THORACOLUMBAR TRAUMA

Dave Anthony G. Dizon, MD

Adrian B. Catbagan, MD

I. Coverage

This chapter will deal with trauma to the thoracolumbar spine. For practical purposes, this will include the regions of the rigid thoracic spine (T1 to 10), the transitional thoracolumbar junction (T10 to L2) and the flexible lumbar spine (L3 to 5) as set by the Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma.[1] (O'Toole JE at al., 2018). We shall be dealing with injuries from acute trauma. Osteoporotic vertebral compression fractures will not be covered in this chapter.

II. Introduction/Epidemiology

The World Health Organization reports more than 5 million deaths per year from injuries which is about 9% of the world's deaths and nearly the number of mortalities from HIV/AIDS, tuberculosis, and malaria combined. Based on WHO data, for those who survive, injuries account for 6% of all years lived with disability. Their data also shows that people from poorer economic backgrounds have higher rates of death from injuries and non-fatal injuries than wealthier people. [2] (Injuries and Violence The Facts 2014 WHO https://www.who.int/violence_injury_prevention/media/news/2015/Injury_violence_facts_2014/en/)

In the Philippines, "accidents" or unintentional injuries were the 5th leading cause of morbidity in 1994 and had increased by 163% from 1986 when it was ranked 7th. Two hospital-based studies revealed falls to be 20% of all trauma admissions and 33% of all admissions in an orthopedic hospital. [3] (RJ Consunji et al., 2004)

In a meta-analysis of the epidemiology of thoracolumbar trauma by Katsuura et al. in 2016, they found the rate of thoracolumbar fracture in blunt trauma patients to be 6.9% (95% CI 3.2%, 10.6%) with the rate of spinal cord injury being 26.5% (95% CI 15.8%, 37.2%). The rate of non-contiguous cervical spine fracture was 10.49% (95% CI 6.29%, 14.7%). L1 was the most common vertebra injured at a rate of 34.4% (95% CI 18.2%, 50.3%). The most common non-junctional vertebra injured was T7 at 3.9% (95% CI 2.81%, 4.99%). The least injured was T2 at 0.26% ((5% CI 0, 0.56%). [4] (Katsuura Y, 2016)

In the same meta-analysis, the rate of associated injuries were as follows: head trauma12.96% (95% CI 10.9%, 14.9%), extremity trauma 18.26% (95% CI 12.31%, 24.21%), pelvic trauma 9.39% (95% CI 2.94%, 15.84%), thoracic trauma 22.64% (95% CI 8.74%, 36.54%), and abdominal trauma 7.62% (95% CI 0, 17.36%).[4]

III. Pathophysiology/Etiology

A. Relevant Anatomy and Pathomechanics

The thoracic spine usually consists of twelve vertebrae and is distinguished from the adjacent cervical and lumbar spines by the presence of the costal facets where the ribs articulate. The first thoracic vertebra is designated as T1 and is the first vertebra with an articulated rib with the subsequent thoracic vertebra designated T2 and so forth, usually up to T12. There may be variations in the number of thoracic vertebrae, most commonly either eleven or thirteen. The cephalad 10 vertebrae are articulated with ribs which attach to the sternum anteriorly giving added rigidity and stability with the lower vertebrae having only floating ribs. The thoracolumbar junction marks the transition from the relatively rigid thoracic spine to the mobile and more dynamic lumbar spine. It is thus a region of great biomechanical stress. The first lumbar vertebra designated L1 is the first vertebra without a costal facet and a corresponding articulated rib. The subsequent vertebrae are designated L2, L3, L4, and L5.

The central spinal canal contains the spinal cord which usually terminates at the level of the L1-L2 disc in the normal adult beyond which it continues as the cauda equina. There are two major enlargements –one at the cervicothoracic junction where the brachial plexus is formed and the latter at the thoracolumbar junction which is the conus medullaris the roots of which give rise to the lumbar plexus. The nerve roots exit at each level of the spine at their corresponding neural foramen. Injuries above the conus medullaris will thus result in upper motor neuron injury features and those to the cauda equina below L2 will give rise to lower motor neuron features. Injury to the thoracolumbar junction and, thus, the conus medullaris, may show mixed features of both upper and lower motor neuron injury.

Injuries to the thoracolumbar spine are usually the result of high-energy injuries. The meta-analysis by Katsuura et al. showed that the most common etiology for a thoracolumbar fracture was a motor-vehicle collision in 36.7% (95% CI 31.35%, 42%) followed by high-energy fall in 31.7% (95% CI 25%, 38.4%), then motorcycle collision in 10.05%, other causes in 9.06% and a struck pedestrian in 4.83%.[4]

The thoracolumbar junction is a critical transition point in the spine where the relatively rigid thoracic spine articulates with the mobile lumbar spine. It is thus at this area where mechanical failure following high energy trauma to the spine usually occurs.[5] (Vacarro AR et al., 2003.) Trauma to the thoracolumbar spine may include axial compression and torsion, shear, flexion or extension, and usually a combination of forces. Axial compression forces will typically result in either a compression fracture or a burst fracture depending on the degree of force involved. Torsion may result in a facet dislocation but usually occurs in combination with another force vector, thus it is not common to see purely a facet dislocation at the thoracolumbar spine. More likely, one will see a facet dislocation in relation to a burst fracture or a fracture-dislocation. Flexion and extension are distraction forces which may result in a spondylolisthesis or outright dislocation such as that seen in the classic Chance's fracture.

IV. Evaluation and Management

Prehospital Care

There is significant risk for the occurrence of further spinal injury during the extraction and transport of a patient with an unstable spine. It is thus imperative that proper precautions be taken during extraction of an injured individual. A team effort in moving the patient and immobilization with a rigid cervical collar and a flat spine board are an important part of the protocol during the prehospital evaluation and extraction of the injured patient.

Evaluation in the Emergency Room

Initial Clinical Evaluation and Management

Upon reception of the trauma patient at the emergency room, a primary survey is performed and the ABCDE's (airway-breathing-circulation-disability-exposure) assessed as per the Advanced Trauma Life Support (ATLS) protocol. In the evaluation of a multiply injured patient, it will be critical to differentiate neurogenic shock from hypovolemic shock. While both will have hypotension in common, a patient with neurogenic shock is bradycardic and is caused by loss of the sympathetic motor tone of the vasculature. Aggressive fluid resuscitation in a patient with neurogenic shock will be potentially disastrous leading to vascular overload and pulmonary edema. Instead, immediate initiation of vasopressors such as dopamine to keep the blood pressure above 100mmHg may correct the circulatory compromise and increase spinal cord perfusion thereby decreasing secondary trauma to an already injured cord. Dahll et al. reviewed the evidence on hemodynamic management of acute thoracolumbar spine trauma patients in formulating their recommendations for the clinical practice guidelines of the Congress of Neurological Surgeons and found insufficient evidence to recommend for or against the use of active maintenance of arterial blood pressure after acute spinal injury, however, in light of the data from pooled SCI patient populations, the attending physician may choose to maintain mean arterial blood pressures greater than 85 mmHg in an attempt to improve neurologic outcome. [6] (Dhall SS et al., 2018)

During the secondary evaluation in the assessment of the patient, it will be important to log-roll the patient during the inspection phase – such choreographed movements will be important until a spinal injury is ruled out. The patient is carefully logrolled by a team with each person supporting the head and neck, the shoulders, upper extremities and pelvis, and both lower extremities and the back examined.

While a history and physical examination will be straightforward in the awake and alert patient, the challenge will be the evaluation of the unconscious, obtunded, or sedated patient. An awake and alert patient will be able to apprise the examining physician of any physical complaints. The obtunded, unconscious, or uncooperative patient must be assumed to have a spinal injury until proven otherwise.

On the initial evaluation of the spine, close attention is paid to the history particularly any complaints of neck or back pain, numbness or muscle weakness whether still present or merely transient or perhaps even transient paralysis if no deficits are present at the time of the initial evaluation. The initial physical survey and neurologic evaluation should begin before logrolling the patient for inspection of the back. During inspection, take note of any abdominal hematomas or ecchymosis indicative of a seatbelt injury which may indicate a possible flexion-distraction injury to the spine. Note that in the meta-analysis of Katsuura et al., up to 38.7% of patients with these flexion-distraction injuries will have a concomitant intraabdominal injury. [4] During the examination of the back, take note of any hematomas along the midline and tenderness along the midline indicative of a possible PLC injury along with any palpable disruption of the bony anatomy.

A complete neurologic evaluation must be performed on the awake and cooperative patient. The American Spine Injury Association (ASIA) Classification tool is an excellent guide in making a thorough sensory and motor examination which will also help standardize communication between doctors. Also, to facilitate communication, standardized grading of the neurologic deficits using either the ASIA impairment scale of the Frankel Classification should be used.

In the patient with neurologic deficits, it will be important to determine whether there is sacral sparing by testing for rectal sphincter tone, perianal sensation and anal reflexes. This will mean the difference between a complete cord injury versus an incomplete cord injury. It is well documented that patients with complete neurologic deficits will have a poorer prognosis for neurologic recovery compared to those with partial deficits. For acute injuries, it will be important to determine whether or not a patient is in spinal shock. Spinal shock is defined by Dittuno et al. as depressed reflexes caudal to the level of spinal cord injury. [7] (Dittuno JF, et al. 2004.) Nockels goes further to describe it as an acute neurologic syndrome indicating complete paralysis, loss of sensation, absent reflexes, and muscular hypotonia at the time of initial evaluation. [8] (Nockels RP., 2001) The hallmark sign of the bulbocavernosus reflex is a contraction of the rectal sphincter elicited by squeezing the glans penis in the male or stimulating the clitoris in the female or tugging on the Foley catheter in catheterized patients, the presence of which supposedly signals the end of the period of spinal shock. Stauffer claims that there is a 99% chance that spinal shock will resolve within 24 hours [9] (Stauffer ES., 1984), though some sources say that it may last as long as 72 hours. However, the concept of spinal shock is still being criticized and challenged. One criticism is that there is no universal agreement on when spinal shock really ends. In the review article by Dittuno et al., for example, spinal shock is described as a continuum of recovery of reflexes which spans four phases, the completion of which can take as long as 12 months. It is also claimed that the actual period of spinal shock itself carries no prognostic value and some authors believe that a belief in the concept may actually cause delay in the treatment of a patient who may actually benefit from early treatment to end the noxious stimuli causing the spinal injury. It is hoped that further research may eventually settle these issues. At this point, the accepted practice is that the examining physician should do regular neurologic evaluations on the patient and check the bulbocavernosus reflex regularly until it is positive or until 72 hours has elapsed and it is only at this point that the patient is declared out of spinal shock, regardless, and thus declare the status of the neurologic deficits as either complete or incomplete.

The Congress of Neurological Surgeons, in their Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Neurological Assessment, state that the entry ASIA Impairment Scale grade, sacral sensation, ankle spasticity, urethral and rectal sphincter function, and abductor hallucis motor function can be used to predict neurological function and outcome in patients with thoracolumbar fractures. Lumbar injuries particularly to the conus and cauda equina had the best prognosis for neurologic recovery as graded by the ASIA classification most likely due to the higher concentration of lower motor neurons and the ability of these neurons to develop “root escape”. Ankle spasticity was noted to be highly accurate in predicting neurogenic bladder dysfunction. The development of voluntary external anal/urethral sphincter contraction has a significant correlation to bladder recovery and the absence of pinprick sensation at the perineal region predicts poor bladder recovery. [10] (JS Harrop et al., 2018)

Pharmacologic Management of Spinal Cord Injury

The National Acute Spinal Cord Injury Study is a multicenter prospective randomized controlled trial published by Bracken et al. consisting of three trials dubbed NASCIS I, II and III which studied the effects of methylprednisolone in improving neurologic outcomes after acute spinal cord injury. In the studies, patients with complete neurologic deficits given methylprednisolone recovered an average of about 20% of their lost motor function, compared to 8% motor recovery in untreated patients. Patients with partial deficits recovered an average of 75% of their function, compared to 59% in patients who did not receive the drug. In 1990, the second National Acute Spinal Cord Injury Study (NASCIS-2) was published by Bracken et al. where they reported some beneficial effect with the use of methylprednisolone (MP) in patients with traumatic spinal cord injury if it was given within 8 hours post-injury. Patients treated with naloxone or treated with methylprednisolone more than 8 hours after injury did not improve significantly more than patients given a placebo. [11] (Bracken MB, et al., 1990.) A bolus dose of 30 mg/kg is given intravenously on the first hour then 5.4 mg/kg/hour for the next 23 hours if initiated within 3 hours but may be continued for 48 hours for those started within 8 hours post-injury. MP has been shown to improve oligodendrocyte survival and decrease the extent of intramedullary spinal cord hemorrhage in patients.[12] (Wood KB et al., 2014)

The level of evidence of the NASCIS trials, however, have been challenged because the conclusions were drawn from post hoc subgroup analysis, attempts to reproduce the studies have led to inconsistent results and the significant increase of complications with MP use in SCI patients has also been cause for worry. These have led to a decline in its use for SCI patients over the last 3 decades, though it is still considered a treatment option in some clinical guidelines. A meta-analysis was published by Z. Liu et al., on the use of high dose methylprednisolone for acute traumatic spinal cord injury in which they finally enrolled 16 studies which included 3 randomized controlled-trials and 13 observational studies and after analysis concluded that based on the evidence, high-dose methylprednisolone treatment, in comparison to controls, does not contribute to better neurologic recovery but may increase the risk of adverse events in patients with acute SCI. They therefore recommended against the use of high-dose MP early after acute SCI. [13] (Z Liu et al., 2019)

V. Radiographic Evaluation

At the emergency room, if the patient is deemed stable, the appropriate radiographic imaging is ordered. For screening purposes and since it is the quickest that may be performed in most centers, an anteroposterior and lateral radiograph of the spine is usually sufficient. With these views, the examiner will be able to assess the coronal and sagittal alignment, decrease in the vertebral body height, and widening of the interpedicular and interspinous distance and be able to determine stability based on these parameters. One should take into consideration that the cervicothoracic junction will be obscured by the overlap of the shoulder girdle on the lateral view. A swimmer's view lateral may be ordered to assess the proximal thoracic spine, though due to the image being taken in an oblique angle with the x-ray beam pointing from the axilla cephalad to the opposite first rib. Once the spine radiographs are assessed, a through physical examination will follow, with the necessary precautions taken with regards to any spinal injuries noted on the radiographs. Katsuura et al. noted a rate of non-contiguous cervical spine fracture of 10.49% (95% CI 6.29%, 14.7%) [4], thus given the possible disastrous consequences of an unrecognized cervical spine fracture, it should be mandatory to screen the cervical spine in patients with a documented thoracolumbar spine injury, especially in patients with neck pain.

Patients who are unconscious, sedated, or uncooperative and thus unable to provide an adequate examination are assumed to have spinal instability and protected as such and until they have clearance with the appropriate radiographs at the minimum, though ideally with the performance of a 3-dimensional computed tomography (3D CT) of the spine. [12] (KB Wood et al., 2014) Brown et al have shown that, in their institution, a helical CT scan identified 99.3% of cervical, thoracic and lumbar fractures, and those fractures that were missed by the helical CT scan required minimal to no treatment. [14] (Brown CV et al., 2005)

After a thorough assessment is performed at the emergency room, more specialized radiographic imaging may be ordered. A 3-dimensional computed tomography of the spine will be helpful in assessing the bony morphology of the fracture. Magnetic resonance imaging is perhaps the best modality for the diagnosis of a soft tissue injury. Performing an MRI can be quite time-consuming, however, and thus it not usually not among the first-line diagnostics in a multiply injured patient in need of emergent treatment. Its role in this setting is, perhaps, in the trauma patient in whom the radiographic and CT scan findings do not correlate with the clinical picture.

In patients with neurologic deficits, a magnetic resonance imaging of the spine will be invaluable in determining the injury to the soft tissue, particularly the spinal cord and the intervertebral discs, as well as the posterior ligamentous complex (PLC) which has a bearing on spinal stability. Either of these imaging modalities would actually be imperative on the outset if you are highly suspecting an injury to the cervicothoracic junction and your radiographs are equivocal in this regard.

Radiographs

An anteroposterior and lateral radiograph are usually sufficient. When assessing the radiographs, take note of the coronal and sagittal alignment and any abnormal soft-tissue shadows. The AP radiograph will be useful in assessing a traumatic scoliosis deformity caused by a fracture, or lateral displacement from a subluxed or dislocated spine. A normal AP of the spine should show a progressive increase in interpedicular distance per level – an abrupt increase in interpedicular distance at the affected vertebra relative to the adjacent normal vertebrae superior and inferior to it may denote a burst fracture. The lateral radiograph will be useful in assessing the sagittal alignment – a focal increase in thoracic kyphosis or decrease in lumbar lordosis may result from a compression or burst fracture. This is best measured by the Cobb method which measures the angle formed by drawing a line on the superior endplate of the normal vertebra immediately superior to the fractured vertebra and a line drawn on the inferior endplate of the normal vertebra immediately inferior to the injured one. Due to the radiographic parallax caused by the thoracic kyphosis and the lumbar lordosis, a lateral radiograph will also be the best view to assess the degree of vertebral body compression, the retropulsion from a burst fracture, the decrease in disc space height from a possible traumatic disc herniation, or the amount of translation from a spinal dislocation. A focal abnormal increase in width between spinous processes may indicate a possible injury to the posterior ligamentous complex (PLC).

Keynan et al. recommended the following radiographic parameters to be used routinely in the assessment of thoracolumbar fractures: the Cobb angle to assess sagittal alignment in the setting of posterior ligamentous disruption or vertebral fracture; vertebral body translation percentage to express traumatic anterolisthesis; the anterior vertebral body compression percentage to assess vertebral body compression; and on a CT scan, the sagittal-to-transverse canal diameter ratio, the canal total cross-sectional area (measured or calculated), and the percent canal occlusion to assess canal dimensions. [15] (Keynan O at al.,2006)

Mehta et al studied the applicability of using weight-bearing radiographs in the assessment of patients with thoracolumbar spine injury. His group mobilized patients with compression and burst fractures within 48 hours after injury and had radiographs performed prior to mobilization and weight-bearing radiographs performed after mobilization. About 25% of their patients exhibited a significant change in kyphosis and collapse prompting a change in plan to surgical management, thus concluding that a weight-bearing radiograph may play a role in decision-making for thoracolumbar fractures. [16] (Mehta JS et al., 2004)

Computed Tomography

A CT scan will provide the physician with a more detailed picture of the morphology of the spinal injury. Features such as laminar fracture or a unilateral facet dislocation which may not be always appreciable on a plain radiograph will be easily appreciated. The degree of comminution and retropulsion into the spinal canal of fragments from a burst fracture, which may affect the surgical plan, is easily assessed. It is standard protocol to request for fine cuts of about 1mm of the injured levels. Ideally a helical CT should be performed because the sagittal and coronal reconstructions can provide additional detail such as assessment of the congruity of the facet joints, focal kyphosis, and subluxation or dislocation of a spinal motion segment.

Magnetic Resonance Imaging

The MRI is currently the most superior diagnostic modality for visualization of the spinal cord and the surrounding soft tissues. Its use is critical in determining the cause of spinal cord compression wherein the clinical picture or level is not consistent with the level of injury on standard radiographs or on a CT scan such as in the setting of an epidural hematoma, an intramedullary hematoma, or an occult traumatic intervertebral disc herniation.

VI. Classification Systems

With the advent of radiographs, different classification systems have been proposed and published over the last century. Each of the proposed systems had as its basis either the patho-mechanics, the concept of stability or instability, the morphological characteristics, or the radiologic picture of the injury whether on plain radiographs, computed tomography and even magnetic resonance imaging. Yet, while our understanding of the injured spine has progressed with the advancement of radiologic modalities, the development of the ideal classification system with excellent interobserver and intraobserver variability, consistent prognostication criteria, and a reliable pathway for recommending definitive treatment still eludes us.

At the core of the diagnosis and management of thoracolumbar injury is the concept of stability. At the core of any discussion about spinal stability is the spinal motion segment. It would be best to think of the spine as an intercalated system. Each unit in the system is termed as a spinal motion segment consisting of two vertebral bodies and their articulation, the intervening intervertebral disc and the corresponding ligaments which link one vertebra to the other – the anterior longitudinal ligament (ALL), the annulus fibrosus, the posterior longitudinal ligament (PLL), the intertransverse ligaments, the facet joint capsule, the ligamentum flavum, the interspinous ligament and the supraspinous ligament.

While Boehler in 1929 and Watson-Jones in 1938 developed the first classification systems for thoracolumbar spine fractures [17], Nicoll is recognized as having been the first to publish a workable classification system which helps to differentiate between stable and unstable fractures. [18] (EA Nicoll, 1949). Subsequent classification systems have thus had this as part of their core basis. Holdsworth with his "two-column concept" was one of the first to propose that the integrity of the posterior ligamentous complex of the thoracolumbar spine will help to differentiate between a stable burst fracture and an unstable one. [19] (Holdsworth F., 1970). The spinal motion segment was divided into two columns – the anterior column formed by the ALL and the vertebral body and the intervening intervertebral disc; and the posterior column formed by the PLL, the neural arch and its contents, the pedicles, facet joints and the other posterior ligamentous complex (PLC). He emphasized the importance of the PLC in maintaining stability.

Francis Denis further refined the two-column theory into his three column model where he divided Holdsworth's anterior column into two – the anterior half of the vertebral body with ALL and the intervening disc forming the anterior column, the posterior half of the vertebral body with intervening disc and the PLL as the middle column and the posterior column as previously described by Holdsworth. [20] (Denis F., 1983). This middle column is the critical in Denis' model such that disruption of the middle column will lead to spinal instability. Denis went on further to define a classification system based on his three-column theory with four basic injury types: compression fractures, burst fractures, seatbelt injuries, and fracture-dislocations. Panjabi et al. performed biomechanical testing of Denis' three column theory but with a slight variation of Denis' definition of the anterior and middle column – for their experiment the anterior column was defined as the anterior two-thirds of the vertebral bodies of a spinal motion segment with the intervening ALL and disc and the middle column as the posterior one-third of the vertebral bodies and the intervening disc and PLL and concluded that their results supported Denis' three-column concept of the pathomechanics of thoracolumbar fractures and "bolstered the concept of the middle column being the primary determinant of mechanical stability of this region of the spine". [21] (Panjabi MM et al., 1995).

There are variables, however, which confound the concept of instability of a burst fracture, however, which the three-column theory does not account for completely. For example, a significant generalized loss of vertebral height may lead to ligamentous laxity and thus instability. The posterior column and sagittal alignment are not adequately described as to their role in stability for a burst fracture. In 1994, McCormack, Karaikovic, and Gaines published their own proposed classification system which they called the "load sharing classification" (LSC) wherein a point system 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. This was developed in response to their patients with unstable burst fractures to determine which patients can be surgically stabilized by short-segment instrumentation with first generation VSP (Steffee) screws and plates and autograft fusion. This point system was shown that when used preoperatively, it could: (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. [22] (McCormack T, E Karaikovic, RW Gaines, 1994)

Currently, the clinical guidelines by the Congress of Neurological Surgeons recommend the use of the Thoracolumbar Injury Classification and Severity Scale (TLICSS) or the AOSpine Thoracolumbar Spine Injury Classification System which uses readily available clinical data such as radiographs and CT scans with or without an MRI to "improve characterization of traumatic thoracolumbar injuries and communication among treating physicians". [23] (Dailey AT et al., 2018)

Most of the older classification systems are based on either the fracture morphology or pathomechanics or both. They do not take into consideration the neurologic damage nor can predictions of the natural history or prognostication of the injury be made and except perhaps for systems like the Load-Sharing Classification system of McCormack et al., they do not infer any recommendations for surgical decision-making. To address these deficiencies, the Spine Trauma Study Group of Vaccaro et al. convened a consensus study which subsequently formulated the Thoracolumbar Injury Classification and Severity Score based on three injury characteristics: 1) morphology of injury determined by radiographic appearance, 2) integrity of the posterior ligamentous complex (PLC), and 3) neurologic status of the patient. Points were assigned to a modifier within each characteristic and a composite score was summed up stratifying patients into nonsurgical and (less than or equal to 4 points) and surgical (greater than 4 points) treatment groups. The authors designed the scoring system to reflect what they found in consensus were the features important in predicting spinal stability, future deformity, and progressive neurologic compromise, and thus aid the attending physician in making appropriate treatment recommendations. [24] (Vaccaro AR et al., 2005)

The TLICSS system, however, overly simplifies the fracture morphology into only three subgroups and, while it may be useful for decision-making, it has limited use for documentation in terms of research and physician-to-physician communication. In 1994, Magerl et al published what is perhaps the most comprehensive and widely used classification system to date in terms of fracture morphology and pathomechanics. The AO Classification of Thoracolumbar Trauma divides the injuries into three basic groups based on the pathomechanics: group A – compression; group B – distraction; and group C – torsion or rotation. Within each group are subclassifications which further defines the morphology of the injury. While the description of the injury utilizing this system gives a moderate interobserver variability, the large scale of the descriptors again makes it a cumbersome classification for regular use. So, the AOSpine Spinal Cord Injury and Trauma Knowledge Forum convened and, in 2013, Vaccaro et al. published the AOSpine Thoracolumbar Spine Injury Classification System incorporating elements of the original AO Thoracolumbar Trauma Classification and the TLICS scoring system. This new classification scheme offered a more detailed description of fracture morphology based on three main injury patterns: type A (compression), type B (tension band disruption), and type C (displacement/translation injuries) with note of a substantial reliability in identification of a morphologic injury type. At the same time, it incorporates the neurologic status and case-specific modifiers with the intention of assisting the attending physician in terms of decision-making. [25] (Vaccaro AR et al., 2013)

VII. Management

Nonsurgical Management

Fortunately, most thoracolumbar fractures are stable and thus amenable to nonoperative management with up to 39.5% being burst fractures and 33.6% compression fractures according to Katsuura et al. [4] Most compression fractures and stable burst fractures of the thoracolumbar spine (AOSpine Type A) with a TLICS score of 3 are managed nonsurgically.

Isolated transverse process fractures are usually treated with early mobilization as tolerated. Multiple transverse process fractures, however, need to be assessed carefully for instability or a reduced fracture-dislocation. Particular attention in terms of work-up must also be paid to a transverse process fracture of L5 which is associated with a pelvic or sacral fracture in up to 50% of patients.[26] (Rechtine GR II. 2006)

Compression Fractures

Compression fractures (AOSpine Type A1) are generally mechanically stable and rarely associated with neurologic compromise. The first line of treatment is usually pain management with analgesics. Should there still be significant pain despite this, management with a spinal orthotic for 8 to 12 weeks may be indicated. The general prognosis with nonsurgical management is generally good but a small number of patients may still experience persistent pain despite healing of the fracture and the clinical outcome does not always correspond to the radiologic outcomes.[27] (Kim BG et al., 2015)

Note that if the focal kyphosis is greater than 30 degrees or there is a decrease of vertebral body height greater than 50%, the attending physician must have a high level of suspicion for a PLC injury and thus consequent operative treatment. Additionally, if the injury is present in three contiguous vertebral bodies, it is also regarded as an unstable compression fracture and surgery may be indicated. [27] (Kim BG et al.)

Burst Fractures

A burst fracture is a two-column injury based on Denis' three-column model and is inherently unstable if we base the criteria on his original article. However, we know for a fact that the majority of burst fractures (AOSpine Types A3 and A4) can be treated nonoperatively and subsequent studies have proven that the status of the PLC will determine the stability or instability of that particular motion segment. It is thus vital to ascertain a PLC injury (thus adding the diagnosis of an AOSpine Type B2) if it exists whether on physical examination or on imaging studies.

The nonsurgical treatment of a stable thoracolumbar burst fracture is similar to that of a compression fracture with analgesics and either orthotics or body casting being the mainstays of treatment. DJ Hoh et al., in the Congress of Neurological Surgeons guidelines on nonsurgical management of burst fractures, recommend that the use of an external brace is at the discretion of the attending physician as, based on the data reviewed, the nonoperative management of neurologically intact patients with thoracic and lumbar burst fractures either with or without an external brace produced equivalent improvement in outcomes and bracing was not associated with increased adverse events compared to not bracing.[28] (Hoh DJ et al., 2018) While there is an incidence of the possibility of progression of the kyphosis and degree of compression of the fracture, the clinical relevance of this with regards to functional outcome is uncertain. In fact, depending on the author, the degree of kyphosis may or may not correlate with the degree of pain or disability of the patient. Also, due to its being a two-column injury, retropulsion of the posterior vertebral body fragments into the spinal canal may very well occur, though this does not always correlate with a neurologic deficit. It is well established by several studies that spontaneous remodeling of the spinal canal or resorption of the canal retropulsion does occur, thus making even burst fractures with spinal canal retropulsion in patients without neurologic deficit amenable to nonoperative treatment. [29,30]

Wood et al, in fact have proven the superiority of outcomes in patients who underwent nonoperative treatment via analgesics and bracing for a thoracolumbar burst fracture over those who underwent operative treatment.[31] (Wood K, et al., 2003) This was upheld by a Cochrane metaanalysis which concluded that there is no significant difference in functional outcome in patients with a thoracolumbar burst fracture without neurologic deficits who underwent nonoperative treatment versus those who had surgery.[32] (Aleem IS & A Nassr., 2016) Nonsurgical management may thus be the logical choice considering the added cost and risk complications with surgery.

Surgical Management

Surgery for thoracolumbar fractures will be due to one or a combination of three reasons: significant deformity, mechanical instability, or neurologic deficit. Significant central canal compromise with cord compression along with significant kyphosis, and instability from disruption of the PLC will be an obvious indication for surgery. Incomplete spinal cord injury will score higher on the TLICS system and warrant more aggressive intervention compared to complete injuries. Based on the TLICSS, a score greater than 4 indicates a need for a surgical solution.

Surgical management also offers particular advantages over nonoperative treatment, particularly for patients who are unable to tolerate months in an orthosis such as patients with multiple injuries, skin lesions, and obesity, among others. [12] With surgical stabilization, early mobilization and rehabilitation will be possible.

There is insufficient and even conflicting evidence with regards to the timing of surgical intervention for thoracolumbar fractures and its effect on neurologic outcomes, however, the group of Eichholz et al. suggest that early surgery be an option in patients with thoracic and lumbar fractures to reduce the length of hospital stay and the attendant complications with the available literature defining early surgery inconsistently from less than 8 hours to less than 72 hours after injury.[33] (Eichholz et al., 2018).

Compression Fractures

While compression fractures are generally stable and thus treated nonsurgically, fractures involving greater than 50% of the uninjured vertebral body height and around 30 degrees of kyphosis may possibly benefit from surgery, particularly with regards to improving the sagittal balance and thus preventing chronic back pain in the long term. Coronal split fractures (AOSpine Type A2) have a propensity for nonunion and thus may be a source of pain, thus surgical management should be considered especially in the lower lumbar spine.[12]

Burst Fractures

Burst fractures may require surgical treatment more often than compression fractures. While generally mechanically stable (AOSpine Types A3 and A4), injury to the

PLC or compromise of the facet joint or the facet capsules (Type B2) will induce instability and thus be an indication for surgery. This should be suspected when there is a large degree of axial compression (>50%) or if there is more than 25 degrees of angulation. [12] Currently, the decision for surgical management of burst fractures are based on the location of the fracture, the amount of vertebral destruction, the presence of neurologic injury, the degree of focal kyphosis and the stability of the posterior column.

Anderson et al. reviewed the clinical outcomes of patients with thoracolumbar burst fractures comparing the anterior approach with the posterior approach and combined anterior-posterior and concluded that the selection of approach does not appear to impact the clinical or neurologic outcomes and there is no apparent advantage of one approach over the other with regards to the radiologic outcome and amount of complications. [34] (Anderson PA et al., 2018)

In terms of long versus short-segment fixation for thoracolumbar burst fractures, the Load-Sharing Classification by McCormack et al[22] has been shown to be a reliable tool for determining preoperatively the possibility of screw breakage when a posterior short-segment construct is used. Having said this, a metaanalysis by Tarek Ahmed Aly found no significant difference regarding radiological outcome, functional outcome, neurologic improvement, and implant failure rate of long compared to short-segment fixation of thoracolumbar burst fractures. These results suggested that extension of fixation was not necessary when thoracolumbar burst fracture was treated by posterior pedicle screw fixation.[35] (Aly TA., 2017)

Is there an added advantage to performing a formal arthrodesis along with the instrumented fixation of a thoracolumbar burst fracture? There is actually grade A evidence that the omission of fusion in instrumented fixation has not been shown to affect the clinical and radiological outcomes and it just adds to the blood loss and operative time for these surgeries. Also, whether the instrumentation is applied using open or percutaneous techniques, the clinical outcomes are equivalent.[36] (Chi JH et al., 2018)

Distraction Injuries and Translation Injuries

Based on the AOSpine Thoracolumbar Classification, distraction injuries fall under type B of which there are three subtypes: B1 is a transosseous tension band disruption which the classic Chance fracture falls into, B2 is a posterior tension band disruption where you have a type A fracture complicated by a PLC injury, and B3 which is a hyperextension injury where the anterior structures, in particular the ALL, are ruptured but there is a posterior hinge preventing displacement. Type C injuries are translation injuries where displacement or dislocation occurs. Types B and C are generally unstable injuries which occur due to high energy trauma and which will require surgical stabilization. Frequently an instrumented fusion is indicated. In the setting of an incomplete injury, particularly for fracture-dislocations, early decompression and fusion has been shown to be more effective than nonoperative treatment. [12]

Outcomes

For the past several decades, there has been much debate among advocates of different treatment options of thoracolumbar injuries, especially with regards to the clinical outcomes of the nonoperative and operative treatment of burst fractures in patients without neurologic deficits. Despite this, a large part of the literature available are mostly retrospective studies and a few prospective ones but with relatively small populations. These are the main sources of data for systematic reviews and metaanalyses. A large multicenter randomized controlled trial comparing the various treatment options is yet to be conducted.[12] Having said this, systematic reviews and metaanalyses comparing nonsurgical with surgical treatment of burst fractures in patients without neurologic compromise show equivalent clinical and radiologic outcomes and stabilization of a mechanically compromised spine usually leads to good clinical results.

In general, patients with incomplete neurologic injuries have a significant chance for recovery whereas the prognosis is poor for those with complete deficits. Harrop et al. reviewed their data looking at a 10-year period between January 1995 to 2005 where 1746 consecutive spinal injured patients were seen, evaluated, and treated through a level 1 trauma referral center. Limiting the patients to those with a T4 to S5 injury, a retrospective analysis was performed on 150 patients, excluding gunshot wounds. One-year follow-up data were available on 95 of these patients. Over this ten-year period, 95 complete thoracic/thoracolumbar SCI patients had only a 4.1% rate of neurologic improvement, compared with 96.0% for incomplete lumbar (conus) patients and 66.7% to 72.2% for all others. There was no link to age or gender, and race and etiology were secondary to region and severity of injury. They concluded that thoracic (T4–T9) SCIs have the least potential for neurologic improvement. Thoracolumbar (T10–T12) and lumbar (conus) spinal cord have a greater neurologic improvement rate, which might be related to a greater proportion of lower motor neurons. Thus, for future research, the exact region of injury must be defined as this has relevance in the potential for neurologic improvement. Combining all anatomic regions of the spine in SCI trials as has been done in most of the previous trials may be misleading if different regions have neurologic improvement at different rates.[37] (Harrop JS et., 2011.*)*

References

1. O'Toole JE at al. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Executive Summary. Neurosurgery 0:1-5, 2018
2. Injuries and Violence The Facts 2014 WHO https://www.who.int/violence_injury_prevention/media/news/2015/Injury_violence_facts_2014/en/
3. RJ Consunji and AA Hyder. The Burden of Injuries in the Philippines: implications for national health research policy. Accident Analysis and Prevention 36 (2004): 1111-1117
4. Y. Katsuura, JM Osborn, GW Cason. The epidemiology of thoracolumbar trauma: a meta-analysis. Journal of Orthopaedics 13 (2016): 183-388

5. Vacarro AR et al. Diagnosis and Management of Thoracolumbar Spine Fractures. J Bone J Surg 85-A(12): 2455-70, December 2003

6. Dhall SS et al. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Hemodynamic Management. Neurosurgery 0:1-3, 2018

7. Dittuno JF, et al. Spinal shock revisited: a four phase model. Spinal Cord (2004) 42, 383–395, March 23, 2004

8. Nockels RP. Nonoperative management of acute spinal cord injury. Spine 2001;26:S31–S37

9. Stauffer ES. Neurologic recovery following injuries to the cervical spinal cord and nerve roots. Spine 1984;9:532–4

10. JS Harrop et al., Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Neurological Assessment. Neurosurgery 0:1-4, 2018

11. Bracken MB, Shepard MJ, Collins WF, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal-cord injury: results of the Second National Acute Spinal Cord Injury Study. N Engl J Med 1990;322: 1405–1411

12. Wood KB et al., Management of thoracolumbar spine fractures. The Spine Journal 14 (2014): 145-164

13. Liu Z et al., High dose methylprednisolone for acute traumatic spinal cord injury A metaanalysis. Neurology 93(9):1-10, 2019

14. Brown CV, Antevil JL, Sise MJ, et al. Spiral computed tomography for the diagnosis of cervical, thoracic, and lumbar spine fractures: Its time has come. *J Trauma* 2005;58:890-5

15. Keynan O at al. Radiographic Measurement Parameters in Thoracolumbar Fractures: A Systematic Review and Consensus Statement of the Spine Trauma Study Group. Spine 2006;31:E156-E165

16. Mehta JS et al. Weight-bearing radiographs in thoracolumbar fractures: do they influence management? Spine 2004 Mar 1;29(5):564-7

17. Azam MdQ and M Sadat-Ali. The concept of evolution of thoracolumbar fracture classifications helps in surgical decisions. Asian Spine J 2015;9(6):984-994

18. EA Nicoll. Fractures of the dorso-lumbar spine, J Bone Joint Surg Br. 1949 Aug;31B(3):376-94

19. Holdsworth. F. W.: Fractures, dislocations and fracture-dislocations of the spine. J. Bone Joint Surg. 52A(8):1534, 1970.

20. Denis. F.: The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 8:817, 1983.

21. Panjabi MM et al. Validity of the Three-Column Theory of Thoracolumbar Fractures A Biomechanic Investigation, Spine 20(10):1122-1127, 1995

22. McCormack T, E Karaikovic, RW Gaines, The Load Sharing Classification of Spine Fractures. Spine 1994; 19:1741-1744

23. Dailey AT et al. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Classification of Injury. Neurosurgery 0:1-4, 2018

24. Vaccaro AR et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex, and neurologic status. Spine 2005;30:2325-33

25. Vaccaro AR et al., AOSpine Thoracolumbar Spine Injury Classification System Fracture Description, Neurological Status, and Key Modifiers. Spine 2013;38:2028-2037

26. Rechtine GR II. Nonoperative management and treatment of spinal injuries. Spine 2006;31:S22–S27

27. Kim BG et al., Treatment of thoracolumbar Fracture. Asian Spine J 2015;9(1):133-146

28. Hoh DJ et al., Congress of Neurosurgical Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Nonoperative Care. Neurosurgery 0:1-4, 2018

29. de Klerk, LWL, Fontijne, WPJ, Stijnen T, Braakman R, Tanghe HLJ, van Linge B. Spontaneous Remodeling of the Spinal Canal After Conservative Management of Thoracolumbar Burst Fractures.Spine 23(9):1057-1060, 1 May 1998.

30. Kwon IH, Sung HH, MinyoungC,Bo KY, and Gyeong HY. A Clinical Study of the Natural Remodeling of Burst Fractures of the Lumbar Spine. Clin Orthop 323:210-214

31. Wood K, et al. Operative compared with nonoperative treatment of a thoracolumbar burst fracture without neurological deficit. A prospective, randomized study. *J Bone Joint Surg Am* 2003;85–A:773–81

32. Aleem IS and A Nassr. Cochrane in CORR: Surgical versus Nonsurgical Treatment for Thoracolumbar Burst Fractures without Neurologic Deficit. Clin Orthop Rel Res (2016) 474: 619-624

33. Eichholz KM et al., Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Timing of Surgical Intervention. Neurosurgery 0:1-3, 2018

34. Anderson PA et al. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Surgical Approaches. Neurosurgery 0:1-3, 2018

35. Aly TA. Short Segment versus Long Segment Pedicle Screws Fixation in Management of Thoracolumbar Burst Fractures: Meta-Analysis. Asian Spine J 2017; 11(1):150-160

36. Chi JH et al. Congress of Neurological Surgeons Systematic Review and Evidence-Based Guidelines on the Evaluation and Treatment of Patients with Thoracolumbar Spine Trauma: Surgical Approaches. Neurosurgery 0:1-4, 2018

37. Harrop JS et al. Neurologic Improvement After Thoracic, Thoracolumbar, and Lumbar Spinal Cord (Conus Medullaris) Injuries*. Spine, 2011;36(1), 21–25*

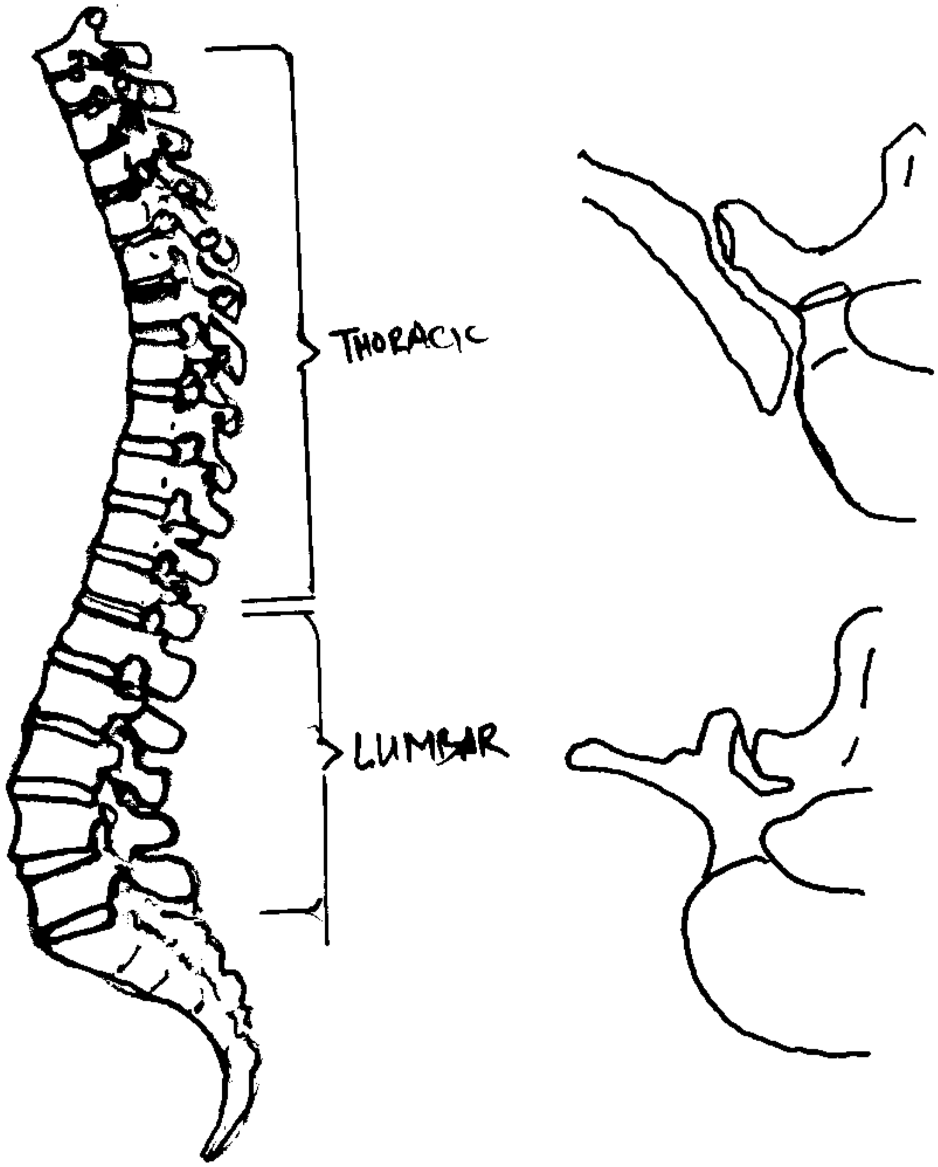

FIGURE 1. Thoracic and lumbar spine.

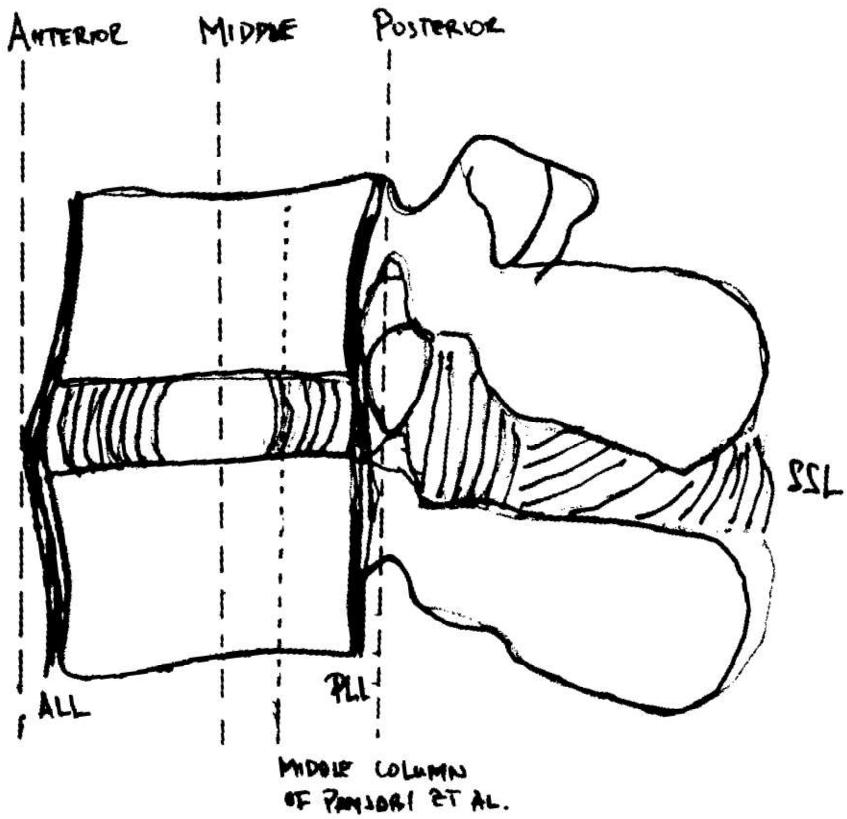

FIGURE 2. The 3-column theory of Denis. In the original description published in Spine 8:817, 1983, the anterior column starts at the anterior longitudinal ligament (ALL) and includes the anterior half of the vertebral bodies with the intervening anterior half of the intervertebral discs, the middle column comprises the posterior half of the vertebral bodies

with the intervening disc including the posterior longitudinal ligament (PLL), and the posterior column includes all structures posterior to the PLL, particularly the pedicles, laminae, the spinous processes and the intervening supraspinous ligament (SSL) and posterior ligamentous complex. For their biomechanical study, Panjabi et al. in Spine 20(10):1122-1127, 1995 modified the anterior column and middle column into the anterior 2/3 and posterior 1/3 of the vertebral body with the intervening discs and the ALL and PLL, respectively.

TABLE 1. Basic modes of failure of the 3 columns of the four major spinal fracture patterns according to Denis, Spine 8:817, 1983

TYPE OF FRACTURE	**COLUMN**		
	Anterior	**Middle**	**Posterior**
Compression	Compression	None	None or distraction (severe)
Burst	Compression	Compression	None
Seatbelt type/ Chance's Fracture	None or compression	Distraction	Distraction
Fracture dislocation	Compression rotation shear	Distraction rotation shear	Distraction rotation shear

TABLE 2. The Load- Sharing Classification (McCormack et al., Spine 19(15):1741-44, 1994)

Amount of comminution/involvement	30% or less comminution of the vertebral body	1
	30-60% comminution	2
	>60% comminution	3
Amount of apposition/ displacement	0-1 mm displacement	1
	At least 2 mm of displacement in less than 50% of the cross-sectional area of vertebral body	2
	2mm or greater displacement in over 50% of the cross-sectional area	3
Amount of correction of	3^{o} or less correction	1
	4^{o} to 9^{o} of correction	2

kyphotic deformity	10º or more correction	3

*significant chance of screw breakage with point total greater than 6

TABLE 3. The Thoracolumbar Injury Classification and Severity Score (Vaccaro A et al., Spine 2005;30:2325-33)

Injury Morphology		
Type	*Qualifier*	Points
Compression		1
	Burst	1
Translational/Rotational		3
Distraction		4
Integrity of Posterior Ligamentous Complex		
PLC disrupted in tension, rotation, translation		Points
Intact		0
Suspect/Indeterminate		2
Injured		3
Neurologic Status		
Involvement	*Qualifiers*	Points
Intact		0
Nerve Root		2
Cord/Conus Medullaris	Complete	2
	Incomplete	3
Cauda Equina		3

*≤3 points is nonsurgical, 4 points may be managed either nonsurgically or surgically, >4 points is a surgical case

FIGURE 2. The AOSpine Thoracolumbar Classification System (Vaccaro et al., Spine 2013;38:2028-2037