Spine Tips & Tricks: Thoracolumbar Injury Anatomy, Biomechanics and Classification

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Introduction

An understanding of the anatomy and biomechanics of the thoracolumbar junction is essential to appreciate the unique injury patterns that occur in this region of the spine. Due to the complexities of these injuries, there have been numerous attempts to effectively classify them. While there are many historical classification systems, review of their progression provides valuable insight into the nuances of this subject and allows context to better appreciate the current management of these injuries. This article aims to review the current and historical classification of these injuries and summarize how management can be best guided.

Anatomy and Biomechanics of the Thoracolumbar Junction

The thoracolumbar junction is comprised of the thoracic vertebrae from T10 to L2. There are several distinct anatomic features of the transition from thoracic to lumbar vertebrae that contribute to the patterns of injury seen. The thoracic spine is more rigid than the lumbar spine due to the attachments of the ribcage. This prevents motion in the stiff thoracic spine and concentrates any external forces acting on the spine at the junction of T10 to L2 (T11 and T12 articulate with floating ribs, which do not confer the same amount of stability as ribs connecting to the sternum) as opposed to diffusing the energy throughout a larger segment of the spine. The transition from thoracic kyphosis to lumbar lordosis in this region further reduces the ability of this segment of the spine to dissipate forces in the sagittal plane. In addition, the transition from coronally oriented facets in the thoracic spine to more sagitally oriented facets in the lumbar spine increases the amount of potential motion in this plane.[1]

The axial load of the body on the spine from the force of gravity is not centered on the spine, but approximately 3.5 cm anterior to the C7 plumb line.[2] Thus gravity creates a compressive force along the anterior column of the spine, resisted by the vertebral bodies, and a tensile force through the posterior column countered by the posterior ligamentous complex. The importance of the posterior ligamentous complex as a tension band construct is highlighted throughout numerous injury classifications. Finally, the compressive strength of the vertebrae in the thoracolumbar junction is less than the lower lumbar vertebrae[3], making this portion particularly susceptible to fracture.

Historical Classification Systems

There have been numerous classification systems introduced to objectively stratify thoracolumbar injury. These injuries have been classified by mechanism, fracture morphology, functional anatomic units, columns, presence of ligamentous injury and various assortments of those criteria. Reconciling all the different aspects of these potentially complex injuries into a reproducible and universally accepted system that can guide treatment makes this classification technically challenging.

The first classification system was described by Lorenz Bohler in 1930[4], separating injuries by mechanism such as compression, flexion, extension, distraction, shear and torsion. Watson Jones incorporated fracture morphology such as wedge fractures or comminution into classification in 1938. In addition, Watson Jones introduced the concept of the critical role of the posterior ligamentous complex in stability of the spine.[5] In 1949, Nicoll provided a basic but important component of classification: stable versus unstable fractures. Stability can be important in two functions. In the short term, acute stability of the spinal column requires ensuring the general relationship between vertebrae is maintained to prevent neurologic injury. Long term stability is important in preventing chronic pain or eventual deformity of the spine. Nicoll also proposed the concept of separating the spine into discrete structures to be examined separately: the vertebral body, disc, facet joints and inter-spinous ligament.[6] Holdsworth in 1970 drove the concept of classification by mechanism, thoroughly describing five distinct mechanisms of injury.[7] He also was a proponent, along with Kelly and Whitesides, of the two column model of the spine, with the anterior column being composed of vertebral body and disc, and the posterior column composed of pedicles, lamina, facets and posterior ligamentous complex.[7,8]

In 1983, Denis proposed a classification system that divided fractures by mechanisms of compression, burst, seatbelt injuries and fracture dislocations with further subdivision of each category. With this classification system, Denis proposed the well-known three column model. The foundation of this model is that an intact middle column, which consists of posterior longitudinal ligament as well as the dorsal aspect of the disc and vertebral body, is crucial to stability.[9] Even more complicated classification systems have been introduced since, such as the AO classification introduced by Magerl in 1994. This consists of 53 types of fractures sorted based on three main mechanisms (flexion, distraction and rotation).[10] Ultimately, simplicity lends itself to strong inter-observer reliability, which is essential for a classification system to be useful. While many classification systems struggled to accommodate the multitude of aspects, lasting acceptance of these prior systems was limited due to their inability to ultimately guide treatment.

Thoracolumbar Injury Classification and Severity Scale

In 2005, the Spine Trauma Study Group led by Vaccaro proposed the Thoracolumbar Injury Classification and Severity Scale (TLICS)[11], which is currently a widely-adopted pathway to describe these injuries as it also guides management. The TLICS incorporates injury morphology, posterior ligamentous complex integrity, and neurologic status into a point based scale that identifies patients who would benefit from operative vs. non-operative treatment. The TLICS incorporates these facets by evaluating the injury morphologically on CT scan as well as the patient's clinical neurologic exam to assess for acute stability that may manifest with neurologic symptoms or cause deterioration of neurologic status. Long term stability of the spine is addressed by evaluation for posterior ligamentous complex injury by MRI. A point based scoring system makes the TLICS functionally useful in operative decision making, while morphologic stratification that is not overly burdensome or complex achieves high inter-observer reliability due to the simplicity of the system. This highlights the importance of a classification system where a consensus on operative intervention can be reached, as there is still significant controversy. While instrumentation provides assurance of spinal stability, excellent outcomes of non-operative treatment with bracing in thoracolumbar injury have been reported if the patients are appropriately selected.[12] Despite validation of the TLICS, including a study showing 96% of thoracolumbar injury treatments are accurately predicted by the TLICS[13], universal acceptance has not been achieved by this system.

AOSpine Thoracolumbar Classification System

The AOSpine classification system was introduced in 2013 by Vaccaro and an international group of surgeons to address the continued lack of universal acceptance of a classification system. The system expands upon the TLICS to incorporate a more detailed morphological classification modeled after the Magerl system. The posterior ligamentous complex and the neurologic status are still incorporated in the operative decision making.[13] The algorithm for determining treatment was designed with input from hundreds of surgeons across many international regions.[14] It remains to be seen if this will increase international acceptance of a single common system.

Conclusion

Unlike fracture classification systems in other parts of the skeleton, the thoracolumbar region has many unique biomechanical and anatomical considerations that must be understood to fully appreciate the injuries that occur. The many classification systems that have been introduced struggle to reconcile the vast complexity and variation of differences seen in morphology and mechanism with the more pertinent and simplistic determination of stability and need for operative intervention. While universal acceptance of a single classification system may eventually lend clarity to a complicated and controversial topic, studying the evolution of these classification systems allows for a more thorough understanding of injury to this region of the spine and the advantages and drawbacks of the various classification systems.

References

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