Ashdin Publishing
Journal of Orthopaedics and Trauma
Vol. 1 (2011), Article ID 235406, 5 pages
doi:10.4303/jot/235406

Review Article

A Review of Thoracolumbar Spine Fracture Classifications

Hey Hwee Weng Dennis and Hee Hwan Tak

Department of Orthopaedic Surgery, National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074
Address correspondence to Hey Hwee Weng Dennis, hwee_weng_hey@nuhs.edu.sg

Received 22 January 2011; Accepted 25 March 2011

Abstract The management of traumatic thoracolumbar spine fractures has been controversial. Most columnar models explain stability based on the sagital profile of the spine. In Denis' classification, the middle column provides the greatest mechanical stability and bears the greatest axial load of the spine. The load sharing classification scores the extent of damage to the vertebral body, the displacement of fragments at the fracture site, and the amount of corrected kyphosis. Recently, TLICS was devised based upon the currently recognized three most important injury characteristics: (1) radiographic morphology of injury, (2) integrity of the posterior ligamentous complex, and (3) neurological status of the patient. Subsequently, a composite score (TLISS) can be calculated and patients are stratified into surgical and non-surgical treatment. The emphasis placed on the posterior ligamentous complex as a determinant of spinal stability, encourages magnetic resonance imaging to be the investigation of choice for most thoracolumbar spinal injuries.

Keywords classification; fractures; posterior ligamentous complex; spinal stability; thoracolumbar spine

1 Introduction

Classification systems are generalizations that attempt to identify common attributes within a group to predict the behavior or outcome without sacrificing too much detail. Because of the inherent heterogenecity of fractures, classifying them can be difficult. Despite numerous studies that were conducted, the management of traumatic thoracolumbar spine fractures remains one of the most controversial areas in modern spine surgery. Currently, none of the classification systems published to date have integrated algorithms for the care of patients with thoracolumbar injuries. Available classifications are limited by a number of fundamental problems. They fail either because they are "too simplistic" and each classification group remained varied in their behavior or because they are "too complex" and that made them hard to apply and reproduce. The remaining ones probably fall out of favor due to their lack of clinical applicability and inability to guide decision-making and prognosis. In fact, it may be time we should reflect and see if there really is "the ideal" classification of thoracolumbar spine fractures.

2 History to the classification of thoracolumbar spine injuries

We believe that to properly apply any of the commonly cited classification schemes for thoracolumbar fractures, we must not only know the injury categories described in the original studies but also be familiar with the rationale for developing the classification. Since Bohler's [3] sentinel attempt at classifying such injuries in 1929, many classification systems have been described. In the 1930s, Watson Jones [25,26] considered spinal fractures to be pure flexion fractures and treated them with hyperextension casts. In 1949, Nicoll [19] reported on 166 thoracolumbar fractures in coal miners and classified these injuries as anterior wedge fractures, lateral wedge fractures, fracture dislocations, and isolated neural arch fractures. He defined stable versus unstable fractures using an anatomical classification for which the major determinant of stability was the integrity of the interspinous ligament. This serves as a foundation for later classifications.

3 The columnar models

Multiple modern classification systems have been used in the context of thoracolumbar spine injuries. Most columnar models aim to explain stability by determining the importance of structures based on the sagital profile of the spine. In the 1960's, two-column theories were introduced. Holdsworth's [11] (1963) initial two-column model defines only two spinal columns: an anterior column consisting of the anterior longitudinal ligament, vertebral body and its adjacent intervertebral disc and posterior longitudinal ligament; and a posterior column consisting of the pedicles, facet joint complex, transverse processes, ligamentum flavum, spinous processes and its inter- and supraspinous ligaments. He proposed that the stability of the spine relies predominantly on the posterior column. This classification had a major impact on the understanding of thoracolumbar

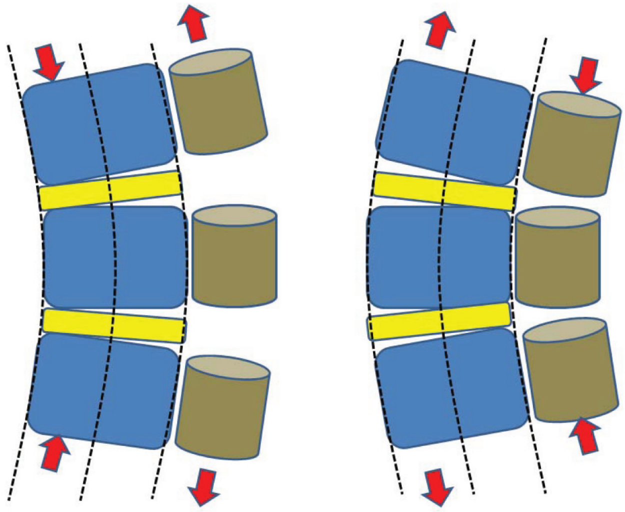

Figure 1: Neutral axis of spine in the middle column during forward bending and extension.

injuries. Kelly and Whitesides' model [12] (1968) described a two-column theory based on a solid anterior column of vertebral bodies and a hollow posterior column of the neural arches. They emphasized the importance of the posterior elements contributing to the stability of the weight bearing anterior column of the spine. In their description, a greater instability reflects a greater severity of injury.

Denis [8] (1983) later designed the sagital profile of the spine into 3 columns: anterior, middle and posterior columns, with the middle column consisting of the posterior half of the vertebral body, the posterior annulus and the posterior longitudinal ligament. The middle column being in the neutral axis of the spine during forward flexion and extension was believed to provide the greatest mechanical stability and bear the greatest axial load of the spine (Figure 1). This has allowed differentiation between compression fractures and burst fractures—the former involving only the anterior column and the latter both the anterior and the middle columns. A chance fracture is then defined as a transverse injury to the spine that involves all three columns.

Based on the anatomically defined structures by White and Panjabi [27], a slightly different columnar concept was proposed by Louis [14]. He described a 3-column concept consisting of the vertebral body column and intervertebral discs; and 2 facet joint complexes. Although such a model takes into consideration the stability from facet joints at each segment of the spine, it only looks into the bony stability and undermines the importance of soft tissue complexes as contributors to spinal stability. As such, it has fallen out of favor and is rarely used clinically.

The Magerl-AO system [16] (1994) uses the 3-column concept described by Denis and classifies thoracolumbar spine injuries based on the pathomorphological criteria into 3 types (A: compression involvement of anterior and middle columns, B: distraction involving 3 columns, C: axial torque and rotational deformity). Each of these types is further divided into 3 groups and 3 subgroups reflecting progressive scale of morphological damage and the degree of instability. This classification incorporates not only the mechanism of injury but also fracture pattern, and it attempts to categorize every injury based on stability. Due to its complexity, it has a promising role for research but will not be ideal in routine clinical practice. Despite widespread usage of the AO classification, it has lower inter-observer reliability and is less useful in therapeutic decision making and prognostic purposes [20,28,29].

Understanding that the thoracolumbar spine is capable of combined movements in multiple axes, it is reasonable to conclude that no theory using a single sagital profile classification will be sufficient to accurately explain the issue of mechanical stability of the thoracolumbar spine. In fact, a recent study showed that a posterior longitudinal injury did not worsen the outcome of non-operative treatment of thoracolumbar fractures with bracing. Early mobilization might further complicate the issue [6]. However, both Holdsworth's and Denis' works have paved our understanding of thoracolumbar spine injuries, and have given us a great understanding of what we termed now as compression, burst, and chance fractures.

4 Compression, burst and chance fractures

Both compression and burst fractures have a predilection for the thoracolumbar spinal segments. Although Denis' model considered the middle column to be the primary determinant of spinal stability, compression fractures may be deemed unstable in the event of posterior ligamentous disruption making up the posterior column [19]. This may result in progressive collapse of the anterior column and eventual kyphosis of the thoracolumbar spine. Therefore, it is important that one actively scrutinizes the lateral plain radiographs to look for widening of interspinous spaces at adjacent levels. Burst fractures can be stable or unstable. Multiple studies on stability of burst fractures have proved too complicated for popular use [15,17,21]. In these studies, the stability of the burst fracture could be summarized into several points: (1) loss of height ($> 50\%$), (2) kyphotic angle > 20 degrees, (3) substantial posterior column injury, (4) progressive deformity (i.e. either loss of height or kyphosis) and (5) progressive neurological deficit. The initial radiographic assessment of patients with thoracolumbar compression and burst fractures should hence include measurement of the loss of vertebral height and the kyphotic angle.

Since 1948, Chance [4] described a fracture that involved a compression injury to the anterior portion of the vertebral body, and a transverse fracture through the posterior portion of the vertebral body to the posterior elements of the spine. This type of fracture is caused by violent forward flexion, causing distraction injury to the posterior elements. It is also commonly known as a "seat-belt injury" due to its association with the sudden forward flexion that occurs when one is involved in a head-on automobile collision while being restrained by a lap belt without a shoulder belt. As this fracture pattern has a high association with intra-abdominal injuries (45%) [1], one should always perform a computed tomograhic screening for such patients. It is widely accepted that Chance fractures are unstable injuries. Magnetic resonance imaging is often advocated either for the purpose of assessing neurological injury (10–15%) [10] or to evaluate the extent of soft tissue damage. Delineating the pattern of injury is important as a soft tissue chance injury is less likely to heal in a brace compared to a bony chance injury.

Also known as "flexion-distraction" injury, chance fracture was further described by Gertzbein [9] (1988) into types A–F depending on the fracture location across all three columns of the spine and whether a compression or burst fracture coexist. This classification is purely descriptive and even though it suggests the mechanism of injury, it does not necessarily indicate the severity of each pattern. Another recent classification by Chapman [5] (2008) known as the Harborview Flexion-Distraction Injury (FDI) describes chance fracture into four stages based on region, injury pattern, ASIA grade, and motor score. In this classification, a higher stage indicates greater severity of injury. In stage 1, posterior column distraction occurs without anterior column compression. In stage 2, facet joints begin to sublux and an anterior vertebral compression injury is noted. In stage 3, burst injury to the vertebral body occurs. In stage 4, disengagement occurs without evidence of translation or rotation of the spine.

5 Newer concepts—load sharing model and injury severity scoring

Knowing the functions of the spine which include load bearing and mobility, stability might be better viewed separately in axial loading and in truncal movement. Although sagital plane columnar models may be appropriate when explaining stability of the spine especially in forward bending and extension, they may not be the most ideal in explaining failure in axial loading. Even when Denis proposed the middle column of the spine as the main determinant of stability, it was secondary to the understanding that the neutral axis lies within the middle column during forward bending and extension.

The load sharing classification described by McComack [18] (1994) not only highlights the fact that axial load transmission travels through the vertebral bodies and intervertebral discs, it also aims to explain the reason behind poor patient outcomes from conservative treatment of thoracolumbar spine fractures. It is a scoring system based on the extent of damage to the vertebral body, the displacement of fragments at the fracture site, and the amount of corrected kyphosis (Figure 2). These three factors are each assigned a point value 1–3 based on severity. The maximum score is thus 9 and the minimum score is 3. A higher score indicates a greater severity of injury.

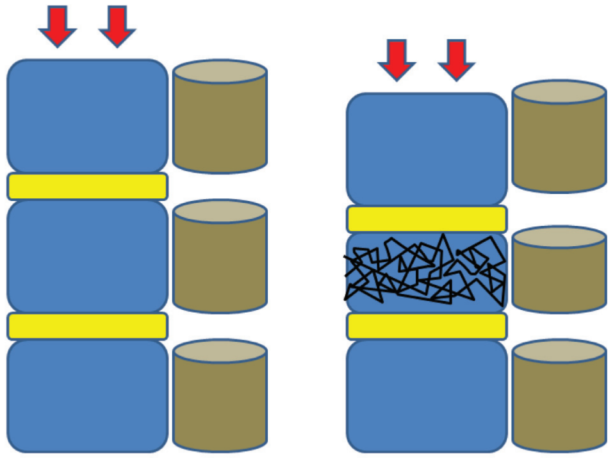

Figure 2: Vertebral body and intervertebral disc contributing to stability in axial loading.

Several studies have found better inter- and intra-observer reliability in this classification [7,24], although critics described it as a mere recognition of radiographic imaging and thus was expected to have poor reproducibility like the earlier models. This classification was particularly useful when predicting implant failures (screw breakage) in thoracolumbar fractures after additional short segment posterior instrumentation. This allows for the selection of certain fracture subtypes.

As can be seen, despite numerous classifications described for thoracolumbar spine injuries, there is still no classification system that has achieved global acceptance and clinical utility. This is probably due to the complex biomechanics of the spine, the numerous forms of injury configuration, and the inability to recognize what seems pivotal in the understanding of thoracolumbar spine injuries [2,20]. The most recent classification by Vaccaro [13,22,23] (2005), the Thoracolumbar Injury Classification and Severity Score (TLICS) was devised based upon what is currently recognized as the three most important injury characteristics: (1) morphology of injury determined by radiographic appearance, (2) integrity of the posterior ligamentous complex and (3) neurological status of the patient (see Table 1). From these three characteristics, a composite thoracolumbar injury severity score (TLISS)

Morphology		
	Compression	(1 point)
	Burst	(1 point)
	Translation/rotation	(3 points)
	Distraction	(4 points)
Posterior ligamentous complex		
	Intact	(0 points)
	Suspected/indeterminate	(2 points)
	Injured	(3 points)
Neurologic status		
	Intact (ASIA-E)	(0 points)
	Nerve root	(2 points)
	Cord/conus	
	Complete (ASIA-A)	(2 points)
	Incomplete (ASIA-B,C,D)	(3 points)
	Cauda equina	(3 points)

NB: A score of ≤ 3 indicates non-operative treatment; ≥ 5 indicates operative treatment.

Table 1: Thoracolumbar injury classification and severity score (TLICS-TLISS).

can be calculated and patients are then stratified into surgical and non-surgical treatments. In TLISS, a maximum score of 10 points and a minimum score of 1 point can be calculated. Not only does a higher score indicates a greater severity, but also an arbitrary score of 5 and above prompts operative management. Patients with a low score of 3 and below should be treated conservatively.

One important aspect of this score is its distinction between injury morphology rather than injury mechanism used by previous studies. The study group believed that a description of the morphology would be more reliable than a pure description of the mechanism which may result in the same morphology. As such, it could be expected that patients will be treated directly based on their injury morphology than the mechanism that might have caused such a morphology. An obvious advantage of this classification is its incorporation of the three most currently acceptable parameters into a single objective scoring system: the pathomorphology of the injury, the stability of the spine attributed predominantly by the posterior ligamentous complex and the neurological status of the patient. Even though one may contend that such a classification still over-simplifies our understanding of the stability of the spine, there is no doubt that it is easily reproducible and guides our management towards thoracolumbar spinal injuries. We also believe that with its emphasis on the posterior ligamentous complex as the chief determinant of spinal stability, magnetic resonance imaging will eventually be the investigation of choice for most thoracolumbar spinal injuries.

6 Summary

Multiple classification systems are used to describe thoracolumbar spine fractures, each with its own strengths and weaknesses. Columnar models, load sharing concepts, and injury severity scoring are the most commonly used modern classifications. However, there remains no consensus and no globally acceptable algorithm in the management of such injuries. Treatment for patients with thoracolumbar spine fractures will thus vary based on the surgeon's beliefs and preferences.

References

[1] P. A. Anderson, F. P. Rivara, R. V. Maier, and C. Drake, *The epidemiology of seatbelt-associated injuries*, J Trauma, 31 (1991), 60–67.

[2] L. Audigé, M. Bhandari, B. Hanson, and J. Kellam, *A concept for the validation of fracture classifications*, J Orthop Trauma, 19 (2005), 404–409.

[3] L. Böhler, *The Treatment of Fractures* [*A translation of "Technik der Knochenbruchbehandlung im Frieden und im Kriege" by M. E. Vienna*], Wilhelm Maudrich, Austria, 1929.

[4] G. Q. Chance, *Note on a type of flexion fracture of the spine*, Br J Radiol, 21 (1948), 452–453.

[5] J. R. Chapman, J. Agel, G. J. Jurkovich, and C. Bellabarba, *Thoracolumbar flexion-distraction injuries: associated morbidity and neurological outcomes*, Spine, 33 (2008), 648–657.

[6] G. Chow, B. Nelson, J. Gebhard, J. Brugman, C. Brown, and D. Donaldson, *Functional outcome of thoracolumbar burst fractures managed with hyperextension casting or bracing and early mobilization*, Spine, 21 (1996), 2170–2175.

[7] L.-Y. Dai and W.-J. Jin, *Interobserver and intraobserver reliability in the load sharing classification of the assessment of thoracolumbar burst fractures*, Spine, 30 (2005), 354–358.

[8] F. Denis, *The three column spine and its significance in the classification of acute thoracolumbar spinal injuries*, Spine, 8 (1983), 817–831.

[9] S. D. Gertzbein and C. M. Court-Brown, *Flexion-distraction injuries of the lumbar spine. Mechanisms of injury and classification*, Clin Orthop Relat Res, 227 (1988), 52–60.

[10] G. Gumley, T. K. Taylor, and M. D. Ryan, *Distraction fractures of the lumbar spine*, J Bone Joint Surg Br, 64B (1982), 520–525.

[11] F. Holdsworth, *Fractures, dislocations, and fracture-dislocations of the spine*, J Bone Joint Surg Am, 52 (1970), 1534–1551.

[12] R. P. Kelly and T. E. Whitesides Jr., *Treatment of lumbodorsal fracture-dislocations*, Ann Surg, 167 (1968), 705–717.

[13] J. Y. Lee, A. R. Vaccaro, M. R. Lim, F. C. Öner, R. J. Hulbert, R. Hedlund, et al., *Thoracolumbar injury classification and severity score: a new paradigm for the treatment of thoracolumbar spine trauma*, J Orthop Sci, 10 (2005), 671–575.

[14] R. Louis, *Unstable fractures of the spine. III. Instability. A. Theories concerning instability*, Rev Chir Orthop Reparatrice Appar Mot, 63 (1977), 423–425.

[15] R. Louis, *Spinal stability as defined by the three-column spine concept*, Surg Radiol Anat, 7 (1985), 33–42.

[16] F. Magerl, M. Aebi, S. D. Gertzbein, J. Harms, and S. Nazarian, *A comprehensive classification of thoracic and lumbar injuries*, Eur Spine J, 3 (1994), 184–201.

[17] P. C. McAfee, H. A. Yuan, and N. A. Lasda, *The unstable burst fracture*, Spine, 7 (1982), 365–373.

[18] T. McCormack, E. Karaikovic, and R. W. Gaines, *The load sharing classification of spine fractures*, Spine, 19 (1994), 1741–1744.

[19] E. A. Nicholl, *Fractures of the dorso-lumbar spine*, J Bone Joint Surg Br, 31B (1949), 376–394.
[20] F. C. Oner, L. M. Ramos, R. K. Simmermacher, P. T. Kingma, C. H. Diekerhof, W. J. Dhert, et al., *Classification of thoracic and lumbar spine fractures: problems of reproducibility. A study of 53 patients using CT and MRI*, Eur Spine J, 11 (2002), 235–245.
[21] M. M. Panjabi, J. N. Hausfeld, and A. A. White III, *A biomechanical study of the ligamentous stability of the thoracic spine in man*, Acta Orthop Scand, 52 (1981), 315–326.
[22] A. R. Vaccaro, R. A. Lehman Jr., R. J. Hurlbert, P. A. Anderson, M. Harris, R. Hedlund, et al., *A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex, and neurologic status*, Spine, 30 (2005), 2325–2333.
[23] A. R. Vaccaro, S. C. Zeiller, R. J. Hulbert, P. A. Anderson, M. Harris, R. Hedlund, et al., *The thoracolumbar injury severity score: a proposed treatment algorithm*, J Spinal Disord Tech, 18 (2005), 209–215.
[24] X.-Y. Wang, L.-Y. Dai, H.-Z. Xu, and Y.-L. Chi, *The load-sharing classification of thoracolumbar fractures: an in vitro biomechanical validation*, Spine, 32 (2007), 1214–1219.
[25] R. Watson-Jones, *The results of postural reduction of fractures of the spine*, J Bone Joint Surg Am, 20 (1938), 567–586.
[26] R. Watson-Jones, *Fractures and Joint Injuries*, E&S Livingstone, Edinburgh, UK, 3rd ed., 1943.
[27] A. A. White and M. M. Panjabi, *Clinical Biomechanics of Spine*, Lippincott, Philadelphia, PA, USA, 1978.
[28] J. A. Willén, U. H. Gaekwad, and B. A. Kakulas, *Acute burst fractures. A comparative analysis of a modern fracture classification and pathologic findings*, Clin Orthop Relat Res, 276 (1992), 169–175.
[29] K. B. Wood, G. Khanna, A. R. Vaccaro, P. M. Arnold, M. B. Harris, and A. A. Mehbod, *Assessment of two thoracolumbar fracture classification systems as used by multiple surgeons*, J Bone Joint Surg Am, 87 (2005), 1423–1429.