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Chance-Type Fractures of the Thoracolumbar Spine: Imaging Analysis in 53 Patients

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OBJECTIVE. Chance-type fractures are subtle unstable injuries that are often associated with intraabdominal injuries. CT-based observations made during routine interpretations revealed involvement of a burst component to this fracture pattern and a clue on the transaxial images to its presence. The purpose of this review was to determine how often these features occurred in a retrospective study of a large sample because these findings influence diagnosis and management.

MATERIALS AND METHODS. A retrospective review of all patients identified from the University of Maryland Shock Trauma Center trauma registry and IDXRad system diagnosed with flexion–distraction injuries of the thoracolumbar spine over an 8-year period was performed. Three trauma radiologists assessed the admission spinal radiographs, CT studies with multiplanar images, and available MRI examinations. Imaging findings were confirmed by consensus. Abdominopelvic CT studies and surgical reports were reviewed for evidence and type of intraabdominal injury. A literature review of previous similar series was performed.

RESULTS. Fifty-three patients were identified for inclusion in the study. Associated intraabdominal injury occurred in 40% and most commonly involved the bowel and mesentery. A close examination of the fracture patterns on CT revealed that a burst-type fracture with posterior cortex buckling or retropulsion was a common finding (48%). Also, serial transaxial CT images often (76%) showed a gradual loss of definition of the pedicles that we refer to as the "dissolving pedicle" sign. The study showed that the horizontally oriented fracture planes through the posterior elements can often be recognized radiographically, but these fractures can be very subtle.

CONCLUSION. Intraabdominal injuries occurred in 40% of flexion–distraction thoracolumbar fractures in our study cohort, which is slightly lower than previously reported. About half of the patients with this injury displayed a burst-type component that could have a significant influence on surgical management. The dissolving pedicle sign can assist in recognition of this often subtle injury on transaxial CT.

Keywords: fracture, spine, trauma

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The flexion–distraction fracture of the spine was first described in 1948 by G. Q. Chance [1]. This pattern of injury had not been recognized before the use the lap seat belt. Since the late 1960s, with the common placement and use of seat belts in automobiles across North America, case reports describing these transverse fractures began to emerge sporadically in the medical literature. Soon, small cohorts of cases were analyzed, and associations between lap belt use and spinal injuries were made. At the same time, and often in independent studies, the relationship between lap belt use and intraabdominal injuries was recognized.

Approximately 160,000 cases of thoracolumbar spine fractures occur annually in the United States. Most victims are young males involved in motor vehicle collisions. Other mechanisms include falls, sporting events, and assaults. Thoracolumbar spine fractures often result in long-term disability.

Although thoracolumbar spine fractures are common in major blunt trauma, they are often missed or diagnosed in a delayed fashion, thereby potentially increasing morbidity. Flexion–distraction, or Chance-type, fractures are often subtle on both radiography and CT and are unstable injuries that usually do not present with a neurologic deficit. In addition, these fractures are frequently associated with significant intraabdominal injuries. For this retrospective review, we analyzed imaging findings in 53 patients with flexion–distraction fractures of the thoracolumbar spine to determine the spectrum of radiologic findings and diagnostic findings that may be subtle.

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Materials and Methods

A retrospective review of all patients from the University of Maryland Shock Trauma Center trauma registry and IDXRad system (GE Healthcare) diagnosed with flexion–distraction injuries or Chance fractures of the thoracolumbar spine over an 8-year period was performed after institutional review board approval was obtained. Three trauma radiologists assessed admission spinal radiographs, CT studies with multiplanar images, and available MRI examinations using anonymous hard-copy films in a blinded fashion. Patients without adequate or available radiographs were excluded from the study. Patient demographic information, including age, sex, injury level or levels, injury pattern, and radiographic and CT signs were evaluated. Anteroposterior (AP) and cross-table lateral radiographs were independently assessed, as were transaxial and sagittal CT images, with a prepared checklist. Imaging findings were confirmed by consensus.

Abdominopelvic CT studies and surgical reports were reviewed for evidence and type of abdominal injury. Patient treatment and follow-up were evaluated by chart review. A literature review of previous similar series was performed.

Fifty-three patients with a Chance-type fracture of the thoracolumbar spine were identified using radiographs and CT examinations. All 53 patients had concurrent CT evaluation of the abdomen and pelvis. CT examinations were performed on an MX8000 4-MDCT scanner (Philips Medical Systems) from April 2001 to April 2003 or a single-detector Somatom Plus 4 scanner (Siemens Medical Solutions) from May 1995 to April 2001. Spinal protocols on 4-MDCT were unenhanced 1.3-mm images with 50% overlap and 3-mm sagittal and coronal reformations. On the single-detector helical scanner, acquisition consisted of 3-mm-thick images with 50% overlap and 3-mm sagittal and coronal reformations. Abdominopelvic CT examinations were performed on the scanners mentioned with the administration of oral and IV contrast material. Images were acquired at 5-mm intervals and reviewed on hard copy by consensus of the authors.

MRI examinations were performed in eight patients on either a 1.5-T Picker Eclipse scanner (Marconi Medical Systems) from 1997 to 2005 or a 1.5-T EchoSpeed scanner (GE Healthcare) from 1995 to 2004. Acquisition sequences were as follows for the lumbar spine using the Picker Eclipse scanner: sagittal turbo spin-echo T1, proton density, and T2; and axial turbo spin-echo T1 and turbo fast spin-echo T2. In addition, the acquisition sequences for the thoracic spine were as follows: T1 and proton density fast spin echo, axial T2* with magnetization transfer, and axial T2 fast spin echo. On the EchoSpeed scanner, the MRI sequences for the lumbar and thoracic spine included sagittal spin-echo T1, proton-density, and T2; and axial T1 and gradient-echo. Also a sagittal inversion recovery sequence was performed for the thoracic spine.

Results

Demographics

Fifty-three patients were identified with 55 separate Chance-type fractures of the thoracolumbar spine. Thirty-eight males (72%) and 15 females (28%) were evaluated. The mean age for the study group was 26 years, ranging from 9 to 54 years. The mechanism of injury was motor vehicle crash in 38 (72%); fall in nine (17%); struck by a falling object in two (4%); and assault, sporting event injury, and bicycle crash in one each (2%). The Glasgow coma score, a measure of best motor, verbal, and eye-opening responses on a scale from 3 to 15, in our series ranged from 10 to 15, with 88% of patients presenting with a normal Glasgow coma score of 15; the Glasgow coma score for two patients was not available. The injury severity score (ISS), an anatomic severity scale to evaluate multitrauma patients and predict probability of survival, ranged from 2 to 43, with a mean of 19; the ISS for seven patients was not available. Two patients were paraplegic, one secondary to a noncontiguous burst fracture. A significant diagnostic delay was identified in only one case with 3 weeks between admission and surgical fixation.

Fractures

Radiography—All patients had AP and lateral radiographs of the thoracolumbar spine. The distribution of the Chance-type fractures is outlined in Table 1 and ranged from T4 to L5. Among the injuries, 78% occurred at the thoracolumbar junction, between T12 and L2. Two patients had two-level Chance-type fractures, one contiguous (T11, T12) and the other noncontiguous (T12, L4). On AP spinal radiographs, increased interspinous distance was seen in all patients, which is indicative of the flexion–distraction mechanism of injury. The resulting relative radiolucency over the involved vertebral body is referred to as the "empty vertebral body" sign (Fig. 1). A transverse fracture through the pedicles was seen in 66%, and increased intercostal spacing was noted in 50% of the thoracic spine injuries. Other radiographic signs supporting the diagnosis of flexion–distraction injury included horizontally oriented fractures across the transverse processes, laminae, and articular processes. Lateral radiographs showed fanning or distraction of the spinous processes, indicative of a hyperflexion mechanism, in 80% of patients and pedicle radiolucency in 73% (Fig. 2).

TABLE 1: Distribution of Chance-Type Fractures

Injury Level	Chance-Type Fracture	
	No.	%
T4	1	1.8
T6	1	1.8
T7	1	1.8
T9	1	1.8
T11	2	3.6
T12	14	25.5
L1	21	38.2
L2	8	14.5
L3	1	1.8
L4	3	5.5
L5	2	3.6
Total	55	100

CT—Transaxial CT images of the thoracolumbar spine revealed uncovering of articular facets secondary to the vertical distraction of the posterior elements, previously described as the naked-facet sign [2] in 40% of patients (Fig. 3). In evaluating the horizontally oriented Chance fracture, serial transaxial CT images revealed a gradual loss of definition of the pedicles, a sign that we refer to as the "dissolving pedicle" sign (Fig. 4). This sign was the most common finding on transaxial CT images, identified in 76% of patients. Whenever transaxial images displayed the "dissolving pedicle," reformations in the sagittal plane always confirmed a Chance-type fracture pattern. Chance fracture imaging findings on CT and conventional radiography are summarized in Table 2.

MRI—Eight of fifty-three patients were examined on MRI. Three of these patients had separate burst fractures, one contiguous and two noncontiguous. MRI revealed marked soft-tissue damage through the posterior elements and surrounding soft tissues in all cases. The sandwich sign [3], which is characterized on T2-weighted images by low-signal hemorrhage along the fracture line with flanking high-signal marrow edema, was also shown in all cases and could be traced through the pedicles (Fig. 5). Neither epidural hematomas nor disk herniations were seen in this series.

Fracture Patterns

A close examination of the fracture patterns on CT unexpectedly revealed that a

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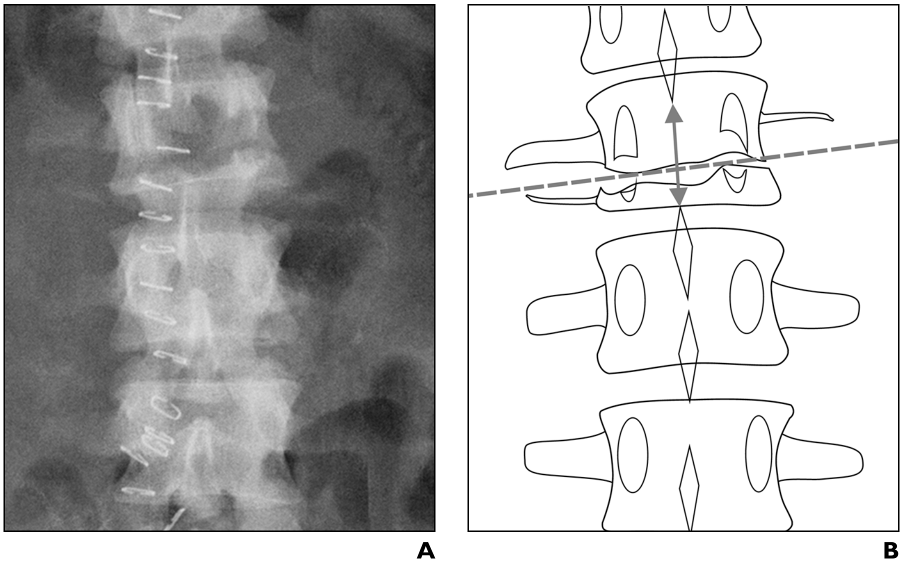


Fig. 1—Chance fracture.
A and **B,** Anteroposterior lumbar spine radiograph obtained after laparotomy in 28-year-old woman and corresponding line diagram show horizontal fracture line through L2 vertebral body across both pedicles and transverse processes. "Empty body" sign is present secondary to displaced L1 and L2 spinous processes.

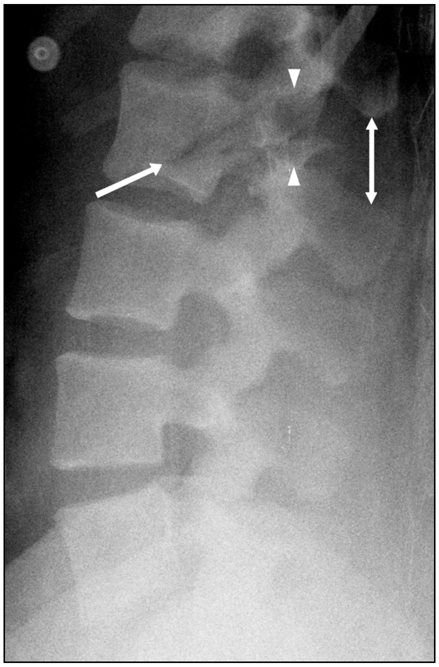
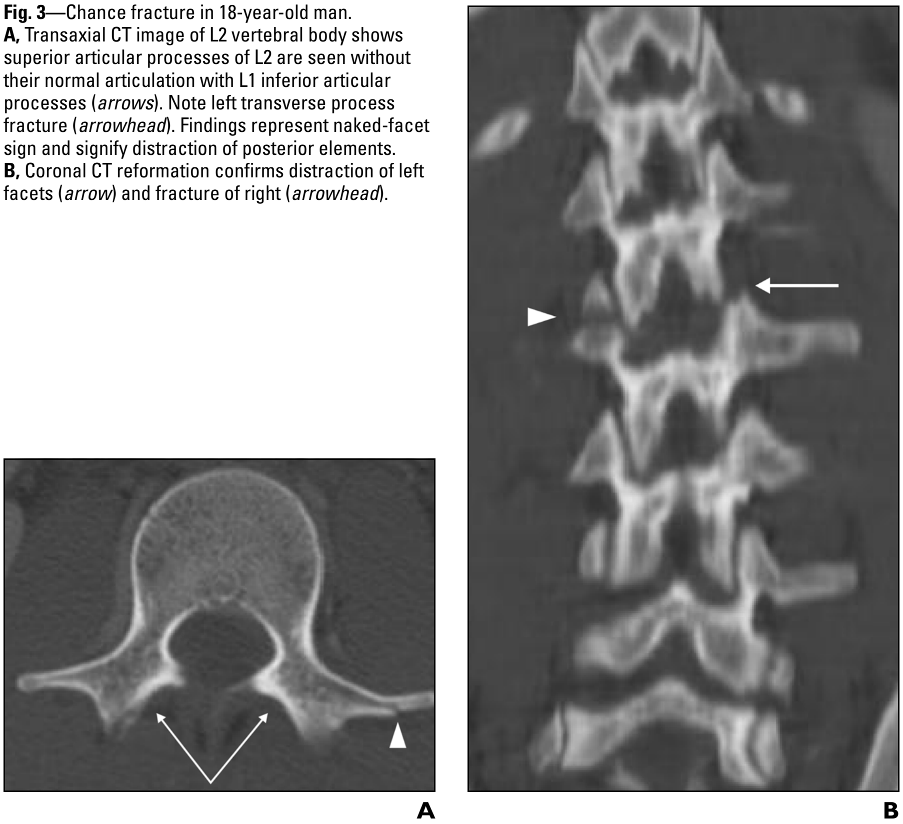


Fig. 2—Chance fracture in 28-year-old woman. Cross-table lateral radiograph of lumbar spine shows fanning of spinous processes (*double-headed arrow*) and fracture extending through pedicle (between *arrowheads*) and into L2 vertebral body (*single-headed arrow*).

Fig. 3—Chance fracture in 18-year-old man.
A, Transaxial CT image of L2 vertebral body shows superior articular processes of L2 are seen without their normal articulation with L1 inferior articular processes (*arrows*). Note left transverse process fracture (*arrowhead*). Findings represent naked-facet sign and signify distraction of posterior elements.
B, Coronal CT reformation confirms distraction of left facets (*arrow*) and fracture of right (*arrowhead*).



burst-type fracture with buckling or retropulsion of the posterior cortex was a common finding, seen in 48% of the patients in our series (Fig. 6). Results of the anterior and middle column injury classification [4] are seen in Table 3. No purely ligamentous Chance-type fractures were identified in this series, although 26% were asymmetric, with bone involvement of one pedicle and a contralateral facet distraction.

Treatment Modalities

The majority of patients in our series (60%) underwent posterior spinal fusion. Management results are presented in Table 4.

Abdominal Injuries

Associated intraabdominal injuries were seen in 21 (40%) of 53 patients; this increases to 43% (20 of 47) if the six patients with thoracic fractures above T12 are excluded. Organ injury distribution is seen in Table 5 and included liver, spleen, pancreas, adrenal glands, bowel, and mesentery. Bowel and mesentery injuries were most common (48% and 38%, respectively) and often coexisted (Fig. 7). Neither renal nor aortic injuries were seen in this series.

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Literature Review

Results of similar reported series [5–22] describing Chance-type fractures and seat belt–related abdominal visceral injury are presented in Tables 6 and 7.

Discussion

Chance [1] described a unique hyperflexion injury of the lumbar spine resulting in a "horizontal splitting of the spine and neural arch" without "…any cord damage." Seventeen years later, Howland et al. [5], unaware of Chance's earlier report, presented a similar case report of a "splitting apart" transverse fracture of a lumbar vertebra.

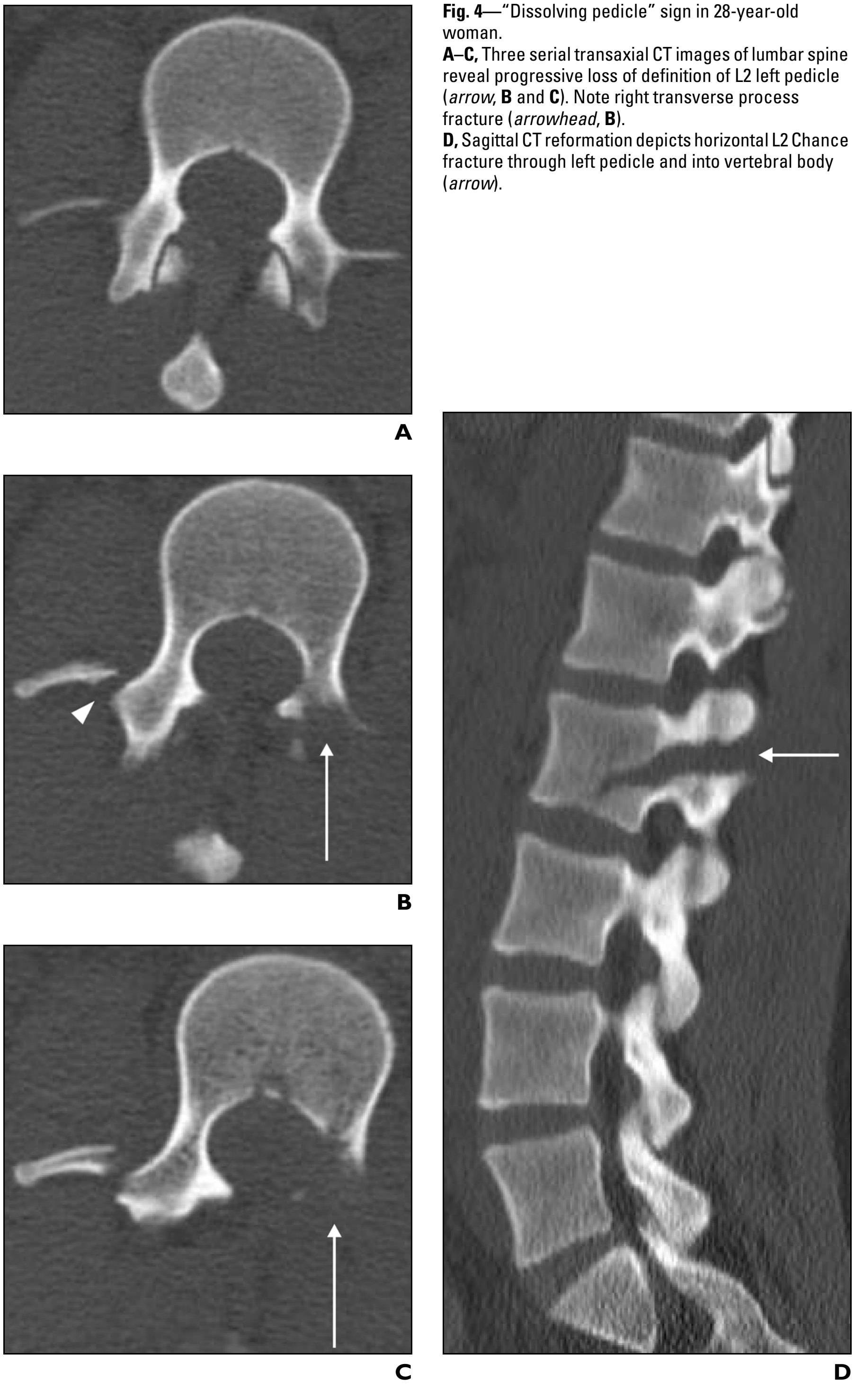

Fig. 4—"Dissolving pedicle" sign in 28-year-old woman.
A–C, Three serial transaxial CT images of lumbar spine reveal progressive loss of definition of L2 left pedicle (*arrow*, **B** and **C**). Note right transverse process fracture (*arrowhead*, **B**).
D, Sagittal CT reformation depicts horizontal L2 Chance fracture through left pedicle and into vertebral body (*arrow*).

It was not until the 1960s that a spectrum of abdominal injuries specific to motor vehicle collision occupants wearing lap belts was observed. Garrett and Braunstein [23] first coined the term "seat belt syndrome" in their landmark article on seat belt safety in 1962. Doersch and Dozier [24] in 1968 discovered a disproportionate number of victims with severe mesenteric and intestinal injuries, although no specific connection with vertebral injuries was established.

The following year, Smith and Kaufer [6] published their series of 24 lumbar spine injuries related to lap belt use. Twenty patients had unusual transverse-type fractures characterized by disruption and longitudinal separation of the posterior elements with minimal or no vertebral body compression or displacement. They termed this injury pattern the "Chance" fracture. Three patients in their series were noted to have sustained intraabdominal injuries.

By 1970, the connection between hyperflexion injuries of the spine and intraabdominal visceral injuries was made. Both injuries were deemed the result of the same forces set in motion by rapid deceleration. Ritchie et al. [7] broadened the term "seat belt syndrome" to include the characteristic transverse fracture of the thoracolumbar spine. In their review of the previously published 37 cases, a delay in diagnosis of 24 hours or more was noted in more than 50% of cases. Delay in diagnosis contributed significantly to mortality. Intraabdominal injuries most commonly involved perforation or transection of small bowel and mesenteric lacerations [17, 25–30], but reports also included colonic perforation [30, 31], splenic rupture [32–34], pancreatic rupture [23], kidney rupture, liver rupture [34], and gravid uterine rupture [35]. Two mechanisms for intraabdominal injuries have been proposed: first, direct compression between the seat belt and spine; and second, entrapment of bowel above or below the level of flexion effectively generating a closed-loop obstruction in the setting of increased intraabdominal pressure.

Case reports of patients with both Chance-type fractures and intraabdominal injuries began to be published. Tables 6 and 7 summarize the literature regarding the frequency of coexisting intraabdominal injury and thoracolumbar flexion–distraction or Chance fracture.

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Radiographic Diagnosis

We present, to our knowledge, the largest series of Chance-type fractures of the thoracolumbar spine yet reported. In our patient population, 78% of fractures occurred at the thoracolumbar junction, but were identified as craniad as T4 and as caudad as L5.

The thoracolumbar junction accounts for approximately 50% of all spinal injuries occurring outside the cervical spine. Biomechanically, this transition zone is susceptible to injury for a number of reasons: first, transition from the relatively rigid thoracic spine to the more mobile lumbar spine; second, change of facet orientation from coronal in the thoracic spine to sagittal in the lumbar spine; third, shift in spinal alignment from a kyphotic thoracic spine to a lordotic lumbar spine; and, fourth, loss of inherent stability in the thoracic spine provided by articulation to the rib cage and sternum (T1 to T10 only, as T11 and T12 are floating ribs).

TABLE 2: Fracture Findings on Radiographs and CT Scans

Imaging Technique	Imaging Plane	Imaging Finding	Frequency (%)
Radiography	AP	"Empty body" sign	100
Radiography	AP	Pedicle radiolucency	66
Radiography	AP	Wide interpedicular distance	18
Radiography	Lateral	Fanning spinous processes	80
Radiography	Lateral	Pedicle radiolucency	73
CT	Transaxial	"Dissolving pedicle" sign	76
CT	Transaxial	Naked-facet sign	40

Note—AP = anteroposterior.

Fig. 5—Inversion recovery sagittal MR images of lumbar spine in 31-year-old man.
A, Chance fracture of L1 shows marked high signal in interspinous ligaments and soft tissues (*arrowheads*). Bone marrow edema (*arrows*) is seen in pedicle and vertebral body.
B, Low-signal fracture line seen centrally in posterior vertebral body (*arrow*) with surrounding edema represents MRI sandwich sign.

Of all thoracolumbar spine fractures, Chance-type fractures are a relatively small percentage. A review of the literature reveals an incidence of 5% among 412 thoracolumbar fractures in the series of Denis [36, 37], 11% among 179 in the series of Gumley et al. [11], and 15% of 271 in the series of Gertzbein and Court-Brown [4].

These fractures are considered unstable, with disruption of the posterior and middle columns, and often extend into the anterior column as well. However, our study confirms the rarity of neurologic injury with these fractures. Only one patient had a neurologic deficit attributable to a Chance-type fracture of T11. No purely ligamentous injuries were identified in our series. Because the study is a retrospective review, perhaps this injury pattern was misdiagnosed or misclassified, such as a fracture–dislocation. Alternatively, the purely ligamentous variant may be very uncommon.

Spine injuries are common in major blunt trauma and may be missed or diagnosis may be delayed in polytrauma patients. This delay can lead to grave neurologic sequelae and has been reported in 24% of all thoracolumbar fractures, with 77% of these occurring in mechanically unstable patients [38]. In a review by Ritchie et al. [7], 50% of diagnoses were delayed by 24 hours or more. A delay in diagnosis contributes to neurologic deficit in 10.5% of spinal fractures compared with only 1.4% diagnosed at initial screening [39]. In addition, noncontiguous injuries can be present 15% of the time. One patient in our series had a delayed diagnosis of 20 days. In that patient, admission CT showed bowel contusion. Retrospective review of the images revealed the presence of a dissolving pedicle sign. Neither sagittal nor coronal reformations were obtained at the time of scanning, as this had not been the standard protocol at that time. The patient returned to the trauma service with persistent back pain, and follow-up radiographs of the thoracolumbar spine showed the overlooked Chance-type fracture.

Intraabdominal injuries are common with Chance-type fractures: 40% of our entire se-

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ries and 43% of those patients with fractures between T12 and L5 sustained internal injuries. Our results are supported by review of all identified prior Chance fracture and flexion–distraction injury series in the literature [1, 5–15], which reveal a total of 51 intraabdominal injuries present in 122 patients for a frequency of 42%. The addition of the results from the current series brings the incidence to 41% (72 of 175).

Imaging findings in Chance-type fractures are often subtle. At the University of Maryland Shock Trauma Center, all trauma patients with suspected fracture of the thoracolumbar spine undergo both AP and cross-table lateral radiography of the thoracic and lumbar spine, although this practice is declining in favor of CT screening of the thoracolumbar spine. At many institutions, the cross-table lateral view may be omitted, making the diagnosis of these fractures on the AP projection critical. The key to diagnosing these flexion–distraction injuries lies in the status of the posterior elements. Fortunately, in this series the empty vertebral body sign was identified in 100% of cases from the AP radiograph. The empty vertebral body sign results from the vertical separation of the posterior elements displacing the spinous processes or spinous process fracture fragments off the vertebral body on the AP projection. In addition, one may see a horizontal fracture through one or both pedicles. There may be associated widening of the interpedicular distance, suggesting a burst component, as well. Other supporting radiographic signs may include transverse fractures across the transverse processes, laminae, and articular processes. There may be widening of the facet joints and increased intercostal spacing.

Distraction of the posterior elements is best characterized on the lateral view. In Chance-type fractures, the fracture line is seen extending from posterior to anterior through the spinous process with fanning, or spreading apart, of the fracture fragments. The fracture then propagates into the pedicles and variably, if at all, into the vertebral body. The ligamentous-only variant appears with fanning of the intact spinous processes and facet joints. There may be increased vertical distance across the posterior intervertebral disk, signifying disruption of the posterior annulus fibrosis associated with focal kyphosis.

Relatively little has been reported describing the CT and MRI appearances of flex-

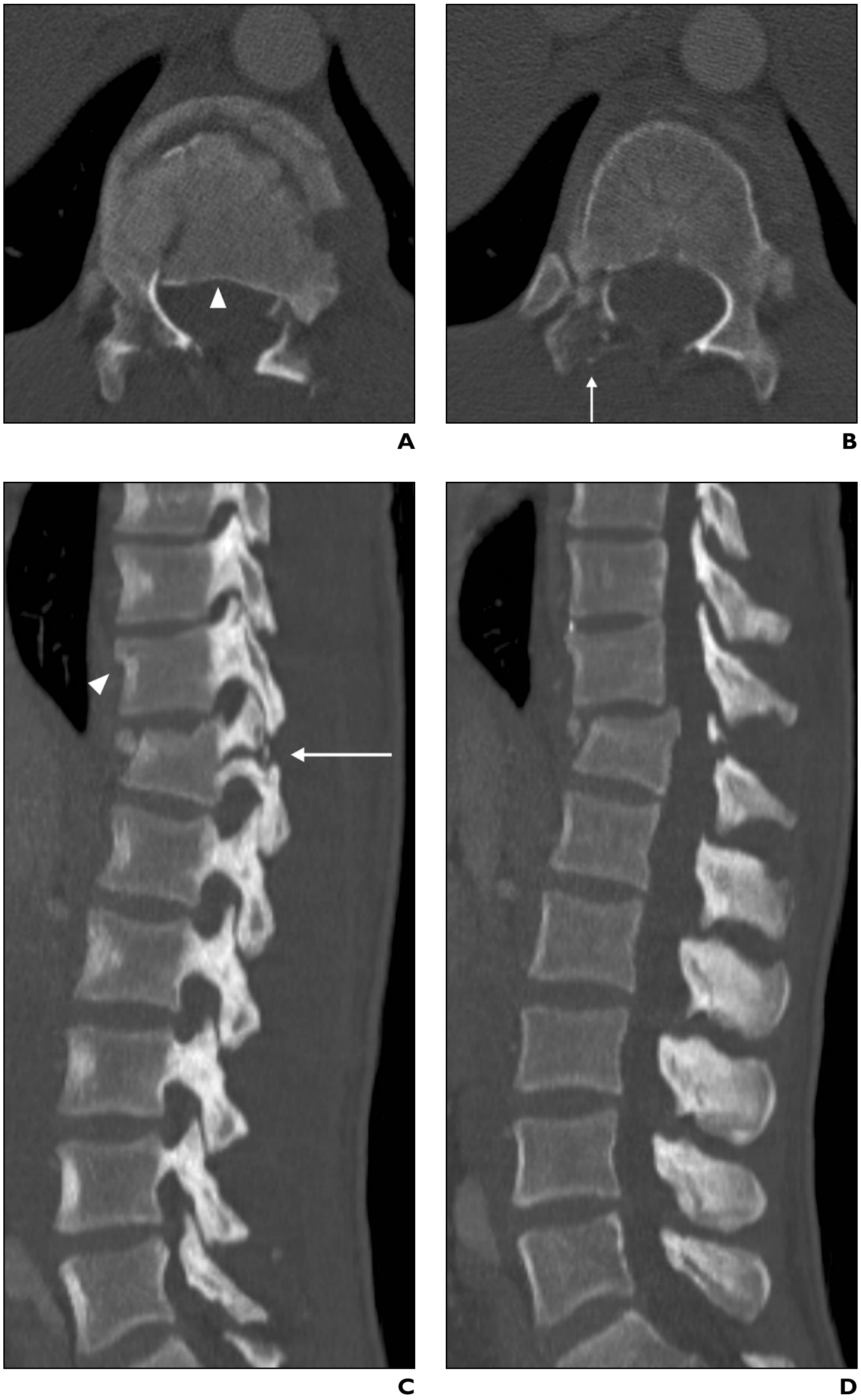

Fig. 6—Chance–burst fracture in 28-year-old man.
A, Transverse CT section through T12 with burst fracture shows retropulsion of posterior vertebral body cortex (*arrowhead*).
B, More caudal section than **A** through T12 shows "dissolving pedicle" sign on right (*arrow*) and naked-facet sign on left.
C and **D,** Midsagittal (**C**) and parasagittal (**D**) CT reformations of thoracolumbar spine confirm Chance-type fracture of T12 with fracture line through pedicle (*arrow*, **C**). Note associated buckling and retropulsion of T12 posterior vertebral body cortex along with loss of vertebral body height anteriorly. Together, these findings represent Chance–burst combination injury. Note is also made of compression fracture of T11 (*arrowhead*, **C**).

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TABLE 3: Vertebral Body Injury Classification and Frequency

Injury Classification [4]	Vertebral Body Injury	Frequency (%)
A	Disk	0
B	Mid vertebral body fracture	4
C1	Superior endplate extension	0
C2	Inferior endplate extension	13
D	Compression fracture	29
E	Burst fracture	48
F	Intact vertebral body	7

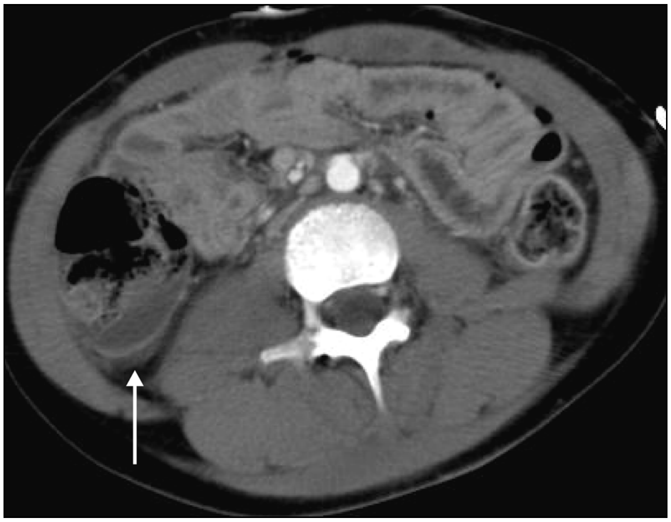

Fig. 7—Transverse CT image of mid abdomen in 9-year-old girl with Chance fracture. Small-bowel loops have diffuse mural thickening consistent with jejunal contusion. Foci of free intraperitoneal air are present signifying perforation. Hemoperitoneum is seen in right paracolic gutter (*arrow*).

TABLE 4: Management of Chance-Type Fractures in 53 Patients

Management	No.	%
Posterior spinal fusion	32	60
Extension cast	4	8
TLSO spinal brace	11	21
Corpectomy and fusion	2	4
None	3	6
Transferred (unknown)	1	2

Note—TLSO = thoracolumbosacral orthosis.

TABLE 5: Frequency of Intraabdominal Injuries

Organ Injured	Frequency (%)
Liver	14
Spleen	24
Pancreas	14
Adrenal glands	5
Kidney	0
Bowel	48
Mesentery	38

ion–distraction thoracolumbar fractures. CT is superior to conventional radiography for depicting fractures of the thoracolumbar spine by removal of overlapping osseous structures. CT accurately shows vertebral column damage—specifically, the integrity of the critical middle column—and helps identify patients at risk of acute neurologic compromise. Evaluation of our current series with single-detector helical CT and MDCT revealed the transverse fracture on transaxial images as a gradual radiolucency through the pedicles. From anterior to posterior, there is progressive loss of definition of the pedicle, a sign that we refer to as the “dissolving pedicle,” observed in 76% of our patients. The dissolving pedicle sign was seen almost twice as often as the naked-facet sign (40%).

Confirmation of the CT diagnosis, however, lies in the sagittal and coronal reformations. Sagittal CT reformations more clearly and accurately depict the radiographic signs as seen on the lateral projection. Thus, the progression of injury from the posterior column of the thoracolumbar spine can be followed anteriorly. Coronal reformations similarly improve on the AP radiograph by more clearly depicting the transverse fracture through the posterior elements.

MRI evaluation provides information regarding the integrity of the posterior and middle column ligaments, annulus fibrosis, and spinal cord in neurologically injured patients. MRI may also reveal the presence of disk herniations and epidural hematomas. T2-weighted and inversion recovery images are best to assess soft-tissue edema, a bone bruise, and spinal cord injury. Ligamentous integrity is optimally seen on proton density–weighted images.

The Chance–Burst Fracture

Almost half the patients in our series showed buckling or frank retropulsion of the posterior vertebral body cortex, consistent with an associated burst component to their Chance-type fracture. Gertzbein and Court-Brown [4] noted the occurrence of this combination in 15% of patients in their 1988 series. Since that publication, no additional reports of this Chance–burst subtype have appeared in the English-language literature, to our knowledge. The majority of the 20 patients Gertzbein and Court-Brown evaluated underwent radiography only, with CT reserved for only those with suspected spinal canal compromise. Screening CT of all thoracolumbar fractures may indeed have found more cases of this type—in particular, those with subtle posterior cortex buckling that is less evident on radiography. Furthermore, case reports and smaller series of Chance fractures suggest the presence of unrecognized burst components. In his review of six such fractures, Rogers [8] reported that a burst component was depicted on a radiograph in one patient, similar to the findings in the series of Rennie and Mitchell [10]. A recent T3 Chance fracture case report by Davis et al. [40] clearly shows retropulsion of fracture fragments into the spinal canal. Interestingly, in each of these examples, the patient had a spinal cord injury.

The diagnosis of a burst component to the Chance fracture may be of major import on injury management. Application of an extension cast in a patient with a retropulsed burst fracture component may cause further posterior displacement with the potential for spinal cord injury or progression [41]. The degree of instability will dictate management, and Gertzbein and Court-Brown [4] recommend that distraction rods, rather

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TABLE 6: Review of Chance Fracture Literature for Chance Fractures and Associated Intraabdominal Injuries

Study		No. of Patients with a Fracture	Type of Fracture	No. (%) of Patients with Intra-abdominal Injury	Comments
Authors [reference no.]	Year of Publication				
Chance [1]	1948	3	Chance	0 (0)	
Howland et al. [5]	1965	1	Chance	0 (0)	
Smith and Kaufer [6]	1969	20	Chance	3 (15)	
Ritchie et al. [7]	1970	3	Chance	2 (66)	
Rogers [8]	1971	5	Chance	4 (80)	
Dehner [9]	1971	7	Chance	3 (43)	
Rennie and Mitchell [10]	1973	2	Chance	1 (50)	
Gumley et al. [11]	1982	20	Chance	8[a] (40)	
LeGay et al. [12]	1990	18	Flexion–distraction	7 (39)	
Reid et al. [13]	1990	7[b]	Chance	3 (43)	Pediatric
Green et al. [14]	1991	16	Flexion–distraction	7 (44)	Diagnosis of fracture was delayed in 5 of 7 patients
Anderson et al. [15]	1991	20	Chance	13[c] (65)	18 pediatric
Rabinovici et al. [16]	1999	258	Not specified	26 (10)	

[a] Bowel, $n = 4$; pancreas, $n = 3$.
[b] Six were wearing a seat belt.
[c] Bowel, $n = 12$.

TABLE 7: Review of Abdominal Injury Literature for Chance Fractures and Associated Intraabdominal Injuries

Study		No. of Patients	No. (%) of Spinal Fractures	Type of Fracture	Comments
Authors [reference no.]	Year of Publication				
Backwinkel [17]	1968	2	1	Chance	
Ritchie et al. [7]	1970	3	2	Chance	
Arajarvi et al. [18]	1987	42[a]	4 (10)	Not specified	All thoracolumbar fractures included
Appleby and Nagy [19]	1989	36[a]	7 (19)	Not specified	All lumbar spine fractures included
Rutledge et al. [20]	1991	531	27 (5)	Not specified	All lumbar spine fractures included
Beaunoyer et al. [21]	2001	18[a]	13	Chance	Pediatric
Inaba et al. [22]	2001	5[b]	3	Chance	

[a] Motor vehicle collision with lap belt.
[b] With injuries to the abdominal aorta.

than Harrington rods, are more appropriate. They further add that patients with spinal canal compromise may benefit from anterior decompression.

Pathogenesis and Mechanism of Injury

In his original publication, G. Q. Chance [1] declared a flexion mechanism responsible for this horizontal fracture pattern, although he could not “think of any anatomic explanation of the peculiar site and direction of the fracture.” Smith and Kaufer [6] explained that the lap seat belt serves as the fulcrum, or axis of rotation, at the anterior abdominal wall, thus subjecting all spinal elements to flexion and distraction or tension forces. This theory explains the high frequency of associated intraabdominal injuries, but it does not account for the presence of compression or burst components. Rennie and Mitchell [10] placed the axis of rotation in line with the posterior longitudinal ligament to account for anterior compression and posterior distraction. Begeman et al. [42] conducted a cadaver study examining sudden deceleration effects on spinal loading while seat belted. Increasing axial loads occurred in direct proportion with higher-velocity sudden decelerations. The spinal column underwent an initial axial load phase, followed by flexion, and finally axial loading again as the body was thrown back into the seat. Gertzbein and Court-Brown [4] postulate that the compression fracture component of the Chance fracture probably occurs at the initial axial load but that the burst is the result of the final axial load, after the spine has already suffered the Chance fracture during the flexion phase of injury.

We hypothesize that the fulcrum, or axis of rotation, begins at the site of the lap belt or other object pressed against the anterior abdominal wall at the time of impact and sudden deceleration. As the spinal column begins to fail in tension, from posterior to anterior, the axis of rotation migrates from anterior to posterior. That is, once the interspinous ligaments tear or the spinous process fractures such that the posterior column fails in distraction and a flexion deformity results, the biomechanics begin to change. The initial flexion and distraction forces begin to invoke an axial loading, or vertical component, driving the effective fulcrum posteriorly from the anterior abdominal wall. With enough focal kyphosis, the axis of rotation migrates behind the anterior vertebral body cortex into the anterior column allowing anterior compression. With greater deceleration forces, the axial load further increases and the axis of rotation migrates beyond the posterior longitudinal ligament beyond the middle column allowing the vertebral body to burst (Fig. 8). In this manner, all three columns fail by initial flexion and distraction and subsequently axial loading, resulting in an unstable injury. With greater forces, the Chance fracture becomes the Chance–burst combination injury, increasing the likelihood of bone retropulsion and spinal cord injury.

Conclusion

Chance-type fractures are unstable injuries that may be subtle radiographically, and patients may present without neurologic deficit. Intraabdominal injuries occurred in 40% of these flexion–distraction thoracolumbar fractures, which is slightly lower than previously reported, and almost half of the patients in our study with this injury display a burst-type component that could have a significant influence on surgical management. Evaluation of the posterior elements on radiographs and the dissolving pedicle sign on transaxial CT can assist in recognition of this injury.

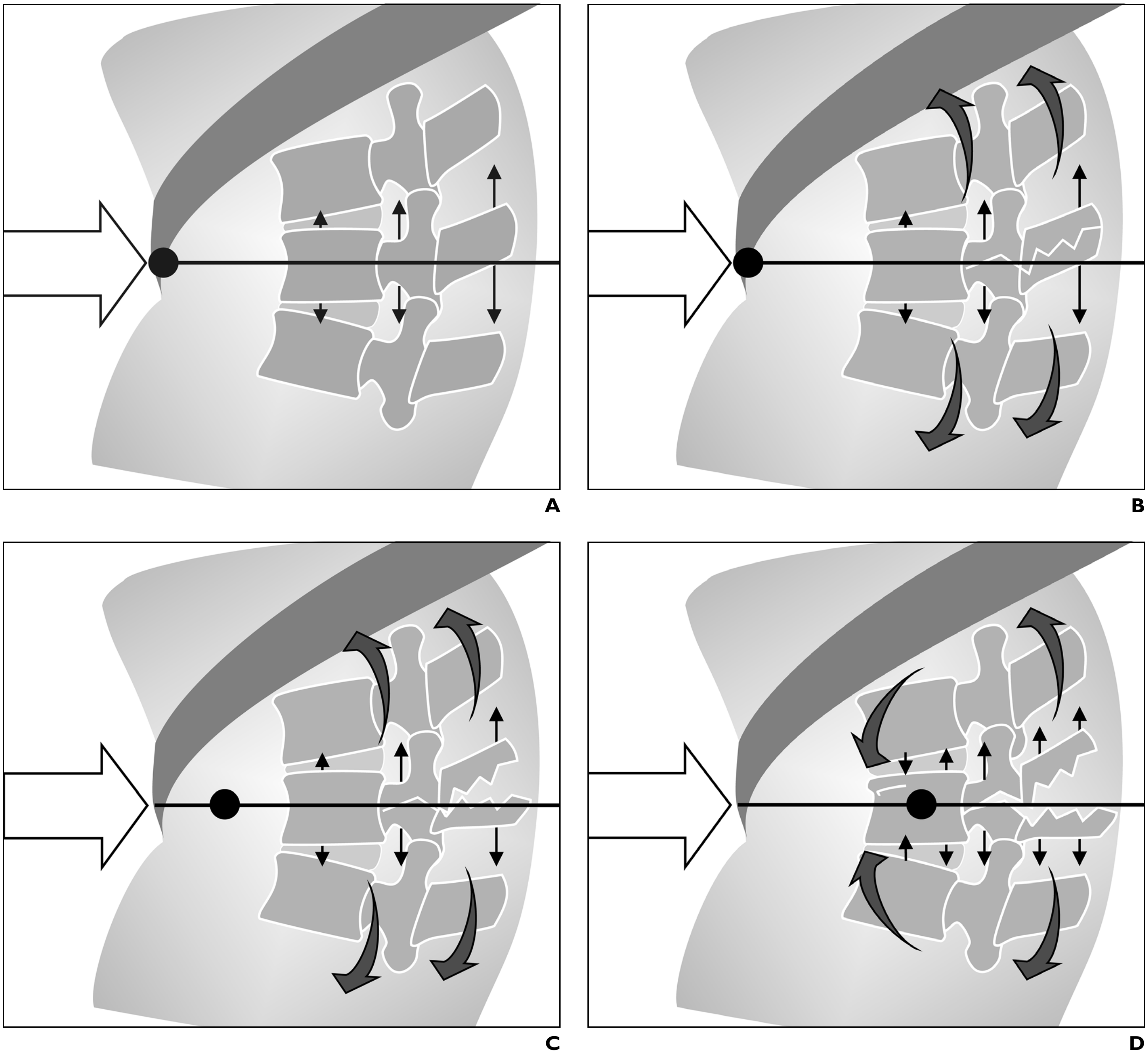

Fig. 8—Diagrams show proposed mechanism of injury for Chance-type fractures. White arrow shows point of contact of seat belt and abdomen, and straight black arrows depict forces. Black circle represents axis of rotation.

A, Representative segment of lumbar spine is illustrated in abdomen restrained by seat belt. On sudden deceleration, point of contact of seat belt and abdomen serves as fulcrum, or axis of rotation, about which all structures posterior are subject to flexion and distractive forces.

B, With enough force, bone integrity is overcome and horizontal Chance fracture results. Curved arrows show axis of rotation.

C, With weakening of fractured spine, initial flexion–distraction force begins to involve an axial load component, driving axis of rotation (*curved arrows*) posteriorly.

D, Once axis of rotation (*curved arrows*) moves posterior to anterior vertebral body cortex, compression begins.

(Fig. 8 continues on next page)

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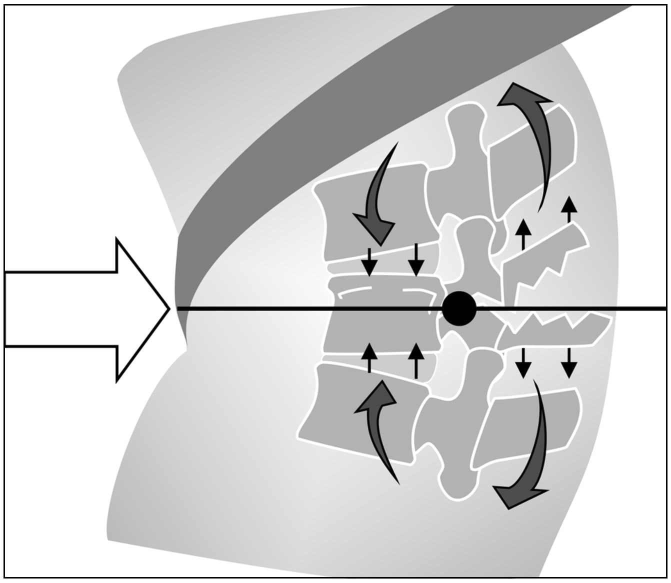

E

Fig. 8 (continued)—Diagrams show proposed mechanism of injury for Chance-type fractures. White arrow shows point of contact of seat belt and abdomen, and straight black arrows depict forces. Black circle represents axis of rotation.
E, With ongoing force, axis of rotation (*curved arrows*) continues to migrate posteriorly in further weakened spine allowing greater axial loads that ultimately cause vertebral body to burst.

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