the affected vertebra from the subjacent disk. Rather than the vacuum defect being adjacent to the inferior vertebral end-plate, as described by Reymond et al. [10], the vacuum defect in the three patients in our series was present in the mid–transverse plane of the disk space, which, we believe, is related to the negative pressure associated with transection of the intervertebral disk during hyperextension.

Spinous process fractures resulting from hyperextension are secondary to compression of the involved spinous process between adjacent processes (fig. 8). This fracture differs pathologically and radiographically from the clay shoveler's fracture, which is an avulsion injury caused by the abrupt traction force of the intact interspinous ligament and characterized radiographically by an oblique fracture limited to the spinous process.

Hyperextension dislocation is pathologically and radiographically distinct from the spinal cord compression injury that occurs in extension and is associated with cervical spondylosis, as described by Taylor [24] and Borovich et al. [20]. In these patients, in whom the lateral cervical spine radiographs were all negative except for the osteophytosis, the central cord syndrome was best explained by pinching of the cord by the osteophytes anteriorly and the in-bulging dura and ligamentum flavum posteriorly, the so-called "Taylor mechanism." At autopsy, Taylor [24] reported that the spinal column, including the anterior longitudinal ligament, was intact. Myelographic cadaver experiments [24] demonstrated that, in hyperextension, a series of posterior indentations at the level of the interlaminar spaces narrowed the canal by as much as 30% secondary to infolding of the ligamentum flavum and dura.

In recent literature, some authors have referred to the hyperextension dislocation in terms that vary from the original pathologic description, that is, "hyperextension sprain (momentary dislocation) with fracture" [15] and "hyperextension sprain" [25]. However, on the basis of autopsy findings, animal experiments [17–19], and in keeping with the generally accepted clinical usage, we strongly advocate that the traditional terminology, *hyperextension dislocation of the cervical spine*, be reserved specifically for this injury, even though, bydefinition, the dislocation is not radiographically present on neutral lateral radiographs of the cervical spine.

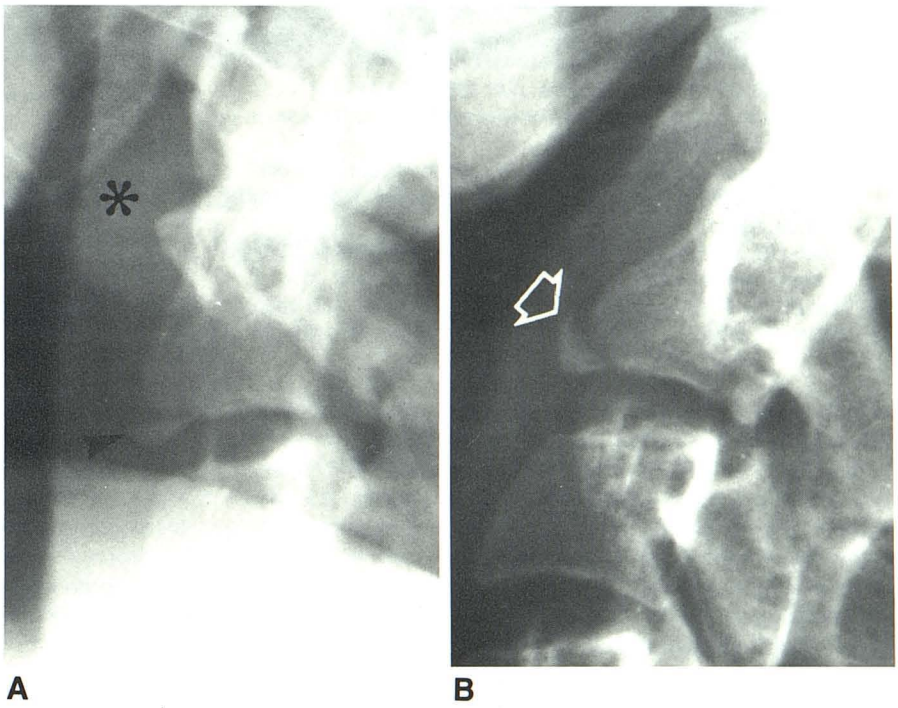
ACKNOWLEDGMENTS

We thank Carol Jahrsdoerfer, Sandra Sundve, and Daphne Foley for assistance in manuscript preparation and Rosalind Vecchio for medical photography.

REFERENCES

1. Clark WH, Gehweiler JA, Laib R. Twelve significant signs of cervical spine trauma. *Skeletal Radiol* **1979**;3:201–205
2. Penning L. Prevertebral hematoma in cervical spine injury: incidence and etiologic significance. *AJNR* **1980**;1:557–565, *AJR* **1981**;136:553–561
3. Schneider RC, Cherry G, Pantek H. The syndrome of acute central cervical spinal cord injury. *J Neurosurg* **1954**;11:546–577
4. Forsyth HR. Extension injuries of the cervical spine. *J Bone Joint Surg [Am]* **1946**;46:1792–1797
5. Marar BC. Hyperextension injuries of the cervical spine. *J Bone Joint Surg [Am]* **1974**;56:1655–1662
6. Scher A. Hyperextension trauma in the elderly: an easily overlooked spinal trauma. *J Trauma* **1983**;23:1066–1068
7. Barnes R. Paraplegia in cervical spine injuries. *J Bone Joint Surg [Br]* **1948**;30:234–244
8. Taylor AR, Blackwood W. Paraplegia in cervical injuries with normal radiographic appearance. *J Bone Joint Surg [Br]* **1948**;30:245–248
9. Cintron E, Gilula L, Murphy W, Gehweiler J. The widened disc space. *Contemp Diagn Radiol* **1981**;141:639–644
10. Reymond RD, Wheeler RS, Parovic M, Block B. The lucent cleft, a new radiologic sign of cervical disc injury or disease. *Clin Radiol* **1972**;23:188–192

Fig. 5.—Comparison of radiographic appearance of avulsion fracture of hyperextension dislocation (**A**) and hyperextension teardrop fracture (**B**). In hyperextension dislocation, fracture fragment (*arrowhead*) is thin, horizontally oriented, and its horizontal dimension is greater than its vertical dimension. Conversely, height of hyperextension teardrop fracture (*arrow*) is greater than, or equal to, its width. *Asterisk* indicates widening of prevertebral soft tissues uniformly associated with hyperextension dislocation.



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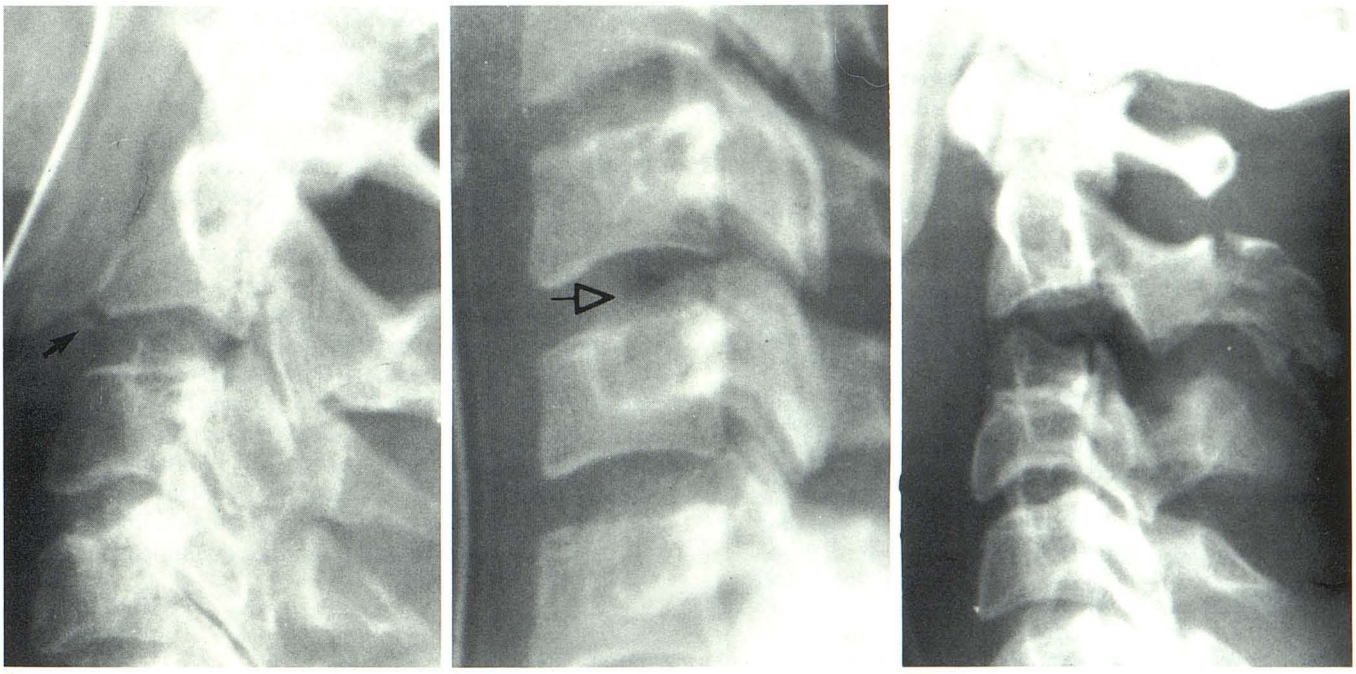

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Fig. 6.—Increased height of second intervertebral space indicates disruption of disk and level of dislocation. Characteristic avulsion fracture (*arrow*) of anterior aspect of inferior end-plate of affected vertebra is also present.

Fig. 7.—Vacuum defect (*arrow*) indicates disk disruption at level of dislocation.

Fig. 8.—Comminution of spinous process of axis from compression by adjacent spinous processes during extreme hyperextension. In addition, intervertebral and interfacetal joint spaces are widened.

11. Weir D. Roentgenographic signs of cervical injury. *Clin Orthop* **1975**;109:9–17
12. Scher A. Diversity of the radiological features in hyperextension injury of the cervical spine. *S Afr Med J* **1980**;58:27–30
13. Harris WH, Harris JH Jr. *The radiology of emergency medicine*, 2d ed. Baltimore: Williams & Wilkins, **1981**
14. Harris JH. *The radiology of acute cervical spine trauma.* Baltimore: Williams & Wilkins, **1979**

15. Gehweiler JA Jr, Clark WM, Schaaf RE, Powers B, Miller MD. Cervical spine trauma: common combined conditions. *Radiology* **1979**;130:77–86
16. Whitley JE. Cervical spine injuries. *AJR* **1960**;83:641–644
17. MacNab I. Acceleration injuries of the cervical spine. *J Bone Joint Surg* [*Am*] **1964**;46:1797–1799
18. Harris W, Hamblen D, Ojemann R. Traumatic disruption of cervical intervertebral disc from hyperextension injury. *Clin Orthop* **1968**;60:163–167
19. Gosch HH, Gooding E, Schneider R. An experimental study of cervical spine and cord injuries. *J Trauma* **1972**;12:570–575
20. Borovich B, Peyser E, Gruskiewicz J. Acute central and intermediate cervical cord injury. *Neurochirurgia* (Stuttg) **1978**;21:77–84
21. Davis A. New aspects of spinal injury. *Arch Surg* **1943**;46:619–634
22. Keller RN. Traumatic displacement of the cartilagenous vertebral rim: a sign of intervertebral disc prolapse. *Radiology* **1974**;110:21–24
23. *Gray's anatomy*, 29th ed. Philadelphia: Lea & Febiger, **1973**
24. Taylor AR. The mechanism of injury to the spinal cord in the neck without damage to the vertebral column. *J Bone Joint Surg* [*Br*] **1951**;33:543–547
25. Braakmann R, Penning L. *Injuries of the cervical spine.* Amsterdam: Exerpta Medica, **1971**