Review Article

Thoracolumbar Spine Trauma Classification

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Abstract

Thoracolumbar spine trauma is among the most common musculoskeletal injuries worldwide. However, there is little consensus on the adequate management of spine injury, in part because there is no widely accepted classification system. Several systems have been developed based on injury anatomy or inferred mechanisms of action, but they have demonstrated poor reliability, have yielded little prognostic information, and have not been widely used. The Thoracolumbar Injury Classification and Severity Score (TLICS) was developed to address these limitations. The TLICS defines injury based on three clinical characteristics: injury morphology, integrity of the posterior ligamentous complex, and neurologic status of the patient. The severity score offers prognostic information and is helpful in medical decision making. Initial application of the TLICS has shown good to excellent reliability and validity. Additional evaluation of the TLICS is needed to prospectively define its clinical utility and identify potential limitations.

Spine fractures account for a large portion of musculoskeletal injuries worldwide. Approximately 75% to 90% of spinal fractures occur in the thoracic and lumbar spine, with most of these occurring at the thoracolumbar junction (T10-L2).[1-3] Despite the high incidence of thoracolumbar fractures, there is little consensus regarding injury classification and management.[4] Treatment varies widely, from bracing to circumferential fusion, based on geographical, institutional, and surgeon preferences rather than on scientific evidence. A principal reason for this variability lies in the lack of a widely accepted classification system. In the absence of a common language with which to accurately define thoracolumbar injuries, it is not surprising that optimal treatment remains elusive.

Ideally, a classification system is descriptive and prognostic. The system must be easy to remember and apply in clinical practice, based on a simple algorithm with consistent radiographic and clinical characteristics. Additionally, the classification should provide information on the severity and natural history of an injury pattern. Finally, by accounting for injury prognosis, the classification should guide clinical decision making. Such a system would be a critical tool for clinical outcomes research.

Historically, classification systems have been based on retrospective reviews and the experience of individual surgeons.[5-7] These systems are typically based on descriptions of anatomic structures (eg, Denis three-column system), proposed mechanisms of injury (eg, Watson-Jones,

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AO), or a combination thereof.[5-8] Many systems are convoluted, with an impractical number of variables. Others are too simple, lacking sufficient detail to provide clinically relevant information.

Although these classification systems have provided commonly used nomenclature, none has gained widespread acceptance. The lack of an accepted system has encouraged authors to define further systems, each hampered by the same limitations as those of the existing systems. The large number of systems has led to increased confusion and decreased agreement and accuracy in classifying thoracolumbar trauma. The Thoracolumbar Injury Classification and Severity Score (TLICS) was developed to address the shortcomings of prior systems and to offer an improved means of classifying thoracolumbar spine trauma.

Historical Classification Systems

The historical sequence and clinical basis of thoracolumbar classification systems was described in excellent detail by Mirza et al[9] (Table 1). These systems are based on either descriptors of anatomic disruption or inferred mechanisms of injury.

Anatomic Disruption

Watson-Jones[6] described the first thoracolumbar injury classification system in 1938. In a retrospective review, he described three injury characteristics: simple wedge fracture, comminuted fracture, and fracture-dislocation. This system was the first to use injury classification as a guide for medical decision making. Watson-Jones suggested different reduction techniques for the management of wedge and comminuted fractures and surgical reduction for certain fracture-dislocations.

Perhaps better known is the anatomic classification of Kelly and Whitesides,[10] which was later modified by Denis.[7] In a review of 11 patients, Kelly and Whitesides[10] divided the spine into an anterior (ie, vertebral body) column and a posterior (ie, neural arch) column. The authors described spinal instability as the presence of disruption in both the anterior column and the posterior column. Although the authors described fracture patterns, it is the "column" concept that has persisted. In 1983, Denis[7] refined this column concept of thoracolumbar trauma by describing a middle column consisting of the posterior vertebral body, posterior longitudinal ligament, and posterior anulus. Denis did not define rigid parameters of stability and instability. Rather, he stratified the risk of neurologic injury based on two-column involvement and mode of failure of the middle column. Although the fracture subtypes proposed by Denis[7] provided little additional information with regard to classifying thoracolumbar injury, his three-column description clearly distinguishes compression fractures (anterior column) from burst fractures (anterior column, middle column).

Neither of these anatomic classification systems accounts for the patient's neurologic status, addresses the importance of the posterior ligamentous structures, provides prognostic information, or guides clinical decision making. The Denis system has shown only fair to good interobserver reliability in separate investigations.[16,17] Although these classifications have provided nomenclature for thoracolumbar trauma, their limitations significantly impede their clinical utility as reproducible tools.

Mechanistic

Holdsworth[11] described the first mechanistic classification system for spinal injuries based on his experience with more than 1,000 patients with spinal column and spinal cord injuries. He categorized fractures as simple wedge, dislocation, rotational fracture-dislocation, extension, burst, and shear. This system was the first to emphasize the role of the posterior ligamentous complex (PLC) in determining spinal stability. Holdsworth[11] also recommended surgical treatment of specific injury patterns (ie, pure dislocations) as well as of dislocations associated with neurologic injury. Although this system offers rudimentary treatment recom-

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Table 1

Data Supporting the Common Classification Schemes

Study	No. of Subjects	Imaging Modality	Classification Variables	No. of Injury Categories (Specific Types)	Treatment or Prognostic Value
Watson-Jones[6]	252	Rad	Radiographic patterns	3 (7)	Postural reduction with hyperextension for good functional results
Chance[12]	3	Rad	Radiographic patterns	1	100% healing rate with extension casting
Nicoll[13]	152	Rad	Radiographic patterns	4 (7)	Only unstable fractures need cast fixation
Holdsworth[11]	"A large number"	Rad	Radiographic patterns	6	Reversing the mechanism of injury can assist nonsurgical reduction
Kelly and Whitesides[10]	11	Rad	Two spinal columns	8	Surgery to restore the involved column
Denis[7]	412	Rad and CT	Three spinal columns; three modes of failure*	5 (21)†	Treatment is not related to injury pattern
McAfee et al[14]	100	Rad and CT	Three spinal columns; three modes of failure*	6	Mode of failure determines treatment type
Ferguson and Allen[5]	Not listed	Rad and CT	Seven mechanisms of injury, with subtypes based on severity	8 (12)	Treatment is not related to injury pattern
McCormack et al[15]	28	Rad and CT	Comminution, fragment apposition, kyphosis with three severity grades for each	9	Severe injury predicts failure of short-segment posterior fixation with plates and screws
Magerl et al[8]	1,445	Rad and CT	Three injury types with three groups per type and additional subtypes	3 (53)†	Higher injury grades imply more severe injury and higher risk of neurologic deficit

* Each column is assigned a presumed mode of failure based on radiography and CT findings. Each category is subdivided by radiographic pattern and injury severity.

† Additional undefined terms such as "more severe" distinguish cases within specific injury types.

Rad = plain radiograph

Adapted from Mirza SK, Mirza AJ, Chapman JR, Anderson PA: Classifications of thoracic and lumbar fractures: Rationale and supporting data. *J Am Acad Orthop Surg* 2002;10:364-377.

mendations, few data have been published to support its claims.[9]

Ferguson and Allen[5] developed their classification based on a retrospective review of spine radiographs. Similar to the subaxial cervical trauma system described by the same authors in 1982,[18] the thoracolumbar system defines injury patterns through inferred mechanisms of injury. Seven injury types and 12 injury subtypes were defined. Injury types include vertical compression, compression flexion, distraction flexion, lateral flexion, translation, torsional flexion, and distractive extension. The authors described a treatment algorithm based on this system as well as on methods of spinal fixation available at that time: posterior distraction, posterior compression, segmental posterior fixation, and anterior fixation.[19] Although this system added to the nomenclature of thoracolumbar trauma, the number of injury patterns and subtypes makes it difficult to use in the clinical setting. Additionally, very few data are available on its reliability and validity. The Ferguson and Allen classification is fundamentally limited because it is based on an inferred injury mechanism rather than on objective radiographic findings (ie, injury morphology).

The AO thoracolumbar system is a more recent mechanistic classification system described by Magerl et al.[8] This system is based on the AO classification that had previously been used for orthopaedic extremity injuries. The AO/Magerl classification defines three major mechanisms of spinal injury—compression (A), distraction (B), and torsion (C)—to indicate increasing injury severity according to increasing grade of injury. Three groups exist within each type

Table 2

Thoracolumbar Injury Classification and Severity Score

Injury Characteristic	Qualifier	Points
Injury morphology		
Compression	—	1
	Burst	+1
Rotation/translation	—	3
Distraction	—	4
Neurologic status		
Intact	—	0
Nerve root	—	2
Spinal cord, conus medullaris	Incomplete	3
	Complete	2
Cauda equina	—	3
Posterior ligamentous complex integrity		
Intact	—	0
Suspected/Indeterminate	—	2
Disrupted	—	3

+ = 1 additional point given to the morphology

of injury (eg, A1, A2, A3), and each group is divided into three subgroups (eg, A1.1, A1.2, A1.3). Injury severity is indicated by increasing values of injury classification. For example, type A injuries are less severe than type C injuries, and type B1 injuries are less severe than type B2 injuries. In addition to the aforementioned limitations of inferred injury mechanisms, the AO system is a victim of its comprehensiveness. The large number of subgroups lends a complexity that limits incorporation of the system into routine clinical practice. This has also limited its reliability, as demonstrated independently by Wood et al[16] and Oner et al.[17] Blauth et al[20] demonstrated only fair interobserver reliability for the three main AO categories (A, B, C; κ = 0.33), with rapidly decreasing reliability with the inclusion of the AO subtypes.

The mechanistic classification systems have inherent limitations. They are based on inferred mechanisms of injury rather than on an objective description of injury morphology.[4] They do not account for the neurologic status of the patient, a critical component in medical decision making. Furthermore, the comprehensive nature of these descriptors adds convolution, decreases reliability, and limits clinical and research utility. Finally, these systems are based on plain radiographs and early CT technology. Improvements in imaging, such as high-resolution CT and MRI, are not reflected. Hampered by such limitations, these systems do not provide sufficient data to guide current surgical and nonsurgical decision making.

Thoracolumbar Injury Classification and Severity Score

Introduced by the Spine Trauma Study Group in 2005, the TLICS was designed to provide a clear, reliable classification system that accounts for many of the shortcomings of prior systems.[21] The TLICS is based on an extensive review of the literature as well as consensus opinion from a multinational group of 40 spinal trauma surgeons from 15 trauma centers in the United States, Canada, Australia, Germany, Mexico, France, Sweden, India, and the Netherlands. The literature review identified the limitations of previously described classification systems as well as the critical components of medical decision making in thoracolumbar trauma. These findings were then reviewed by all involved surgeons and, through consensus opinion, three major injury characteristics were defined: injury morphology, neurologic status, and integrity of the PLC. Point values are assigned to each major category based on injury severity (Table 2). The sum of these points represents the TLICS severity score, which may be used to guide treatment.

Injury Morphology

Injury morphology is divided into three subtypes, with increasing severity: compression, rotation/translation, and distraction. Although these descriptors share the nomenclature of mechanistic systems, the TLICS is unique in that it defines objective radiographic findings for each injury morphology.

Compression injuries are defined by a loss of height of the vertebral body or disruption through the vertebral end plate. This includes traditional compression (ie, anterior column) and burst (ie, anterior column, middle column) fractures. Sagittal and coronal plane vertebral fractures are difficult to classify using the column descriptors.

Rotation/translation injury is identified by horizontal displacement of one thoracolumbar vertebral body with respect to another. It is typified by unilateral and bilateral dislocations and facet fracture-dislocations, as well as bilateral pedicle or pars fractures with vertebral subluxation.

Distraction is identified by anatomic dissociation in the vertical axis, such as a hyperextension injury that causes disruption of the anterior longitudinal ligament, with subsequent widening of the anterior disk space. Fractures of the posterior elements (ie, facet, lamina, spinous process) may also be present in distraction injury. Severe thoracolumbar kyphotic deformities of the spine, caused by tensile failure of the posterior ligamentous structures, represent another clinical example of the distraction morphology.

Prior classification systems had limited utility in the setting of multiple concurrent injuries, whereas the TLICS accounts for this scenario in two ways. First, in the presence of more than one injury morphology, the injury morphology with the highest score is used. For example, an L1-2 flexion-distraction injury with an associated L2 burst fracture would be described as an L1-2 distraction injury with an L2 burst fracture and scored accordingly, with points assigned only to the highest-valued injury—in this case, the distraction injury. Noncontiguous injuries (eg, T7 compression fracture, L1 burst fracture) are classified and scored separately. However, the scores are not summated, and decision making is based on the injury with the highest score as well as on confounding variables such as the presence of noncontiguous injuries.

Neurologic Status

Patient neurologic status is one of the most influential components of medical decision making. The TLICS is unique among thoracolumbar classification systems in including this status. Neurologic injury is a critical indicator of the degree of spinal column injury (ie, spinal stability). Additionally, neurologic injury often warrants surgical treatment to prevent further neurologic decline and to improve patient outcomes. Neurologic status is described in increasing order of urgency: neurologically intact, nerve root injury, complete (motor and sensory) spinal cord or cauda equina injury, and incomplete (motor or sensory) spinal cord or cauda equina injury. In the American Spinal Injury Association classification, injury grades B, C, and D are incomplete injuries, whereas grade A represents a complete spinal cord injury.[22]

Posterior Ligamentous Complex Integrity

The anatomic structures of the PLC include the supraspinous ligament, interspinous ligament, ligamentum flavum, and facet joint capsules. The PLC plays a critical role in protecting the spine and spinal cord against excessive flexion, rotation, translation, and distraction.[23,24] Once disrupted, the ligamentous structures demonstrate poor healing ability and generally require surgical stabilization. In the TLICS, the integrity of the PLC is categorized as intact, indeterminate, or disrupted. Assessment can be made based on plain radiographs, CT scans, and magnetic resonance images.[25] Disruption of the PLC is typically indicated by widening of the interspinous space or of the facet joints, empty facet joints, facet perch or subluxation, and dislocation of the spine. When the evidence of disruption is subtle, the integrity of the ligaments is typically defined as either suspected or indeterminate. In some cases, clinical examination may be helpful in determining the status of the PLC; an obvious gap between the spinous processes is indicative of PLC disruption. Additionally, magnetic resonance images may reveal disruption of the ligamentous structures on T1-weighted imaging or areas of high signal intensity on short tau inversion recovery images.[26,27] Although they add to the clinical suspicion of PLC disruption, MRI findings have yet to be definitively correlated with intraoperative findings.

Table 3

Thoracolumbar Injury Classification System and Severity Score Treatment Guide

Management	Points
Nonsurgical	<4
Nonsurgical or surgical	4
Surgical	>4

Severity Score

The injury scores are totaled to produce a management grade that is, in turn, used to guide treatment (Table 3). A score >4 suggests the need for surgical treatment because of significant instability, whereas a score <4 suggests nonsurgical treatment. A patient with a score of 4 may be treated either surgically or nonsurgically. In the setting of multiple fractures, management is determined based on the injury with the greatest TLICS severity score. For noncontiguous fractures, the severity score of each injury may be used to guide independent treatment.

Validity, Reliability, and Clinical Utility

The fundamental intent of the TLICS is to improve the management of thoracolumbar injury through a reproducible and valid classification system that is easy to learn and that is readily applicable in clinical practice. Vaccaro et al[21] and Whang et al[28] demonstrated good to excellent interobserver and intraobserver reliability with the TLICS. The authors reported Cohen unweighted kappa coefficients of 0.626, 0.477, and 0.455, and Spearman rank correlation values of 0.684, 0.616, and 0.852 for TLICS injury morphology, PLC, and total severity score, respectively. Good to excellent interobserver agreement was reported for management based on the TLICS results.

The Denis and AO classifications have not demonstrated results equivalent to those with the TLICS. Wood et al[16] demonstrated average interobserver kappa coefficient of 0.606 with the Denis system and 0.475 with the AO system. With both systems, as classification subtypes were included (eg, AO A1, A2), kappa coefficients decreased. Oner et al[17] and Blauth et al[20] demonstrated interrater kappa coefficients of 0.34 and 0.33, respectively, with the AO classification system, reporting decreasing reliability when classification subtypes are included.

Validity of the TLICS was initially determined by comparing TLICS treatment recommendations with actual treatment administered in two retrospective case series.[21,28] Agreement (ie, validity) was achieved in 95.4% of cases. Furthermore, 96.4% validity was observed in a prospective series of thoracolumbar trauma patients at a single institution.[29]

Initial data are available on the clinical application of the TLICS. Raja Rampersaud et al[30] examined the differences in application of the TLICS between orthopaedic surgeons and neurosurgeons. Small differences between the groups were noted, but the authors found an overall agreement of 92% on injury management. Ratliff et al[31] demonstrated moderate to substantial interrater agreement ($\kappa = 0.532$ and $\kappa = 0.528$) and intrarater agreement ($\kappa = 0.588$ and $\kappa = 0.658$) based on overall injury classification in their comparison of US-based and non-US–based spine trauma surgeons, respectively. The authors reported significant agreement (74.2%) between US and non-US surgeons regarding injury management using the severity score. Thus, the TLICS may help to bridge the communication gap between spine surgeons across subspecialties and national boundaries.

The TLICS system has been examined in the educational setting as well. Patel et al[32] reported the prospective application of the system at one academic institution. The TLICS was described to all members of the surgical team, including residents, spine fellows, and attending staff, who then applied that knowledge in the routine evaluation of a series of injured patients. This process was repeated with a different group of residents and fellows 7 months later. Statistically significant improvements in interobserver reliability were noted from the first assessment to the second ($P < 0.05$). Cohen kappa coefficient total injury classification and management scores improved from 0.189 and 0.455 to 0.509 and 0.724, respectively. The authors suggested that, given the turnover in residents and fellows, a learning curve cannot account for this improvement. Instead, they suggest that improvements in reliability reflect integration of the TLICS system into the clinical and educational environments at the institution. The TLICS system may be readily applied to routine clinical practice and may facilitate resident and fellow education on thoracolumbar trauma.

Case Examples

An 18-year-old woman presented with severe mid back pain following a rollover motor vehicle collision. Patient assessment revealed a normal neurologic examination with a palpable, tender gap in the thoracolumbar region. CT scans demonstrated a T11-12 fracture-dislocation with a Chance fracture at T12 (Figure 1, A through C). A magnetic resonance image was suggestive of disruption of the posterior ligamentous structures (Figure 1, C).

In this patient, the TLICS scoring was as follows: injury morphology (translation), 3 points; neurologic status (intact), 0 points; PLC (disrupted), 3 points. The total TLICS was 6 points, which indicated the need for surgical treatment. The patient was treated with open reduction and posterior spinal fusion (Figure 1, D).

A 63-year-old man sustained a 15-foot fall at work and reported severe back pain. Assessment revealed a normal neurologic examination with no posterior tenderness, gap, or step-off. CT scans demonstrated an L2 burst fracture with 50% canal occlusion (Figure 2, A and B). No interspinous splaying or focal kyphosis was visualized. MRI revealed no increased signal in the posterior ligamentous structures (Figure 2, C).

Injury in this patient was scored according to the TLICS as follows: injury morphology (compression, burst), 2 points; neurologic status (intact), 0 points; PLC (intact), 0 points. The total severity score was 2 points, which led to the decision to treat the patient nonsurgically. Accordingly, the patient was prescribed a thoracolumbar orthosis and ambulated within 24 hours of injury. The fracture had healed by 6 months after injury, without subsequent disability (Figure 2, D).

A 28-year-old man sustained a fall of 30 feet while skiing. He reported subsequent back pain as well subjective weakness and numbness in the legs. Examination revealed diffuse weakness (grade 2 to 3 out of 5) in all lower extremity muscle groups, diminished rectal tone with intact pinprick, and light touch sensation in the perianal and lower extremity dermatomes. L2 burst fracture with >90% canal stenosis was demonstrated on CT scans (Figure 3, A and B). Focal kyphosis was visualized, and short tau inversion recovery MRI (Figure 3, C) revealed slightly

Figure 1

A B C D

A, Midsagittal reconstructed CT scan demonstrating T11-12 translation injury with anterior dislocation of T11 on T12 in an 18-year-old woman who presented with severe mid back pain following a rollover motor vehicle collision. **B,** Axial CT scan through the T11-12 level demonstrating T12 fracture and right-side facet dislocation. **C,** Midsagittal T2-weighted magnetic resonance image suggestive of posterior ligamentous disruption through the T11-12 posterior interspace (arrow). **D,** Lateral radiograph taken 12 months after open posterior reduction and instrumented fusion at T10-L2.

Figure 2

A B C D

A, Midsagittal reconstructed CT scan revealing an L2 burst fracture without posterior interspinous widening, vertebral translation, or kyphosis in a 63-year-old man who fell from a height of 15 feet. **B,** Axial CT scan through the L2 vertebral body demonstrating 50% canal occlusion. **C,** Midsagittal T2-weighted magnetic resonance image demonstrating no increased signal in the posterior ligamentous structures. **D,** Lateral radiograph taken 6 months after injury demonstrating stable alignment and fracture consolidation.

increased signal in the posterior ligamentous structures.

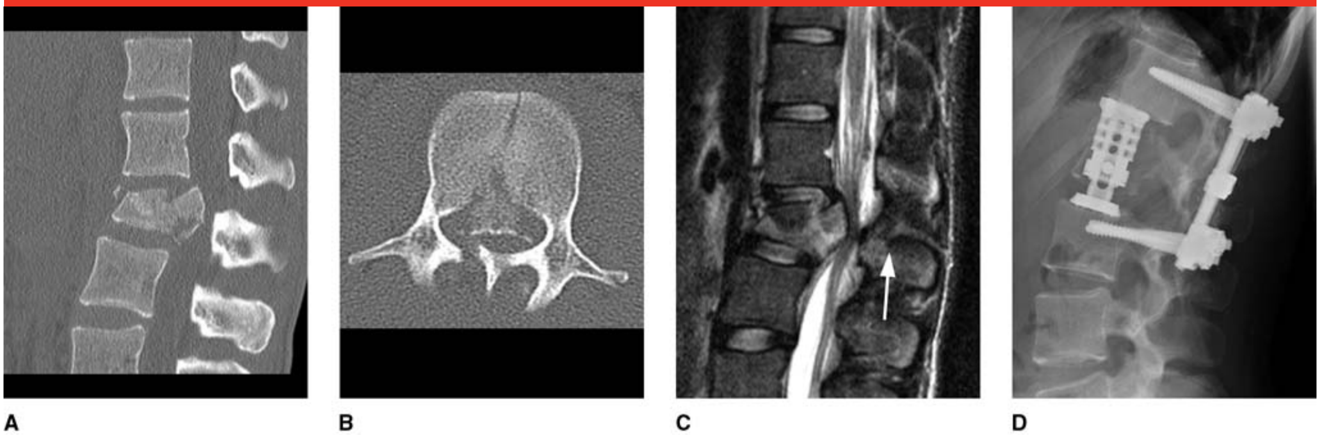
This patient scored 7 points, which indicated the need for surgical treatment, as follows: injury morphology (compression, burst), 2 points; neurologic status (incomplete cord/cauda equina), 3 points; PLC (indeterminate), 2 points. The patient was treated with combined anterior and posterior decompression and fusion (Figure 3, D).

Limitations

The TLICS system and severity score is intended for use in adults with traumatic acute thoracolumbar injuries. It has not been investigated in other populations (eg, pediatric) and thus, cannot be directly applied to other thoracolumbar injuries. The system cannot be applied to symptomatic epidural hematoma, spinal cord injury without radiographic abnormalities, posttraumatic deformity, iatrogenic spinal instability, or pathologic vertebral fractures associated with tumor or infection. The principles that guide surgical decision making in the TLICS—spinal stability and neurologic injury—are, however, applicable to these clinical scenarios.

Only limited information is avail-

Figure 3



A, Midsagittal reconstructed CT scan demonstrating L2 burst fracture with slight posterior widening and kyphosis in a 28-year-old man who sustained a 30-foot fall while skiing. **B,** Axial CT scan through the L2 vertebral body demonstrating 90% canal stenosis. **C,** Midsagittal short tau inversion recovery magnetic resonance image demonstrating canal stenosis as well as indeterminate signal change (arrow) within the posterior ligamentous structures. **D,** Lateral radiograph taken 12 months after combined anterior and posterior decompression as well as fusion at L1-3.

able on the clinical application of TLICS. Many of the articles to date, including this one, have been authored by individuals involved in the creation of the TLICS. It remains to be seen whether similar reliability and validity can be reproduced by other investigators. Published application of the TLICS has primarily been retrospective. Prospective application, with a direct comparison with other classification systems, is needed to clarify the relative and absolute efficacy of the TLICS.

Summary

The TLICS is a recent advancement in the management of thoracolumbar spine trauma. This system was designed to account for the limitations of prior systems by being simple and reproducible, as well as useful in providing prognostic information and guiding medical decision making. The TLICS is the first system to incorporate the neurologic status of the patient, and it is the first that was intentionally designed to be adaptable. In the future, MRI findings may be useful in better defining the status of the PLC in the patient with thoracolumbar trauma.

The TLICS has demonstrated reliability and clinical utility across surgical specialties and levels of surgical experience. The system has been integrated into clinical and educational settings, and it is hoped that use of the TLICS will improve resident and fellow education. By providing a common language and framework for the assessment of thoracolumbar trauma, the TLICS may prove useful in future clinical studies. Although this system shows promise, much is unknown. Further investigation and prospective application of the TLICS are needed to define its clinical utility, predictive value, and validity.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, no level I studies are cited. Reference 2 is a level II study. References 11 and 25 are level III studies. The remainder are level IV and V studies.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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