INSTABILITY OF THE SPINE FRACTURE

E. ALICI * H. BERK * A. KARAKAŞLI * S. GÖÇEN *

ABSTRACT:

The detection of instability in spinal fractures is determining factor in the treatment of these cases.

In this report the acute instability resulted from the spinal fracture is discussed. We tried to define "instability" according to our clinical experience and literature. In conclusion we defined "instability" as the position of a motion - segment under and function which disturbs the neurological structures.

Key Words: *Spine fracture, Instability.*

The stability of the spine with respect to onset of yielding and probable fracture can be predicted if the mechanical behavior is known (1). A useful classification of spine fractures must be both simple and complete, reflect an understanding of the mechanisms of injury, correspond to the pathologic anatomy, determine the treatment options, and be relevant to the prognosis (2). There are many different opinions in the case (3).

Nicoll, proposed that anterior and lateral wedge fractures were stable, and fracture subluxation and fracture dislocations were unstable (4).

Holdsworth suggested a mechanistic classification rather than one based on anatomy. He postulated multiple injury mechanism including flexion, flexion and rotation, extention or compression. As part of this classification he stressed the importance of the entire posterior ligamentous complex consisting of intraspinous, supraspinous ligament and ligamentum flavum. Thus he postulated, a flexion injury did not cause disruption of the posterior ligamentous complex and ligamentum flavum. Thus he postulated, a flexion injury did not cause disruption of the posterior ligamentous complex and was stable. In comparison, a flexion-rotation injury cause disruption of these structures rending the spine unstable.

He described stable injuries as 1) Compression fractures with intact interspinous ligament 2) Wedge fractures in which only the anterior portion of the vertebral body was compressed and the interspinous ligament was intact.

Unstable fractures were: 1) dislocations 2) extention fractures and 3) rotational fracture-dislocation with rupture of the interspinous ligament (5-6).

Bedbrook demonstrated that disruption of the entire posterior ligamentous complex was not always synonymous with spinal instability. He determined that instability could occur if the disc was disrupted and the anterior longutidinal ligaments stripped of the vertebral bodies (7-8). He cited the lack of instability following laminectomies as an example of how important the anterior spinal elements were, compared with the posterior structures in providing stability (8-9).

These two concepts gradually merged into a two column concept of spinal stability composed of an anterior weight bearing column of vertebral bodies and discs and a posterior column of neural arches and ligaments resisting tension (10-11). Whitesides defined stability as the ability to withstand stress without progressive deformity or further neurologic damage (11).

Pope and Panjabi defined an unstable structure as one that is not in an optimal state of equilibrium. The stabilty of the spine is affected by restraining structures that, if damaged or lax, will land to altered equilibrium and, therefore instability (12). A spinal column that is able to maintain aligment when subjected to physiologic loads from any plane that will not compromise the neural elements contained there, is considered stable. If displacement of the spinal column either acutely or during the healing phase of the fracture and neural damage is likely to occur, than the spinal column is considered unstable (13).

The American Academy of Orthopedic Surgeons defined segmental instability as an abnormal response to applied loads caracterized by motion in the motor segment beyond normal constrains (14-15).

* Medical Faculty of Dokuz Eylül University, Department of Orthopeadics and Traumatology, İzmir - TÜRKİYE

White and Panjabi define stability as the ability of the spine under physiologic loads to limit patterns of the displacement so as not to damage or irritate the spinal cord and nerve roots and in addition to prevent incapacitating deformity or pain due to structural changes (16).

Two column concept helped to explain the chronic instability often seen spinal injuries, especially those resulting in a kyphotic deformity. It was unable, however to fully explain all cases of acute instability. Experiments had shown that complete section of posterior elements alone did not result in acute instability in flexion, extention, rotation or shear. It was also necessary to section the posterior part of the anterior column in order to produce acute instability (17-18).

Denis proposed his three-column model of the spine to better reconcile these clinical and biomechanical observations. In his classification system, the posterior column is composed of the posterior bony (spinous process, the lamina, the facets and the pedicles) and the interconnecting posterior ligamentous structures (supraspinous ligament, interspinous ligament, ligamentum flaum and facet joint capsules). The middle column is composed of the posterior aspects of the vertebral body, posterior anulus fibrosus and the posterior logitudinal ligament. The anterior column includes the anterior longutidinal ligament, the anterior anulus fibrosus and the anterior vertebral body (19-20).

Thoracolumbar injuries will behave in a stable manner if the middle column is intact, and in an unstable manner if disrupted, with the following exceptions:

1) Upper thoracic spine injuries: Above T8, an injury may disrupt the middle column, but the fracture will still behave in a stable manner if the sternum and ribs in the area of the injury are intact. The chest wall tends to splint the injury site. If the chest wall (ribs and sternum) is unstable the fracture will also be unstable.

2) Lower lumbar spine: The middle column can be disrupted at L4 or L5, but if the posterior elements are intact or have only longutidinal fractures, the injury will behave in a stable manner. Weight bearing will be tolareted through these posterior elements if the patient has the ability to maintain normal lumbar lordosis, physiologic lordosis prevents excessive weight bearing and collapse in the middle column.

3) Distraction injuries: The Chance fracture and its counterpart through soft tissues may initially be truly instable in the sense that the fracture can suddenly change position. However if in possesion of good motor control the patient can often be judiciously watched for 2 weeks after which time there will be sufficient soft tissue healing to allow nonoperative ambulatory management in an orthosis.

4) Stable burst fractures: Most burst fractures are unstable, however, a stable burst fracture pattern is occasioanally seen. This occur from compression loading of the spine in which there is very little flexion or rotation moment with the posterior elements remaining intact. The stable burst fracture pattern shows a typical burst of the vertebral body but has intact posterior elements, especially the interspinous ligament.

5) Instable compression fractures: The majority of compression, fractures are quite stable. However, in severe compression, fractures with compression of over 70 percent of the vertebral body and if there is disruption of the interspinous ligament, the fracture will often lead to kyphosis with time (3).

Denis classified the burst fracture according to a three-column model, which has become the current standart for evaluating these fractures. He noted that disruption of these structures may lead to instability in flexion and defined the burst fracture involve failure of the anterior and middle column (20).

Mc Afee proposed that the key anatomic structure is the middle column osteoligamentous complex. When this fails in compression without loss of posterior element integrity, the injury is stable. When accompanied by posterior column failure, the lesion is unstable (21).

Argenson demonstrated that the anulus fibrosus and longutidinal ligaments are extremely important in the stability of the spine (22).

Schmorl described the motor segment, which consist intervertebral disc, the posterior longutidinal ligament, the facet joint capsule and ligament, the ligamentum flavum and the interspinous ligament (23).

Farcy and Weidenbaum modified the Denis classification to include expression of bone and soft tissue in each of the three columns, thereby arriving at a six-grade classification. They noted that injuries greater than or equal to Grade 3 were unstable. The bony substance of each column is labeled with a "B" the ligamentous substance of each column is labeled with a "B" the ligamentous subtance of each column with an "L" (25) (Fig. 1).

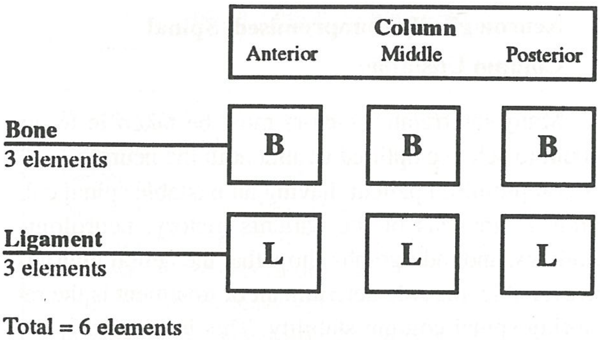

Figure 1

Disruption of three or more bony or ligamentous elements of a column results in instability. MRI is useful in evaluating disc or ligament disruption.

The ability of the spine to support a physiologic load was called the load carring capacity of that lumbar spine. When two columns, the ability of the spine to support that load is decreased by 70% (25) (Fig. 2). With destruction of the anterior column, the spine is unable to resist tortion, with a 95% loss of rigity. Middle and posterior column destruction did not produce a loss of torsional strength greater than 35% (26).

Axial Compression

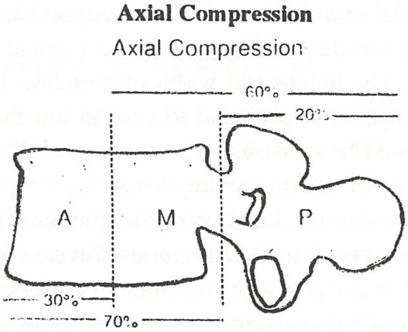

Figure 2

Clinical Considerations;

A detalied review of thoracic and thoracolumbar spine, fractures is published elsewhere (17). A synopsis of some of the most material is given here. Rotational fracture-dislocations of thoracolumbar junction are generally unstable and severe strutural damage of the thoracic spine is generally associated with neurologic deficits.

Table A. Checklist for diagnosis of clinical instability in thoracic and thorocolumbar spine (3):

Elements	Point value
Anterior elements destroyed or unable to fonction	2
Relative sagittal plane translation>2.5 mm	2
Relative sagittal plane rotation>5 degrees	2
Spinal cord or cauda equina damage	2
Disruption costovertebral articulation	1
Dangerous loading anticipated	2
Total of 5 or more points =	Unstable

When there is extensive distruction of the posterior elements there may be localized swelling, tenderness, oedema and a palpable defect under the skin. Wide separation of the spinous processes may be discernible. The anteroposterior radiograph shows wide separation of the spinous processes at the level involved. If there is a rotary dislocation there will be an offset of the spinous processes showing axial rotation at the level of injury. More subtle fractures, subluxations and dislocations of posterior elements are seen on the usual lateral films laminogram or CT scan.

A relative sagittal plane translation greater than 2.5 mm is highly suggestive of thoracic spine clinical instability. A relative sagittal plane rotation of more than 5 degrees is strongly indicative of clinical instability there.

Table B. Checklist for the Diagnosis of Clinical Instability in the Lumbar Spine (3)

ELEMENT		POINT VALUE
Cauda equina damage		3
Relative flexion sagittal plane translation or extention sagittal plane translation	(>10%)	2
Relative flexion sagittal plane rotation	(>10%)	2
Anterior elements destroyed		2
Posterior elements destroyed		2
Dangerous loading anticipated		1
Total of 5 or more points = Clinical instability		

There has been some observed, but not entirely consistent correlation between structural damage and neurologic deficit in the lumbar spine because the space available for the neural elements amply exceeds the space occupied by them. Therefore the presence of neurologic deficit is very likely to be the indicator of clinical instability.

Neurologically Intact, Spinal Column Stable :

The intact neurologic state and stable spinal column is most typical of the patients, who have had a compression fracture. In these patients, the spinal column is stable and treatment of symptoms is all that is needed.

In pure distraction type injuries there is the possibility of the displacement during the first few weeks if some immobilization of the torso is not instituted.

Neurologically Intact, Spinal Column Unstable:

In the neurologic all, intact patient who has an unstable spinal column, early operative intervention is indicated to ensure healing of the spinal column in an acceptable position in a shot period of the time and to allow early rehabilitation. However care should be taken with patients whose burst fractures compromise more than 50 percent of the spinal canal progressive neurolojic loss can occur and requies anterior decompression.

Neurologically Compromised, Spinal Column Stable:

The combination of neurologic compromise and a stable spinal column is rare in adults but it is seen in children. The initial evaluation should include a complete characterization of the neural elements and spinal canal at the level of neural injury. If there is no impingement on the neural elements by extruded disc material or bony fragments, management should be that described above for patients who are neurologically with stable spinal columns, symptomatic conservative treatment. If there is encroachment on the neural elements by disc or bony fragments, surgical intervention is indicated.

Neurologically Compromised, Spinal Column Unstable:

Many interrelated factors must be taken in to account to achieve optimal treatment in the neurologically compromised patient, having an unstable spinal column. If analysis of the patients history, neurologic findings, and radiographs show that the neural injury is irreversible, the sole determinant of treatment is the restoring spinal column stability. This is frequently the case with thoracic fracture-dislocations, where there is a shear component from the initial radiographs and there is a history of immediate and complete neurologic deficit persisting after spinal shock.

Radiologic Evaluations:

High quality anteroposterior and lateral views of the spine permit primary evaluation and classification of deformities in the sagittal and coronal planes. Evaluation often includes a necessary CT scan, or magnetic resonance imaging to visualize the injury.

Plain Radiographs:

The initial examination of the anteroposterior film should rule out dislocation and severe coronal plane angulation. The height and width of vertebral bodies should change from cephalad to caudad but the disc heights should be consistent Examination will reveal irregularities in interpedicular distance as a clue to middle column insult. Rotation of the spinous processes may reveal occult torsional injuries. Severe burst injuries and retropulsion with concomitant posterior arch destruction are consistently associated with an increased interpedicular distance, while lateral compressive forces will result in wedging of the vertebrae in the anteroposterior view (8-19). Lateral radiographs are superior to all methods of imaging in location of the level of the spinal injury (27). They permit evaluation of sagittal plane translation and loss of vertebral height. Both vertebral and disc height may be estimated by averaging the respective measurements of the intact structures above and below. Calculation of the angle of kyphosis or sagittal index may permit estimation of spinal stability.

Table C. Anterior - Posterior Radiographic Evaluation of The Spine

Increased diameter of the body with respect to adjacent body vertebra
Decreased vertebral height
Asymmetry of the affected body
Asymmetry of pedicle or loss of pedicular tear drop
Increased interpedicular distance
Alignment of the spinous processes
Integrity of the lamina and pars interarticularis
Continuity of the facet joints and capsules
Fractures of the transvers process
Fracture of the ribs

Table D. Lateral Radiographic Evaluation of The Spine (1)

Height of the disc space
Continuity of facet joints
Distance between spinous processes
Height of the anterior, middle and posterior aspects of the vertebral body
Continuity of lamina-pedicle and pedicle-body junction
Maintanance of sagittal curves
Normal angulation of adject bodies

Computed Tomography (CT) :

The routine use of CT is indicated in all dislocation, burst and compression fractures, fracture-dislocation, and comminuted multisegmental fractures. CT of severe wedge compression fractures with retropulsion and those fractures that include vertebral arch insult is suggested regardless of the presence of neurologic compromise. In turn fractures of the lumbosacral junction and high thoracic fractures that are difficult to characterize by routine radiographs should be evaluated by CT (28).

The advantages of CT include accuracy in assessing the integrity of the spinal canal, determination of injuries to other organ systems, and accuracy in determining the mechanism of injury. A further advantage is that it provides multiplanar reconstruction images.

The disadventages of CT include its insufficiency for evaluating the level of injury, the amount of vertebral compression, and the presence of noncontiguous fractures; the inability to detect changes in disc space height; and the fact that partial volume averaging may simulate fractures.

Magnetic Resonance Imaging :

MRI is useful in determining the relationship of bony fragments that have been displaced in to the vertebral canal. It is also capable of showing soft tissue damage, including posteriorly displaced discs or spinal cord injury.

A posteriorly displaced disc associated with a traumatic spondylolisthesis may result in the compression of the contents of the canal if a reduction is attempted.

Advantages of MRI include high inherent soft tissue contrast, high sensivity, variable large field of view, multiplane capacity, and its noninvasiveness. Disadvantages include its difficulty to perfome with a patient in respiratory distress; use with previous metallic fixation, either internal or external; and the availabilityof the unit.

DISCUSSION AND CONCLUSIONS :

The regional variation of spinal anatomy has significant clinical implications. The relative size of the neural elements and the space in which they are closed is an important consideration. Generally when a neurologic deficit is associated with significant structural damage, clinical instability should be suspected.

The bony achitecture and the ligamentous elements comprimise the structural components of the spine with all components intact the biomechanical function is normal.

Instability: Is the position of a motion-segment under load and function which disturbs the neurological structures.

REASONS :

1) A ligamental lacksity in motion-segment.

2) Disruption of at least two soft tissues at the anterior, posterior or middle columns.

3) The bone fragments present in the canal.

4) The bone fragments which causes neurological findings the shrink of the canal more than 35%.

5) The compression fractures of the vertebra body more than 50%.

Since the anterior at the vertebra collapses in vertebra compression fractures the superior end plate is longer than the inferior end plate, and due to this it has a pressure on neurological structures (Fig. 3).

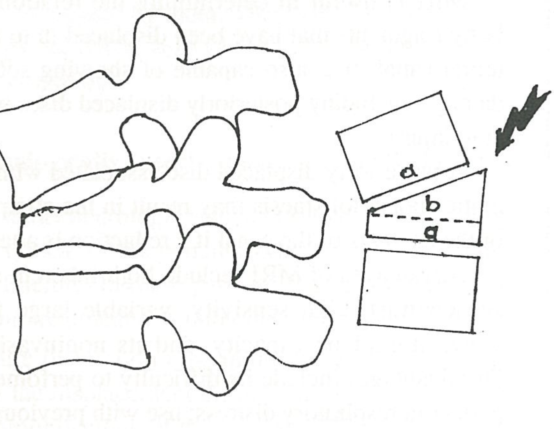

Figure 3

REFERENCES:

1. Bridwell H. Keith, Dewald L. Ronald, The textbook of spinal surgery volum 2 chapter 36, 37, 1991 (J.B. Lippincott).
2. John W. Frymoyer, Adult Spine volume 2 chapter 61, 1991. (Raver).
3. Ewarts C. McCollister, Surgery of the musculoskletal system second edition volume 3 chapter 74-77, 1990.
4. Nicoll E A. 1949. Fractures of the dorsolumbar spine. J. Bone and Joint surg. (Br) 31; 376-394.
5. Holdsworth F.W. 1963: Fractures dislocation of the spine. J. Bone and Joint Surg. (Br) 45: 6-20.
6. Holdsworth F.W. 1970: Fractures, dislocations fracture-dislocation of the spine. J. Bone and Joint Surg. (Am) 52: 1534-1551.
7. Bedbrook G.M. (1971): Stability of the spinal fractures of the spine. J Bone and Joint surg. (Br) 57: 252.
8. Bedbrook G. M (1975): Treatment of thoracolumbar dislocation and fractures with paraplegia. Clin. Orthop 112-27.
9. Bedbrook G.M. Spinal injuries with tetraplegia and paraplegia. J Bone and joint surg. 61 B: 267-284 1979.
10. Kelly R. p. Whitesides T.E. Treatment of dorsolombar fracture-dislocations. Ann Surg. 167: 705-717, 1986.
11. Whitesides T.E. Ali Shan S.G. One the management of unstable fractures of the thorocolumbar spine Rotation stabilization. Spine 1: 99 1976.
12. Pope M.H. Panjabi M.: Bomechanical defination of spinal stability Spine 10: 255 1985.
13. Purcell, G.A., Markolf K.L, Dawson E.G: Twelfth thoracic first lumbar vertebral mechanical stability of fractures after Harrington rod instrumentation. J. Bone and Joint Surg. 63:71 1981.
14. Gertzbein S.D, Selingmen M.D, Holtby R: Centrode pattern and segmental instability in degenerative disc disease. Spine 10: 257 1985.
15. Nachenson A: Lumbar spine instabilityI: A critical update and symposium summary. Spine 10: 290 1985.
16. Luque .R: Segmental spinal intrumentation for the lumbar spine. Clin. Orthoph. 203: 126 1986.
17. White A.A. III, Panjabi M.M: Clinical biomechanics of the spine. Philadelphia, J.B Lippincott 1978.
18. Young M.H: Long term consequences of stable fractures of the thoracic and lumbar vertebral bodies. J. Bone and Joint Surg. [Br] 55; 295 1973.
19. Denis F: Updated classification of thoracolumbar fractures. Ortop. Trans. 6:8 1982.
20. Denis F: The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 8: 817-831 1983.
21. Mc Afee P.C, Yuan H.A, Fredericson B.E, Lubicky j.P, The value of computed tomography in thoracolumbar fractures, J. Bone and Joint Surg. 65 A: 461 1983.
22. Argenson C, Lovet j, Cambas P M: Osteosynthesis of the thoracolumbar spine fractures with c.d. instrumentation. Sauramps medical 1989.
23. Schmorl G, Junghanns h: The human spine in health and disease. grune and Stratton 1971.
24. Bridwell H Keith, De Wald L, Ronald: The textbook of spinal surgery Volume 2. chapter 37.
25. Haher T.R. Tozzi J.M Lospinuso: The cotributionof the three columns of the spine stability: Biomechanical model Paraplegia 27: 432, 1989.
26. Haher T.R. Felmly W. T. Baruch H.: The contribution of the three columns of the spine to rotational stability Biomechanical model spine 14: 663 1989.
27. Angtuaco E. J. Binet E.F. Radiology of thoracic and lumbar fractures Clin. Orthop. 189: 43 1984.
28. Keene J. S: Radiographic evaluation of thorocolumbar fractures Clin. Orthop. 198: 58 1984.