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The Load Sharing Classification of Spine Fractures

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Study Design. A 3 to 4 year follow-up was performed on a consecutive series of 28 patients who had three-column spinal fractures surgically stabilized by short-segment instrumentation with first generation VSP (Steffee) screws and plates and autograft fusion. The follow-up revealed 10 patients with broken screws.

Background Data. Retrospective examination of preoperative radiographs and computed tomographic axial and sagittal reconstruction images clearly demonstrated that the screw fractures all occurred in patients with a disproportionately greater amount of injury to the vertebral body.

Results. A point system (the load sharing classification) was developed that grades: 1) the amount of damaged vertebral body, 2) the spread of the fragments in the fracture site, and 3) the amount of corrected traumatic kyphosis.

Conclusions. This point system can be used preoperatively to: 1) predict screw breakage when short segment, posteriorly placed pedicle screw implants are being used, 2) describe any spinal injury for retrospective studies, or 3) select spinal fractures for anterior reconstruction with strut graft, short-segment-type reconstruction. [Key words: load-sharing classification, short segment instrumentation] **Spine 1994;19:1741–1744**

In the past, thoracic and lumbar spine fractures have been treated with cast or brace immobilization or long segment (several levels above and below) instrumentation and fusion. The introduction of pedicle screw-related implants has resulted in the ability to perform short-segment (one level above and below) instrumentation and fusion from the posterior approach to preserve motion segments.[3,6] However, despite the resulting improvement in sagittal alignment and correction of deformity, recent reports have revealed complications associated with short-segment instrumentation and fusion—i.e., pseudofusion, recurrence of kyphotic deformity, and screw bending or fracture.[4,5,7,8]

After 5 years' experience (1986–1991) with short-segment spinal fracture instrumentation with VSP screws and plates that included treating several patients who had screw fractures, we reviewed a consecutive series of patients to determine the causes of screw fracture and loss of correction.

Our laboratory experience with the load-sharing characteristics of various spinal fracture implant constructs suggested that the anatomy of the fracture itself was more important than the implants being used.[2] We retrospectively examined the load-sharing characteristics of the fractures of a consecutive series of patients on whom surgery was performed between March 1986 and March 1988. This review demonstrated an impelling relationship between the amount and characteristics of injury in the most injured vertebra and the success of posterior short-segment instrumentation with VSP plates and screws. Appreciation of this relationship led to a new fracture classification.

Materials and Methods

From March 1986 to March 1988, a consecutive series of 28 patients with three-column fractures or fracture-dislocations of the thoracic and thoracolumbar spine were treated with VSP plates, pedicle screws, and intertransverse fusion at the University of Missouri Hospital. All patients were treated with short-segment instrumentation one level above and one level below the injured vertebrae with VSP plates and first generation nonintegral-nut VSP screws. All procedures were performed within 2 weeks of injury; 21 were performed within 1 week of injury.

The three-column classification description of these injuries is shown in Table 1. Eleven of the patients were female, 17 were male. Their ages ranged from 19 to 47 years.

All patients underwent bone grafting posteriorly with autograft. All patients used a thoracolumbosacral orthosis, and had significant activity restriction, for 2 to 4 months postoperatively.

The average length of follow-up was 4 years. The minimum follow-up was 3 years on all patients.

Preoperative plain radiographs, tomograms, and sagittal and axial computed tomography (CT) scans were reviewed regarding three separate characteristics of the fracture site: 1) the amount of vertebral body actually comminuted by the injury, as best seen on sagittal CT reconstructions of the fracture site, 2) the apposition of the fracture fragments at the fracture site, as best seen on axial CT cuts through the fracture site, and 3) the amount of correction of kyphotic deformity, as best measured by comparing preoperative and postoperative plain films. (Figures 1A, B, C).

Each of these three factors was subdivided into three degrees of severity. A point value system was used to grade

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Table 1. Classification of Fractures in This Series

Burst Fractures		Fracture/Dislocation		Flexion/Distraction	
Level	n	Level	n	Level	n
T12	3	T12	2	L2	2
L1	11	L1	1	L1	1
L2	1	L2	1		
L3	2				
L4	3				
L5	1				

severity—one point for mild, two points for moderate, and three points for severe.

The amount of comminution/involvement was assessed—one point for comminution when 30% or less of the vertebral body was broken on sagittal CT reconstruction images; two points for 30% to 60% comminution of the body; and three points for greater than 60% comminution.

The amount of apposition/displacement of fracture fragments was assessed—one point for 0 to 1 mm displacement; two points for at least 2 mm of displacement in less than 50% of the cross-sectional area of vertebral body as viewed by CT; and three points for 2 mm or greater displacement in over 50% of the cross-sectional area.

Finally, the amount of correction of kyphotic deformity was assessed—one point for 3° or less correction; two points for 4° to 9° of correction; and three points for 10° or more correction.

■ Results

During the follow-up period, 10 of the 28 patients showed evidence of screw breakage, demonstrated by routine follow-up radiography, re-exploration of the fusion mass with implant removal, or both. Only one patient lost reduction because of screw fracture. The remaining nine patients' screw fractures were minimally displaced. Most were not visible upon radiography, but were identified during implant removal.

Using the load-sharing classification system, all 10 of the fractures that showed evidence of screw fracture in our follow-up had point totals of seven or more, and five of the 10 patients had nine points—the greatest number possible. There were no screw fractures in patients with point totals of six or less (Table 2).

■ Discussion

In long-bone fracture fixation, load sharing between the implant system and host bone is a fundamental principle that encourages excellence of bony apposition at any internally fixed fracture site to permit healing and prevent implant failure. The surgical treatment of acute thoracic and lumbar spine fractures also must include load sharing. In the absence of load sharing, hardware failure and nonunion rates greatly increase. With this in mind, we examined the preoperative and postoperative plain radiographs, tomograms, and CT scans of our consecutive series of patients with thoracic and thoracolumbar fractures.

All three factors used in our system describe, in different ways, the damage done to the anterior column during the injury.

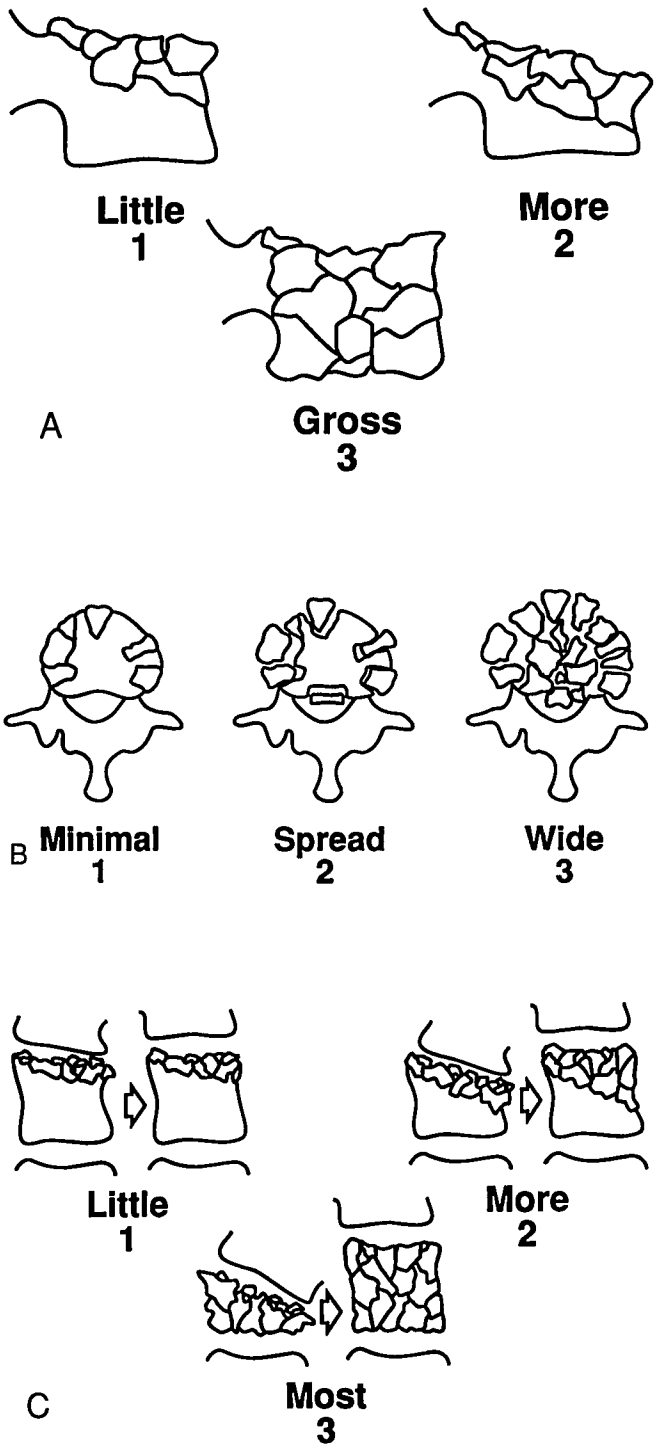

Figure 1. The load-sharing classification. (A) Comminution/involvement. Little (1) = <30% comminution on sagittal plane section CT. More (2) = 30% to 60% comminution. Gross (3) = >60% comminution. (B) Apposition of fragments. Minimal (1) = minimal displacement on axial CT cut. Spread (2) = at least 2 mm displacement of <50% cross-section of body. Wide (3) = at least 2 mm displacement of >50% cross-section of body. (C) Deformity correction. 1 = kyphotic correction ≤3° on lateral plain films. 2 = kyphotic correction 4° to 9°. 3 = kyphotic correction ≥10°.

Table 2. Load Sharing Classification Scores of Patients in This Series

Patient	Comminution/ Involvement of Body	Apposition of Fragments	Deformity (degrees corrected)	Point Scores
1.	1	1	2 (5)	4
2.	1	1	3 (11)	5
3.	3	2	2 (4)	7
4.	3	3	1 (1)	7
5.	3	3	3 (10.0)	9*
6.	2	2	2 (7)	6
7.	3	3	2 (4)	8
8.	3	3	3 (10)	9*
9.	1	1	1 (1)	3
10.	3	2	3 (14.5)	8
11.	3	3	3 (17)	9*
12.	3	3	3 (26)	9*
13.	3	3	2 (8)	8
14.	1	2	2 (4)	5
15.	2	3	3 (15)	8*
16.	2	2	2 (4)	6
17.	2	2	3 (17.5)	7
18.	2	3	3 (33)	8
19.	3	3	3 (18.5)	9*
20.	3	3	1 (3)	7*
21.	1	1	2 (8)	4
22.	3	3	3 (11.5)	9
23.	3	3	2 (8.5)	8*
24.	2	2	3 (14)	7*
25.	3	2	3 (16.5)	8*
26.	3	3	3 (18)	9
27.	2	2	2 (8)	6
28.	2	2	2 (9)	6

* Screw fracture.

The amount of involvement/comminution factor determines the amount and extent of comminution of the most injured vertebra. The supposition here is that vertebral fragments do not transfer load as well as an intact vertebra.

The apposition/displacement of the fragments component of the system assesses the ability of fracture fragments to load share and heal, if they are in apposition. The wider the fracture fragments are displaced, the more poorly they transmit load. If displacement is wide enough, as seen in some particularly grotesque injuries, they may not even heal.

The correction of the kyphotic deformity component of this classification quantitates the gap in the anterior column that occurs when the traumatic kyphosis associated with more severe burst fractures is corrected. This fracture site gap has been beautifully described by DeWald[1] and others. When severe traumatic kyphosis due to vertebral body injury is well corrected, this gap is unavoidable. The creation of such a gap totally eliminates anterior column load sharing and exposes pedicle screw implants to the highest possible cantilever bending loads.[5,9]

Using the three-point system to quantitate the three factors involved in our fracture classification meant that every fracture could be graded from a minimum total of three points to a maximum total of nine points. The clinical patient review documented the ability of our classification to predict screw breakage. All of the spine injuries that showed screw fractures had preoperative point totals of seven or more. In contrast, there were no screw fractures, at a minimum 3 year follow-up, when short segment instrumentation with first generation VSP screws and plates and fusion was used to treat spine fractures that had point totals of six or less.

Note that this classification does not grade ligament damage in any way. For this reason, it cannot be used to make decisions on surgical indications, because ligamentous disruption is a fundamental component of operative indications. Similarly, it has nothing to do with mechanism of injury, unlike every previously reported classification.

There is no question that some of the flexion/distraction (tension/failure) injuries in our series would have been treated nonoperatively by some surgeons. However, because short-segment instrumentation was available, and body casting was unnecessary, we believed we were fully justified in treating these patients operatively, so they could wear a light brace for 6 to 8 weeks rather than wear a cast for 3 to 4 months. In addition, we are confident that the quality of reduction of some flexion-distraction injuries was much better than we could have achieved nonoperatively, although our sample size was insufficient to statistically prove this point.

Thus, our preoperative analysis of bony fracture anatomy can be very useful in determining successful candidates for posterior short-segment instrumentation and fusion with pedicle screws and plates.

Our best candidates for the short-segment posterior approach were patients with flexion-distraction injuries or mild burst fractures or fracture/dislocations with point totals of six or less. The poor candidates were patients with burst fractures or fracture/dislocations with severe comminution of the associated vertebral body and point totals of seven or more.

Since this study was completed—although some surgeons have used transpedicular grafting—we have used short-segment anterior vertebrectomy, instrumentation, and strut graft fusion with the Kaneda device for patients with severe (scores greater than or equal to seven points) burst fractures. We use short-segment posterior pedicle screw instrumentation and fusion, and second stage anterior vertebrectomy and strut fusion for our patients with severe fracture/dislocations.

The combination of our classification, second generation pedicle screws, and anterior short-segment procedures for treating high-point-total injuries has made short-segment instrumentation and fusion the spine reconstruction of choice for younger, more active patients. We have had no screw fractures of any implant, anterior or posterior, since 1988.

Our only candidates for long-segment instrumentation and fusion are patients who are not able to benefit

from short-segment instrumentation—i.e., elderly patients who would not use spinal mobility or patients who are unable to tolerate a two stage reconstruction because of acute (traumatic) or chronic cardiopulmonary problems.

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