AJNR

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AJNR Am J Neuroradiol 1985, 6 (3) 337-341
http://www.ajnr.org/content/6/3/337

Thoracolumbar Burst Fractures: CT Dimensions of the Spinal Canal Relative to Postsurgical Improvement

William P. Shuman[1]
James V. Rogers[2]
Mary E. Sickler[1]
James A. Hanson[1]
James P. Crutcher[3]
Howard A. King[4]
Laurence A. Mack[1]

Cross-sectional spinal canal area was measured before and after surgery in 12 patients with thoracolumbar burst fractures and canal narrowing caused by retropulsed fragments. Patients were classified into Denis type A or type B. Denis type A fractures have comminution of both end-plates of the vertebral body creating multiple smaller fractures; Denis type B fractures have comminution of the superior end-plate only with a single vertical fracture line into the inferior end-plate creating larger fragments. The degree of neurologic impairment was assessed before and after surgery using the Frankel system. There was no correlation between degree of canal narrowing and degree of neurologic impairment. The degree of spinal canal narrowing reflects the final resting position of the vertebral body fragments after trauma; during trauma, greater degrees of canal impingement may have occurred. Also, significant canal narrowing may be present without pinching of the cord or cauda equina. All patients with Denis type A fractures had near-anatomic reduction of fragments out of the spinal canal by surgery; less than half of the patients with Denis type B had good reduction. There was no correlation between reduction of retropulsed fragments and subsequent neurologic improvement. However, this should not preclude surgery as a therapeutic option: Eight of 10 patients with neurologic impairment experienced some improvement in symptoms after surgery; the other two were unchanged.

Thoracolumbar burst fractures result from severe axial loading of the spine with or without flexion, usually due to rapid deceleration (fall, motor vehicle accident). They are relatively rare but frequently result in neurologic damage due in part to retropulsed fragments that narrow the spinal canal. Surgical intervention with distraction Harrington rod placement and spinal fusion may partly or completely reduce fragments out of the spinal canal. Whether this fosters neurologic recovery is controversial. To assess relations between retropulsed fragments and neurologic impairment we quantitatively measured the spinal canal area before and after surgery in 12 patients with thoracolumbar burst fractures. We found no correlation between initial degree of canal narrowing and degree of neurologic impairment. In addition, we found that, while the fracture pattern may predict the degree of improvement in cross-sectional canal area after surgery, there was no correlation between such improvement and neurologic recovery.

Materials and Methods

Between September 1980 and August 1983, 17 patients were treated operatively at Harborview Medical Center for thoracolumbar burst fracture of a single vertebral body by distraction Harrington rod placement in all patients and short spinal segment fusion in some patients. On retrospective review, 12 of these had pre- and postoperative spinal computed tomographic (CT) examinations available. Of these 12, injuries were secondary to motor vehicle accidents in three, to fall from height in eight, and to ski injury in one. Eight of the patients were men; four were women. The mean age was 33 years (range, 23–58). Ten of the patients had some degree of neurologic impairment ranging from dysesthesia to incom-

This article appears in the May/June 1985 issue of *AJNR* and the August 1985 issue of *AJR*.

Received April 9, 1984; accepted after revision August 3, 1984.

[1] Department of Radiology SB-05, University Hospital, University of Washington, Seattle, WA 98195. Address reprint requests to W. P. Shuman.

[2] Department of Radiology, Harborview Medical Center, University of Washington, Seattle, WA 98104.

[3] School of Medicine, University of Washington, Seattle, WA 98195.

[4] Department of Orthopedic Surgery, Harborview Medical Center, University of Washington, Seattle, WA 98104.

***AJNR* 6:337–341, May/June 1985**
0195–6108/85/0603–0337

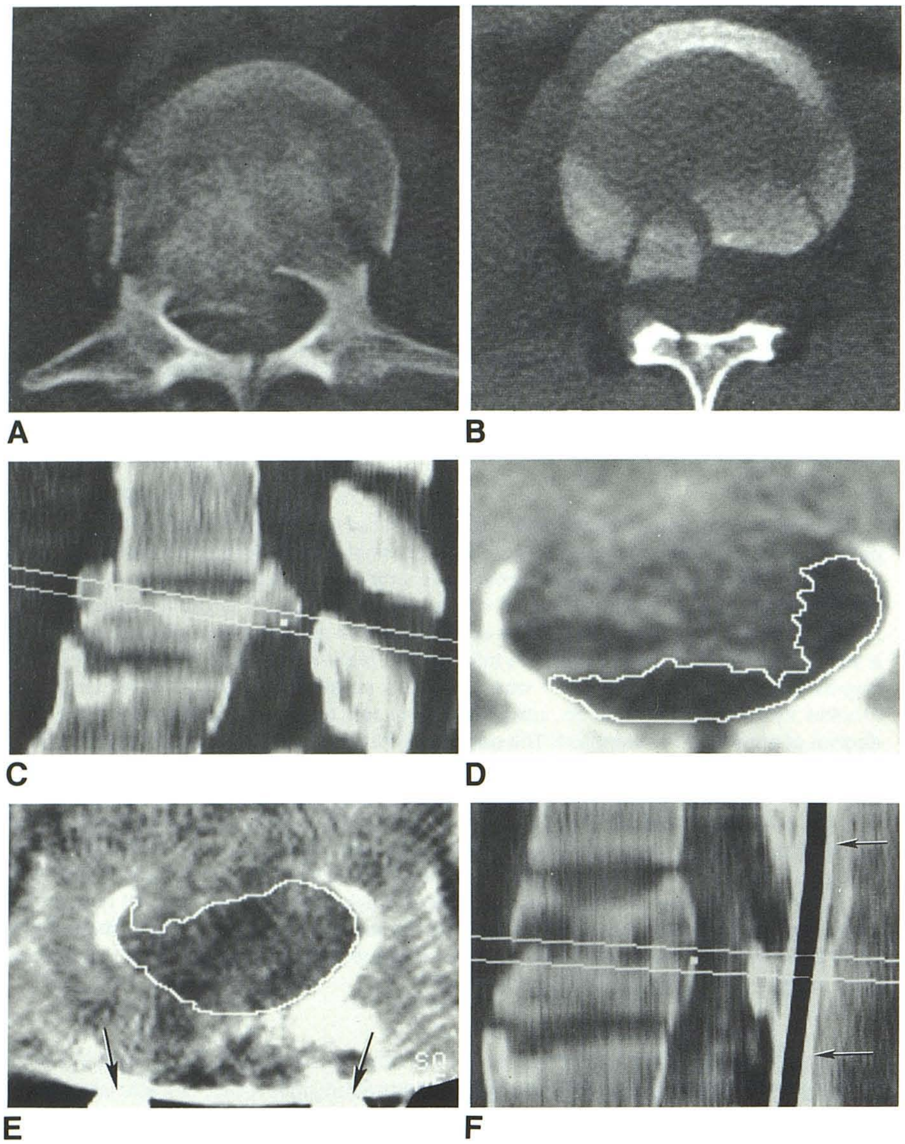

Fig. 1.—Denis type A fracture. **A** and **B**, Extensive comminution of vertebral body and retropulsed bone fragment. **C**, Sagittal reconstruction. Retropulsed fragment in spinal canal. *White lines* are plane of measurement of spinal canal area. **D**, Preoperative spinal canal area measurement using irregular region of interest (trace mode). **E**, Postoperative spinal canal area measurement. Considerable reduction of retropulsed fragments. Harrington rods (*arrows*). **F**, Postoperative sagittal reconstruction. Considerable reduction of fragments out of spinal canal. Harrington rod (*arrows*).

plete motor loss. Neurologic loss was assessed using the Frankel classification system [1] preoperatively and at follow-up (range, 3–36 months; average, 22 months). The Frankel classification has five categories of impairment: A, complete—both motor and sensory loss below lesion; B, sensory only—some sensation present below lesion but complete motor loss; C, motor useless—some motor power present below lesion but of no practical use; D, motor useful—useful motor power present below level of lesion; and E, recovery—patient free of neurologic symptoms.

Pre- and postoperative spinal CT examinations were reviewed on the CT console from magnetic-tape-stored data by two of the authors (J. V. R. and M. E. S.). Postsurgical studies were performed 4 days to 36 months after surgery (average, 10 months). Studies were performed on a GE 8800 CT scanner using 5-mm-thick slices spaced 3 or 5 mm apart through the area of interest as defined by initial plain-film radiographs. All images were enlarged using prospective or retrospective ReView (General Electric, Milwaukee, Wisconsin) and bone algorithm.

Spinal canal cross-sectional area was measured at a window of 1000 using operator-controlled trace mode and computer calculation of pixel size. Measurements were performed at the level of the greatest narrowing (perpendicular to the spinal canal) determined from a midplanar sagittal reconstruction image (Arrange, General Electric) (fig. 1C). Measurements were obtained three separate times in each study by three separate observers at the fracture level before and after surgical intervention for a total of 18 measurements per patient (figs. 1D, 1E, 2C, and 2D). In addition, one observer measured the spinal canal area of the vertebral body above and the vertebral body below three times each and averaged these measurements to provide an estimation of the preinjury area of the canal at the level of injury.

Vertebral body fractures were classified by unanimous agreement among five of the authors (W. P. S., J. V. R., M. E. S., J. P. C., and H. A. K.) using a classification system for burst fractures proposed by Denis [2]. In this system, a type A fracture has comminution of both superior and inferior end-plates (figs. 1A and 1B); a type B

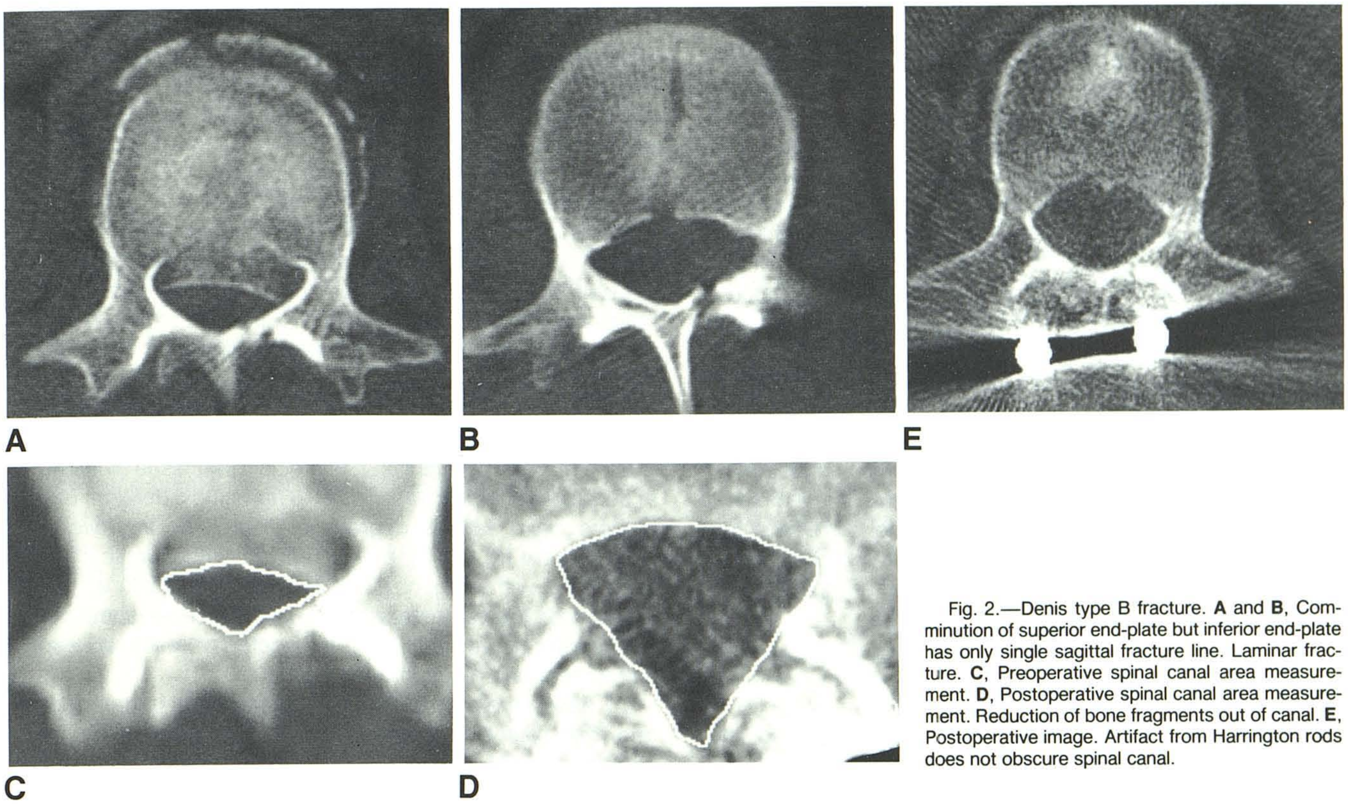

Fig. 2.—Denis type B fracture. **A** and **B**, Comminution of superior end-plate but inferior end-plate has only single sagittal fracture line. Laminar fracture. **C**, Preoperative spinal canal area measurement. **D**, Postoperative spinal canal area measurement. Reduction of bone fragments out of canal. **E**, Postoperative image. Artifact from Harrington rods does not obscure spinal canal.

TABLE 1: **Pre- and Postoperative CT Measurements of Thoracolumbar Burst Fractures**

Denis Type: Case No., Fracture Level	Average Narrowing (%)		Frankel Classification	
	Preop	Postop	Preop	Postop
A:				
1, L3	46	11	E	E
2, L1	54	28	D	D
3, T11	59	31	D	E
4, L1	49	0	C	D
5, L1	71	23	D	E
B:				
6, L1	31	6	C	D
7, L1	44	7	E	E
8, L1	64	38	D	E
9, L1	87	55	D	E
10, T12	63	54	D	E
11, L1	77	0	D	E
12, L1	61	41	D	D

fracture has comminution of the superior end-plate only with a single vertical fracture line extending to and through the inferior end-plate (figs. 2A and 2B).

Surgical therapy involved relatively long distraction-type Harrington rod placement and short spinal fusion in the region of the single vertebral body burst fracture. In one case, operative manipulative reduction of a retropulse fragment was performed. In all other cases, any reduction of the retropulse fragment occurred as a result of the distraction Harrington rod placement.

TABLE 2: **Pre- and Postoperative CT Measurements of Thoracolumbar Burst Fractures by Denis Type**

Denis Type, No.	% Average Narrowing (Range)		Change
	Preoperative	Postoperative	
A, 5	56 (46–71)	19 (0–30)	−37
B, 7	61 (31–87)	29 (0–55)	−32

Results

Interobserver variation among the three observers averaged 4.6% (range, 1.4%–7.9%). Intraobserver variation among the three measurements by each observer averaged 2.6% (range 0.6%–4.7%). Neither figure was believed to be large enough to compromise this technique for CT measurement of canal area.

Five of the fractures were classified as type A in the Denis system; seven were classified as type B (tables 1 and 2). In the type A patients, the cross-sectional area of the spinal canal was narrowed initially by an average of 56% (range, 46%–71%). In the type B patients the cross-sectional area was narrowed initially by an average of 61% (range, 31%–87%). Postoperatively the narrowing was reduced in the type A patients to an average 19% (range, 0–30%); the narrowing was reduced in the type B patients to an average 29% (range, 0–55%). The difference between these two groups is not very statistically significant ($p = 0.30$). However, all type A patients experienced significant improvement in spinal canal cross-sectional area, considered to be good anatomic reduction of the retropulsed fragments by the surgeons. Of the type B patients, three had significant improvement in spinal canal cross-sectional area, considered to be good anatomic reduction; two had some improvement in spinal canal area, considered to be fair reduction; and two had little improvement in spinal canal area considered to be poor reduction of the retropulsed fragments. Nine of the 12 patients had posterior element fracture in addition to burst fracture of the vertebral body.

Eight of 10 patients who had neurologic impairment experienced some improvement of their symptoms after surgery; the other two were unchanged. There was no correlation between severity of initial neurologic impairment as judged by the Frankel classification system and degree of spinal canal narrowing ($r = 0.1$). Similarly there was no correlation between degree of improvement in neurologic impairment and degree of improvement in the postoperative spinal canal cross-sectional area ($r = 0.02$).

Discussion

Thoracolumbar spine fractures have been classified into several types including wedge-compression fracture, Chance fracture, flexion-distraction injury, translational injury, and burst fractures [3]. Burst fractures may be further classified into stable and unstable, based on whether the posterior elements are involved [3]. There is some controversy with this subclassification, however, since some unstable burst fractures with intact posterior elements have been reported [4]. Regardless, unstable burst fractures have a greater tendency for progressive posttraumatic kyphosis and progression of neurologic symptoms [3]. Burst fractures are relatively rare: they constitute about 1.5% of spinal fractures [5].

Most burst fractures exhibit comminution of the superior end-plate. Fragments that protrude into the spinal canal almost always originate from the posterosuperior corner of the vertebral body [6]. The comminution of the superior end-plate may extend throughout the vertebral body and include comminution of the inferior end-plate. Alternatively, the superior end-plate comminution may coalesce as it extends inferiorly into a single vertical fracture line that exits out the inferior end-plate. The central vertebral vein enters the vertebral body posteriorly near the inferior edge of the pedicles in the midline; this may provide a weak point with which the single vertical component of the fracture aligns [6]. Whether the superior comminution extends inferiorly as a comminution of the inferior end-plate or as a single fracture line defines, respectively, Denis type A and Denis type B fractures. Denis [2] believed type A injuries resulted primarily from severe axial loading of the spine, while type B resulted from combined axial loading and flexion.

The thoracolumbar region (T12–L2) is particularly vulnerable to traumatic fracture. Above this region the apophyseal joints overlap to limit extension, and the rib articulations (costotransverse and costovertebral) provide additional stability [7]. Below this region the vertebral bodies are larger, the intraspinous and supraspinous ligaments are stronger, and the action of the psoas serves to reinforce [8]. At the thoracolumbar region, however, the facet joints rotate from the coronal into the sagittal plane, allowing more flexion, extension, and sliding motion during trauma [7].

Treatment of burst fractures has been controversial for some time. Most authors advocate surgical stabilization to lessen patient discomfort, promote early ambulation, decrease morbidity associated with prolonged bed rest, shorten hospitalization time, and prevent progressive kyphosis [5, 8–11]. Others have found no significant difference in hospitalization time or short-term morbidity between surgical and nonoperative (bed rest and external bracing) therapy [12].

Whether surgical intervention improves neurologic outcome is even more controversial. It is a significant issue since 40% of thoracolumbar fractures result in neurologic defects. Some authors claim various degrees of neurologic improvement after surgery [5, 8, 10]; others report no neurologic change associated with surgery [12, 13]. Brant-Zawadzki et al. [7] suggested that recoverability may be related to whether the cord and/or nerve roots were transected or mere nerve-root entrapment had resulted from the trauma.

CT assessment of thoracolumbar fractures is more accurate than plain-film assessment [14]. Compared with linear tomography, CT takes less time, requires less patient movement, and delivers less radiation dose [15–18]. CT can miss horizontal fractures, and, even with sagittal and coronal reconstructions, may not depict all alignment abnormalities. However, no other imaging method demonstrates retropulsed fragments and resultant narrowing of the spinal canal as well as CT. The presence of metallic Harrington rods does not impair postoperative measurement of the canal [19] (figs. 1F and 2E).

Our technique for measuring the spinal canal has been reported before [20]. We found little inter- and intraobserver variation and believed this technique was reliable and reproducible. We also believed that averaging the cross-sectional canal area of the uninjured vertebral bodies above and below provided a reasonable assessment of the preinjury cross-sectional spinal canal area at the fracture level; change in cross-sectional canal area through this region is linear when that area is measured at the same relative point on each vertebral body [20]. There was no difficulty in classifying the fractures into Denis type A or B; unanimity among the observers was easily achieved.

Our results suggest that good operative reduction of retropulsed fragments can be expected in patients with Denis type A fractures. Results with Denis type B fractures are less predictable. We speculate that Denis type A fractures (multiple small fragments) may be reduced more readily by distraction Harrington rods than Denis type B (several larger fragments) because it is easier to get many small pieces of bone back into the volume previously occupied by the intact vertebral body than it is to get several larger fragments reduced and realigned.

We agree with those authors who report no correlation between degree of neurologic impairment and degree of spinal canal narrowing preoperatively [3, 7, 9]. The degree of spinal canal narrowing reflects the final resting position of the vertebral body fragments after the trauma; during the trauma event, greater degrees of canal impingement may have occurred. Similarly, significant canal narrowing may be present without pinching of the cord or cauda equina.

We also found no significant correlation between degree of improvement in spinal canal cross-sectional area and degree of eventual neurologic recovery. This suggests that several other variables (edema, hemorrhage, nerve versus cord transection) in addition to spinal canal narrowing are determinants in how much recovery of function is possible. However, surgery is valuable because it makes mobilization of the patient easier and may shorten total hospitalization time. Reduction of fragments and immobilization of the spine may also prevent subsequent development of spinal stenosis due to bony overgrowth and subsequent worsening kyphosis.

ACKNOWLEDGMENTS

We thank Debra Burch, George Rine, Larry Fetke, and Betsy Munk for their assistance.

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