CT of Facet Distraction in Flexion Injuries of the Thoracolumbar Spine: The "Naked" Facet

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AJNR Am J Neuroradiol 1980, 1 (1) 97-102
http://www.ajnr.org/content/1/1/97
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Vertical distraction of the articular processes is an important sign of ligamentous disruption due to flexion injuries of the thoracolumbar spine. In addition to illustrating this finding in cross section (the “naked” facet), computed tomography in the transaxial plane allows assessment of the presence and position of fracture fragments that may encroach on the spinal canal. Image reconstruction in sagittal and coronal planes provides a clear demonstration of the degree of bony compression, facet distraction, and kyphosis associated with flexion injuries without additional patient manipulation or radiation exposure.

Flexion injury of the thoracolumbar spine usually results in a simple compression fracture of a vertebral body [1]. Less often, flexion injury results in a horizontal fracture through the posterior neural arch with distraction of the bony fragments and variable extension into the vertebral body (the Chance or seat belt fracture) [2, 3].

The widespread use of lap-type seat belts during recent years has resulted in an increased frequency of a third pattern of flexion injury in motor vehicle accidents. In this pattern, there is minimal compression of the vertebral body but extensive disruption of the ligamentous framework of the posterior elements with resultant vertical distraction of the articular processes [4]. This pattern has also been described in patients who have fallen or jumped from a height [5].

While plain film examination of the spine is an essential part of the primary screening evaluation of patients with flexion injuries, diagnosis of disruption of the posterior neural arch usually requires additional radiographic studies, specifically tomography or computed tomography (CT). In our report, we describe an important observation, the “naked” facet, that can be easily recognized on CT examination of the traumatized thoracolumbar junction. This sign is the CT appearance in the transverse plane of the vertically distracted articular processes.

Subjects and Findings

Four patients sustained flexion injuries of the thoracolumbar spine with resultant ligamentous damage and vertical distraction of the articular processes. All were young women 14–22 years old. Two were injured in automobile collisions while wearing lap and shoulder-type seat belts and two were injured in falls, one from a height of 3.6 m and one after an attempted handstand.

All four patients were examined within a few hours after injury. Only one showed evidence of neurologic deficit with relatively mild weakness of the lower limbs that gradually cleared...
over 3–4 weeks. The other three demonstrated no evidence of injury to the spinal cord or cauda equina at any time during their clinical course.

On initial examination in all four patients, plain anteroposterior and lateral radiography demonstrated mild anterior compression of the body of T12 (one case) or L1 (three cases) with varying degrees of kyphosis (figs. 1A, 1B, 2A, and 2B). Only one patient demonstrated forward dislocation of the next higher vertebra (fig. 1B). In one patient, the posteroinferior aspect of the higher vertebra was avulsed and remained aligned with the compressed lower vertebra. In all cases, the interspinous distance at the involved vertebral level was noted to be increased on the anteroposterior radiograph (figs. 1A and 2A), indicating bony or ligamentous disruption in the posterior neural arches. However, the precise nature of the injury to the posterior elements could not be definitely established on the plain films.

In each case, tomography in both anteroposterior and lateral planes revealed disruption of the apophyseal joints bilaterally at the affected level. This was manifested as vertical distraction of the inferior articular processes of the upper vertebra in relation to the superior articular processes of the lower vertebra. The facets were not completely distracted but appeared to be “perching” [5] with only minimal surface contact (figs. 1C and 2C).

The two patients injured in automobile accidents were evaluated by CT. (CT was either unavailable or not elected in the other two patients.) The axial images demonstrated abnormal apophyseal joints at the affected levels. The inferior articular facets of the upper vertebra lay free or “naked” (figs. 1E and 2D), and on successively lower images the superior articular facets of the lower vertebra also appeared “naked” (figs. 1F and 2E). For comparison, the normal facet joints at L1–L2 level in one patient are illustrated (fig. 1G). The opposing articulating surfaces are clearly seen at the same axial level indicating that the joints are intact bilaterally. While the axial CT images at the traumatized levels did not precisely illustrate the degree of anatomic distortion in the sagittal and coronal planes, image reconstruction with data from the axial images permitted a clear demonstration of bony compression, distraction, and avulsion in these planes (figs. 2F and 2G).

In a patient who sustained a Chance fracture of the posterior elements and body of T12 (figs. 3A–3C), axial CT revealed bilateral
Fig. 2.—Case 2. Compression fracture of L1 with facet distraction. A, Increased distance between spinous processes of T12 and L1. B, Impaction of superior end plate of L1. Posterior elements obscured by overlying ribs. C, Tomogram. “Perching” of inferior facets of T12 on superior facets of L1. Upper dashed line is level of D; lower dashed line is level of E. D, Axial CT at level of inferior articular processes of T12. Bilaterally, facets appear “naked” (arrows) (not in apposition with superior facets of L1). E, 8 mm below D. Superior articular processes of L1 visualized with “naked” facets facing posteromedially (arrows). Fracture anteriorly in body of L1. F, Parasagittal CT reconstruction at level of left articular processes of T12 and L1. Articular processes distracted (arrow) and body of L1 compressed. G, Coronal CT reconstruction at level of T12–L1 apophyseal joints confirms “perching” of inferior articular processes of T12 on superior articular processes of L1 (arrows) (compare with C). Rib 12 also in plane of reconstruction.

disruption of the bony neural arch (figs. 3E and 3F). Axial images also showed normal articulating facet joints both above and below the level of the fracture at T11–T12 (fig. 3D) and T12–L1 (fig. 3G). The reconstructions in the sagittal (figs. 3H and 3I) and coronal (fig. 3J) planes confirmed the bony disruption of the neural arch and also the intact facet joints.

Discussion

The pattern of structural derangement in flexion injury of the thoracolumbar junction depends on the horizontal plane in which the stress vectors are resolved. If the vector is resolved horizontally at the level of the intervertebral disc (fig. 4A), it will pass successively through the disc, ligamenta flava, intervertebral foramina, apophyseal joints, and interspinous ligaments. The only bony injury may be a wedge fracture of the anterosuperior part of the lower vertebral body. If the vector is resolved horizontally at the level of the vertebral body (fig. 4B), it will pass successively through the body, pedicles, laminae, and spinous process, and these structures will yield, resulting in the type of fracture originally described by Chance [2].

In the usual type of flexion injury of the spine, the compression forces are sustained by the anterior half of the vertebral body, resulting in a wedge or compression fracture. In this situation, there is no significant distraction of the posterior elements [6]. However, when sudden deceleration occurs while the individual is wearing a lap seat belt, the fulcrum of the flexion force passes through the point of contact of the belt with the anterior abdominal wall. Therefore, the entire spine lies well posterior to the flexion axis and all its components are subject to distraction forces,
making ligamentous disruption much more likely and the degree of compression of the vertebral body less severe. This applies particularly to young patients with strong abdominal musculature (fig. 4A). In elderly people or those with hypotonic musculature, the abdominal wall offers less resistance to the seat belt, and the flexion axis is further posterior (e.g., just anterior to the vertebral body). In such cases, the compressive force on the vertebral body is greater and the distraction force on the posterior elements is less severe.

Facet distraction also occasionally occurs in association with fractures of the mid or upper thoracic spine, but re-
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Fig. 4.—A, Pattern of structural disarrangement in patient wearing lap-type seat belt when vector of flexion force passes through intervertebral disc. Vertebral body compressed. Posterior ligaments, including capsules of apophyseal joints and surrounding and interspinous ligament, distracted and torn. B, Vector of flexion force passes through vertebral body (Chance fracture). Vertebral body compressed. Posterior body structures, including pedicles, lamina, and spinous process, distracted and fractured.

quires an extreme degree of flexion force. The associated approximation of the anterior ends of the ribs tends to counteract the tension on the posterior spinal elements and limits the degree of compression of the vertebral bodies [7]. However, when the combined compressive and flexion forces overcome this splinting mechanism, fracture-dislocation occurs and paraplegia is almost invariably the consequence [8].

Differentiation of the primarily bony injury (Chance fracture) from the primarily ligamentous injury is not merely academic. There are important differences in management. The osseous injury tends to heal spontaneously if satisfactory reduction is achieved and the patient is immobilized in a hyperextension cast. The ligamentous injury tends not to heal and requires operative fixation to prevent the complication of late instability. In this situation, Harrington rod instrumentation has been used to achieve a satisfactory reduction of the distracted articular processes and associated kyphosis [9, 10].

The traditional radiographic methods of examination of patients sustaining spinal trauma are plain films and tomography. On plain radiographs, the bony anatomy and relations of the posterior neural arches in the thoracolumbar spine may be obscured by overlying vertebral bodies on frontal views and by overlying ribs on lateral views (figs. 1A, 1B, 2A, and 2B). Oblique views may be of value in assessing the apophyseal joints [11], but it is often difficult to appreciate minor degrees of facet displacement [12]. Tomography in the frontal plane provides satisfactory visualization of the vertebral bodies, the posterior neural arches, and the apophyseal joints. However, evaluation of the position of fracture fragments arising from the posterior aspect of the vertebral body, which may encroach on the spinal canal, requires lateral tomography. Even with a universal tomographic device capable of both horizontal and upright tomography, the manipulation of the patient required for combined frontal and lateral views may be hazardous in the presence of an unstable spinal injury.

The advantages of CT in this situation can be considerable. The injury can be visualized in the third plane (transverse), allowing a more precise localization of fracture fragments in relation to the spinal canal and the intervertebral foramina. Patient manipulation is reduced to simple supine positioning on the couch of the CT unit. Furthermore, the radiation dose associated with CT examination of the spine [13] is usually significantly lower than with conventional tomography (C. C. Chamberlain, personal communication).

Slice thickness of CT spine sections can be varied to suit the needs of the particular case. We generally obtain overlapping 8-mm-thick sections in the area of interest. This minimizes the risk of poorly visualized regions due to the partial-volume effect. In the region of the thoracolumbar junction the superior facets, joint space, and inferior facets of the normal apophyseal joint can all be visualized on a single axial section (fig. 1G). The "naked" facet sign means that the inferior facets related to the involved apophyseal joints are optimally visualized on a section above the one in which the superior facets related to the same joint are best seen (figs. 1E, 1F, 2D, and 2E). The number of intervening sections depends on the extent of facet distraction.

The findings can be confirmed by image reconstruction in selected sagittal and coronal planes, which yields images corresponding to those obtained by lateral and anteroposterior tomography respectively [14]. Thus, a demonstration of the distorted anatomy in three planes of view can be obtained without additional radiation and without having to move the patient from the supine position.

In our institution, standard anteroposterior and crossstable lateral radiographs of the thoracolumbar spine are initially obtained. If a spinal fracture is identified, CT is performed next. Sagittal and coronal reconstructions nearly always provide sufficient detail for anatomic and pathologic
analysis of displaced fractures at the thoracolumbar junction. Conventional tomography is now reserved for those cases in which either the CT scan is technically inadequate or where nondisplaced horizontal spinal fracture is suspected.

REFERENCES