TÜRKİYE CUMHURİYETİ'NİN YÜZÜNCÜ YILI

Spinal Injuries

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BIDGE

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Spinal Injuries

Editor: Utku ADİLAY

ISBN: 978-625-372-289-0

Page Layout: Gözde YÜCEL

1st Edition:

Publication Date: 25.06.2024

BIDGE Publications,

Certificate No: 71374

www.bidgeyayinlari.com.tr - bidgeyayinlari@gmail.com

Krc Bilişim Ticaret ve Organizasyon Ltd. Şti.

Güzeltepe Mahallesi Abidin Daver Sokak Sefer Apartmanı No: 7/9 Çankaya / Ankara

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Introduction

Spinal trauma is a common indication for diagnostic imaging, and the use of advanced imaging in the evaluation of spinal injury has become routine in major trauma centers. In order to better understand spinal injuries, it helps to think of the spine as having five separate parts. These parts are the cervicothoracic, low cervical, thoracic, thoracolumbar, and low lumbar spine segments. Most spinal injuries occur in the lower cervical and thoracolumbar regions.

Understanding the anatomy and injury patterns of the spine is vital for the effective identification and treatment of spinal trauma. Spinal trauma can be divided into five different anatomical regions.

Craniocervical Injuries: This area refers to the upper spine where the cervical (neck) and thoracic (upper back) segments meet. Injuries in this region can affect the cervical spine, the thoracic spine, or the junction between them.

Lower Cervical Injuries: This segment includes the lower cervical spine, usually between C5 and C7. Injuries in this area can affect arm and hand functions and may also affect neck stability.

Upper Thoracic Injuries: The thoracic spine is located in the middle back and is connected to the ribs. Injuries to the thoracic spine can affect chest and abdominal functions, as well as the legs, depending on the severity and location of the injury.

Thoracolumbar Injuries: This area refers to the transition point of the thoracic spine to the lumbar spine. Injuries in this area are common and can affect the upper and lower body, including the trunk, legs, and pelvic organs.

Lower Lumbar Injuries: The lowest segment of the spine, usually involving the L4 and L5 lumbar vertebrae and sometimes the sacrum. Injuries in this area can affect mobility, lower body functions, and bowel and bladder control.

CHAPTER I

Craniocervical Injuries

Utku ADİLAY

At the craniocervical junction, there are three bones (occipital base, C1 and C2), two joints (atlanto-occipital and atlantoaxial), and several extrinsic and intrinsic ligaments. This helps keep the cerebellum, cranial nerves, and blood flow to the brain. Careful identification of each injured component and the degree of pulling is important, as these details determine stability and management. [1]

Spinal fractures are quite common in patients evaluated after blunt trauma in the emergency department, with a prevalence of 8% to 15%. [2] Non-contiguous spinal fractures are common, especially in patients diagnosed with spinal fractures after high-energy blunt trauma. [3] According to data from the United States National Trauma Data Bank, a review of more than 83,000 patients diagnosed with spinal fractures shows that 19 percent of these patients had non-contiguous spinal fractures.

In an international meta-analysis, it was found that there are particularly large differences in the incidence of spinal injuries between developed and developing countries, up to a threefold difference. [4] Most studies show that the first peak of spinal injuries usually occurs in young adults aged 15–29 years and the second peak in adults older than 65 years. In the United States, the average age at injury has increased over time, from 29 years in the 1970s to 42 years in 2015. The mortality rate is significantly higher in older patients. [5]

Motor vehicle-related accidents account for almost half of all spinal cord injuries, with severe trauma being the fastest increasing cause of spinal injuries. [6] Travelers involved in rollover accidents are at particularly high risk of cervical spine injury. [7] Following falls and violent acts (primarily gunshot wounds), sports activities are other common causes. [8] Falls account for an increasing proportion of spinal injuries, especially in older adults. Missed or delayed spinal trauma can lead to a 7.5-fold increase in the incidence of neurological injury.[6]

1.1.Mechanisms of Injury

Spinal column damage can cause spinal cord or brain damage by various mechanisms. [9]

1.1.1.Transection

Spinal injuries, such as penetrating or massive blunt trauma, can cause damage by cutting all or part of the spinal cord. Less severe trauma can cause neurological effects such as displacement of bone fragments into the spinal canal and disc herniation (acute traumatic spinal cord injury).

1.1.2.Compression

When an older person has cervical osteoarthritis or spondylosis or is forced to extend their neck, the spinal cord may be compressed between the arthritically enlarged anterior vertebral posterior and the hypertrophied ligamentum flavum. Hemorrhages in the spinal canal, such as spinal epidural hemomatoma, can also compress the spinal cord.

1.1.3.Contusion

Conditions like spinal cord contusions, bone dislocations, subluxations, or fracture fragments can be the cause of it.

1.1.4.Vascular Compression

When there is a level discrepancy between a spinal injury and a known significant deficit, primary vascular damage to the spinal cord should be suspected. Furthermore, a number of spinal fracture patterns are closely associated with vertebral artery injuries, which can lead to paralysis and permanent disability if diagnosis and appropriate interventions are delayed.

Certain conditions may predispose some patients to cervical spine injuries. For example, patients with Down syndrome may be predisposed to atlanto-axial dislocation, while patients with rheumatoid arthritis may be predisposed to transverse ligament rupture of C2.

1.2.Occipital Condyle Fractures

Occipital condyle fractures usually cause pain in the upper cervical region and lower cranial nerve symptoms and may sometimes be associated with atlas fractures. These fractures usually occur as a result of axial loading with a lateral or anterior force.

Anderson and Montesano described three different types of condyle fractures.[10]

Type 1: There is an undisplaced fracture of the condyle, usually unilateral.

Type 2: The fracture of the condyle extends to the skull base; the alar ligament and tectorial membrane are usually intact.

Type 3: The fracture of the condyle is displaced towards the foramen magnum, which may result in atlanto-occipital slippage (30-50%).[7] The injury is an avulsion fracture of the occipital condyle where the alar ligament attaches. If displacement of the fracture occurs, especially if the tectorial membrane is damaged, this indicates instability. Such fractures may require surgical intervention.

1.3.Atlanto Occipital Dislocation

If you hurt your atlas (C1) or axis (C2) in a pure flexion way, the atlanto-occipital or atlanto-axial joint can dislocate, even if there isn't a broken odontoid.[11]

Some measurements are used in plain lateral radiography to assess the presence of atlanto-occipital joint dislocation. However, the accuracy and inter-observer reliability of these measurements have not been adequately studied, especially in trauma patients.[12]

The basion-posterior axial line interval (BAI) and the basion-dental interval (BDI) show a certain relationship in normal adults.[13] It is determined using a line drawn along the posterior border of the anterior body of C2. Two lines are then drawn from this line: one perpendicular to the basion (i.e., the tip of the clivus at the occipital base) and one from the basion to the tip of the dens. If either exceeds 12 mm, this may be atlanto-occipital joint dislocation.

The Powers ratio is often used to assess atlanto-occipital dislocation. OA stands for the distance between the midpoint of the posterior margin of the foramen magnum (opisthion) and the midpoint of the posterior surface of the anterior arch of C1. BC is the distance between the base and midpoint of the posterior laminar line of C1. [14] A ratio greater than one may indicate an anterior subluxation.

Another imaging sign that points to atlanto-occipital dislocation is a break in the "Wackenheim's basilar line," which is a line drawn from the back of the clivus to the tip of the odontoid bone. 15 Normally, the downward extension of this line should touch the back of the odontoid tip. If the line extends in front of or behind the odontoid tip, this may suggest an atlanto-occipital dislocation.

1.5. Atlanto-Axial Dislocation

It is a frequently encountered type during flexion-rotation traumas. It is a type of injury that can be seen on open-mouth odontoid radiographs or CT scans. Interpretation of odontoid radiographs is important because a false positive asymmetry between the odontoid and the lateral masses of C1 may be seen when the skull is rotated.

Clinical signs may present in a wide spectrum, ranging from neck pain to quadriplegia and may result in severe morbidity or death. Lower cranial nerve signs may also be observed. Such injuries are usually high-energy and account for approximately 1 per cent of acute cervical injuries. They are especially common in children and usually occur in association with other body and head injuries. [4, 8]

Submental injuries, mandibular fractures and posterior pharyngeal wall destruction may indicate atlanto-occipital injury. Vertebral artery and basilar artery injuries or subarachnoid haemorrhage at the craniocervical junction may also be seen.

Direct radiographs usually show a large cavity at the atlanto-occipital junction. Prevertebral soft tissue oedema may also be evident. Such injuries are usually fatal. However, in survivors of atlanto-occipital injuries, radiological evidence may be difficult to detect. Radiological diagnosis can be made by increasing the gap between occiput and atlas on lateral cervical radiographs.

According to the classification of Traynelis and colleagues, there are 3 types of classification according to the displacement of the occiput above the axis:

Type 1 (anterior): The cranium is displaced in front of the atlas.

Type 2 (Longitudinal): It is an increase in the distance between the cranial atlas (10 mm in children, more than 5 mm in adults).

Type 3 (posterior): The cranium is displaced towards the back of the atlas.

1.6. C1 (Atlas) Fractures

A burst (Jefferson) fracture occurs when a vertical compression force is transmitted from the occipital condyles to the lateral masses of the atlas.

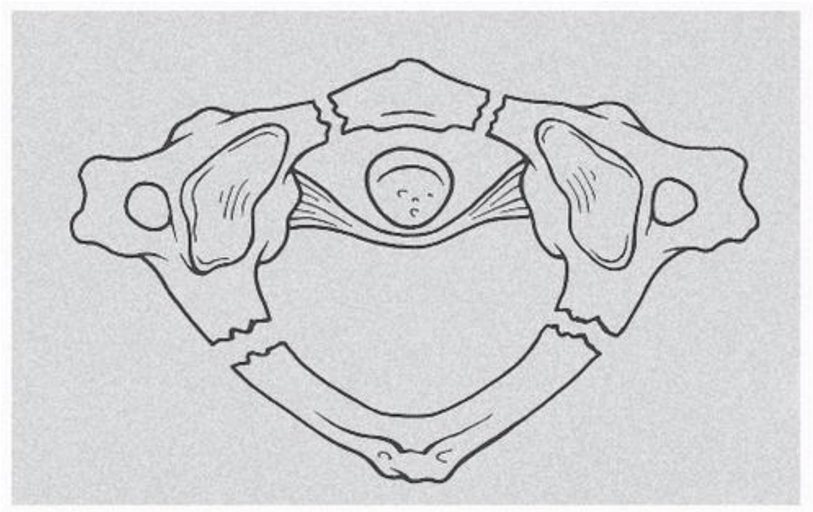

Figure 1.1 *C1 burst fracture (Jefferson fracture)*

This force pushes the lateral masses outwards and leads to fracture of the anterior and posterior arch of C1, with or without damage to the transverse ligament. Tearing of the transverse ligament is a sign of instability. When the transverse ligament is damaged, prevertebral hemorrhage can make the space in front of C1 and the odontoid (dens) on the lateral graph bigger. An atlantodental interval (ADI) greater than 3 mm in adults or 5 mm in children is an indication of instability. When you look at an open-mouth odontoid radiograph from the front to the back, you can see that the C1 masses go all the way to the edges of the articular columns of C2. Jefferson's fracture may be difficult to recognize on plain radiography if there is minimal displacement.

Symptoms such as neck tenderness, pain, pharyngeal swelling, and dysphagia may be seen. Dysphagia may occur in isolated fractures, but spinal cord damage is rare. Severe trauma may be fatal. During axial loading, fracture occurs in the anterior and posterior elements of the weak atlas, while lateral displacement may occur in lateral masses. It can be seen in four forms:

a. Horizontal fractures of the anterior arch: It develops due to compression and is usually stable alone.

b. Isolated posterior arch fractures: A linear fracture line is seen; there is no separation.

c. Lateral mass fractures: There is no comminution.

d. Explosion (Jefferson) fracture: The most serious fracture may also have an axis fracture, causing lateral masses to separate.

1.7. Traumatic Spondylolysis of C2

This is called a hanging man fracture and is caused by excessive hyperextension of the craniocervical region. it is an injury that occurs when the axis is exposed. In this case, the axis pedicle fractures may be bilateral, with or without dislocation. However, spinal cord injury is generally rare. [16]

It accounts for 7% of cervical spine fractures. Traumatic axial spondylolisthesis. Although various classifications have been made, the classification made by Levine and Edwards and Effendiden.in accordance with the modified calcification injury fracture dislocation pattern because it is the most widely accepted. Traumatic hyperflexion and axial loading as a result of fracture. The fracture occurs in the pars interarticularis, the weak part of the axis. The fracture line is usually in the form of bilateral arch fractures, causing displacement from C2 to C3. The neurological examination is usually normal. This condition usually develops as a result of compression of the C2 nerve. [5]

Type 1: The first type involves hyperextension-weighted axial loading, and the fracture line goes through the pars interarticularis. The displacement of C2 from C3 is greater than 2 mm, which is small. It is stable.

Type 2: Hyperextension axial loading, then flexion loading, is the proposed mechanism in these fractures. C2's When the posterior arch fractures, it slides anteriorly over C2-C3. With a fracture of the isthmus, there is more than 3 mm separation (displacement), the angulation is more than 40 degrees, and there is separation in the PLL.

Type 2A: There is less displacement and more angulation than type 2. A mechanism of loading dominated by flexion-distraction forces is proposed. Distraction lifts the body of C2, widening the C2-C3 gap and separating the fracture ends of the posterior arch of C2. The fracture is unstable.

Type 3: Flexion occurs with compression trauma. Together with bilateral facet dislocation, they cause bilateral pars fractures. C2 slips anteriorly over C3. The average displacement is 10.4 mm and the angulation is 15.6 degrees. These are highly unstable fractures. [5]

1.8. Odontoid Fractures

Different anatomical and biomechanical characteristics of the upper cervical region It must be assessed differently from other regions. For this region, the consequences are catastrophic. Acute cervical trauma results in odontoid fractures in approximately 20% of cases. [1, 7, 9, 13]

The risk and management of fractures are still debated in the literature. Today, Anderson and D'Alonzo's classification of the anatomical location of the fracture is used.

Type 1: Oblique avulsion fractures occurring at the dens end above the transverse ligament. Direct radiographs and axial CT may miss them, so reformatted CT should be supportive. They are rarely seen and are usually stable fractures. However, whether they cause instability in the atlantoaxial complex is controversial. Although usually stable, instability may occur with an avulsion injury to the atlantoaxial ligament. Type I fractures may be associated with atlantooccipital distraction trauma. In these cases, the dynamic motion of the atlantoaxial joint should be assessed with cervical spine radiographs.

Type 2: Fractures occurring at the base of the odontoid process. This is the most common type of fracture. These are usually unstable fractures.Free bone fragments are what cause Type IIA fractures, which are unstable fractures that happen at the base of the odontoid process.

Type 3: Progression of the fracture line from the base of the odontoid to the body of the axis. Some type III fractures are fractures from the base of the dens and fracture fragments extending to the base. Typical type III fractures can be treated with orthoses. High-Level Type III Odontoid Fractures These can be confused with Type II fractures, but these types of fractures are considered unstable and surgery is required. If the fracture line involves the superior articular surface of the axis, it is considered a Type III fracture.

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CHAPTER II

Lower Cervical and Upper Thoracic Injuries

Salim KATAR

2.1. Lower Cervical Injuries

Injuries to the mid to lower cervical spine, known as subaxial injuries, account for approximately 65% of cervical spine fractures. These injuries are classified based on the mechanism of injury, which can include flexion compression, extension compression, vertical compression, flexion-distraction, extension-distraction, and lateral flexion or rotation. [1] Each type of injury affects the spine in different ways and influences the approach to treatment. To provide a comprehensive evaluation and guide management, the Subaxial Injury Classification and Scoring (SLIC) system is utilized. This system incorporates both imaging findings from CT and MRI scans and clinical observations into a unified score. The total SLIC score categorizes patients into three management groups: nonsurgical (total SLIC score = 3), indeterminate (=4), or surgical (= 5) [12] (Table 1.1).

In this scoring system, each level of the cervical spine that is injured is assigned a separate score based on the severity and type of injury. The most severe injury is what determines a patient's final score, and the classification is based on the highest score among the injured levels. For instance, if an injury involves both distraction and translation, it is scored based on the translation component, as this usually represents a more severe condition. [2, 3]

Understanding and accurately applying the SLIC system is crucial for radiologists, as it facilitates clear and effective communication with trauma surgeons. By using standardized terminology and scoring, radiologists can help ensure that the appropriate treatment plan is determined. Patients who receive a high SLIC score generally need surgical intervention to address issues such as spinal cord compression and to stabilize the spine, which can be critical for preventing long-term neurological damage. On the other hand, a lower SLIC score usually means that conservative treatments like bracing and physical therapy may be enough, which means that surgery may not be necessary. This classification system not only aids in the immediate management of cervical spine injuries but also contributes to long-term patient outcomes by guiding appropriate treatment strategies.

Table 1.1. *Subaxial Injury Classification and Scoring (SLIC) system*

Category	**Score**
Neurologic status	
Intact	**0**
Root injury	**1**
Complete cord injury	**2**
Incomplete cord injury	**3**
Incomplete cord injury with ongoing cord compression	**4**
Morphology	
No abnormality	**0**
Compression	**1**
Burst	**2**
Distraction (facet diastasis >2 mm, facet subluxation with<50% overlap, posterior disk space widening and >11°angulation)	**3**
Rotation (anterolisthesis >3.5 mm but <50% of caudal vertebral body anterior-posterior (AP) dimension) *or* translation (anterolisthesis >3.5 mm and >50% of caudal vertebral body anterior-posterior (AP) dimension)	**4**
Discoligamentous complex	
Intact	**0**
Indeterminate	**1**
Disrupted	**2**

2.2. Upper Thoracic Injuries

The ribs, sternum, and spine act as a ring to support the T1–T10 vertebrae, limiting their mobility in comparison to the cervical and thoracolumbar regions, which are more flexible. Consequently, traumatic injuries in this part of the thoracic spine are less frequent. In younger individuals, fewer than 25% of thoracic fractures involve the T1–T10 vertebrae. These fractures typically occur from significant trauma such as falls, motor vehicle accidents, or seizures. [4] Among these, the most common fracture pattern is superior endplate compression. When this kind of fracture happens, the paraspinal swells, the anterior vertebral height drops, and the anterior cortex and subchondral bone are damaged. The posterior height stays the same, and there is no retropulsed bone or misalignment. Mild anterior height loss isn't always a sign of one thing; it could be caused by changes in the body or a condition like Scheuermann disease, which is linked to disc height loss, Schmorl's nodes, and kyphosis [19]. However, impacted subchondral trabecular bone is a more accurate sign. It shows up as a transverse zone of sclerosis running parallel to the endplate and gets stronger as the healing process goes on. While mild compression fractures are generally stable and may not require aggressive intervention, those with more than 40% height loss pose a risk for developing delayed kyphotic deformity, especially when multiple contiguous fractures are present. [4]

For young individuals, fractures in the upper thoracic spine are typically the result of significant trauma, such as high-impact collisions or severe falls. Conversely, in elderly patients with osteoporosis, fractures can occur from relatively minor trauma, making them challenging to detect on standard radiographs. Osteoporotic thoracic fractures are quite common, with studies showing that 18% of white women over the age of 50 and 78% of those over 90 years old have at least one thoracic compression fracture. These fractures often coincide with additional fractures in the lumbar region. [5] Osteoporosis lowers bone density, which makes it easier for fractures to spread to the back edge of the vertebral body. This can cause more height loss and the bone to push back into the spinal canal, which can make the spine less stable and nerves more compressed.

Figure 2.1. *T9 burst fracture, sagittal and axial section computer tomography*

In elderly patients, distinguishing between osteoporotic fractures and pathological fractures can be particularly challenging. Fractures that only happen in areas above T7, significant posterior height loss or bulging of the posterior cortex, cortical erosion of the vertebral body or posterior elements, the presence of a soft tissue mass, and the replacement of the vertebral body fat signal on imaging studies are all signs of possible neoplasia. A benign process, on the other hand, is shown by a simple transverse fracture line with band-like partial marrow replacement limited to either the upper or lower half of the vertebral body and a linear cleft of fluid or gas. [6] When it's not clear what's wrong, advanced MR techniques like phase imaging, which finds microscopic fat inside benign lesions, and techniques that find areas of restricted diffusion within neoplastic tissue can be very helpful. Nonetheless, some fractures may remain indeterminate, necessitating a biopsy to confirm the diagnosis. [7]

Severe upper thoracic injuries, including burst fractures with retropulsed bone, anterior and posterior distraction injuries, and fracture dislocations, are relatively rare but can have serious consequences. A mix of hyperflexion, axial loading, and rotary/shear forces can cause fracture-dislocations in the upper thoracic spine. This can cause ligaments to tear, complex fractures, and the spine to become out of place. This malalignment may include vertebral translation, rotation, and telescoping, which complicates the injury. [7] The unique anatomical feature of the upper thoracic spine its disproportionately small spinal canal relative to the spinal cord contributes to a higher risk of neurological deficits. Additionally, soft tissue hemorrhage and injuries to visceral and mediastinal structures are frequently associated with these severe injuries. Comprehensive evaluation of such complex cases typically requires both CT and MR imaging to thoroughly assess fractures, ligament damage, neural elements, and paraspinal soft tissues. These imaging modalities are essential for planning appropriate treatment and managing potential complications.

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CHAPTER III

Thoracolumbar and Lower Lumbar Injuries

Adil Can KARAOĞLU

3.1. Thoracolumbar Injuries

The thoracolumbar region is notably prone to injury, representing the second most frequent site of spinal trauma after the lower cervical spine. This area is particularly vulnerable due to its transitional nature, where the more rigid thoracic spine meets the more flexible lumbar spine. The thoracolumbar junction is subjected to significant biomechanical stress during activities involving bending, twisting, and axial loading. This susceptibility means that injuries in this region are common, especially in high-impact situations such as falls, motor vehicle accidents, or severe sports injuries.

Initially, the Denis classification system was the predominant framework for categorizing thoracolumbar injuries. The spine is split into three separate columns by this system: the anterior column has the anterior vertebral body and the anterior longitudinal ligament; the middle column has the posterior vertebral body, the posterior longitudinal ligament, and the posterior annulus fibrosus; and the posterior column has the neural arch and structures that go with it, like the spinous and transverse processes. Denis emphasized the role of the middle column in maintaining spinal stability, as it plays a critical role in resisting compressive forces and maintaining the alignment of the spine. [1]

Denis's classification categorizes thoracolumbar injuries into four types based on the columns involved:

1. **Compression fractures**: These affect only the anterior column and are characterized by a loss of vertebral height due to collapse of the anterior part of the vertebral body.
2. **Burst fractures**: When someone has a burst fracture, both the anterior and middle columns are affected. The vertebral body often breaks into large pieces, and these pieces may travel back into the spinal canal.
3. **Seat belt injuries** result from distraction forces that impact the middle and posterior columns, typically seen in cases of high-impact accidents where the force of a seat belt can cause disruption of these columns.
4. **Fracture-dislocations**: These involve disruption of all three columns and are associated with severe spinal instability, often resulting from severe trauma that causes both fracture and displacement of vertebrae.

While the Denis system was revolutionary for its time, it had limitations as it primarily relied on radiographic images and did not fully address injuries where the anterior column is compressed while the posterior elements fail due to distraction. Such patterns are better visualized using MR imaging, which can provide detailed views of soft tissue injuries and ligamentous damage.

Modern classification systems have evolved to address these limitations and offer a more comprehensive framework for assessing thoracolumbar injuries. The current standard combines the AO-Magerl classification (Arbeitsgemeinschaft für Osteosynthesefragen) with the TLICS (Thoracolumbar Injury Classification and Severity Score) system. [2] This integrated approach was developed through international consensus among spine surgeons and is designed to cover a wider range of injury patterns and clinical scenarios.

The AO/TLICS system classifies thoracolumbar injuries into three main categories based on fracture morphology:

1. **Type A (compression fractures)**: These fractures involve compression of the anterior column and may include simple wedge fractures or more complex patterns with varying degrees of height loss.
2. **Type B (tension band disruptions)**: These injuries affect the tension band structures of the spine, which can be anterior or posterior, and include burst fractures and those with significant ligamentous disruption.

3. **Type C (displacement/translation fractures)**: These involve significant vertebral displacement or translation and often result from high-energy trauma or severe instability.

Each category has several subtypes that provide further detail about the nature of the injury. For instance, Type A fractures can range from simple anterior wedge compression to more complex cases involving multiple vertebrae. Type B fractures may include those with significant posterior element disruption or tension band injuries. Type C fractures encompass severe dislocations or translational injuries, which are often associated with high-impact trauma.

Assessment of thoracolumbar injuries requires accurate imaging to evaluate both bone and ligament injuries. CT scans are effective for visualizing bony structures and determining the extent of vertebral body damage, while MRI is crucial for assessing soft tissue injuries, including ligamentous damage and spinal cord compression. This comprehensive imaging approach helps in accurately classifying the injury and planning appropriate management.

After figuring out the type of fracture, the neurological status and patient-specific factors like age, overall health, and bone quality are looked at. These factors affect how likely it is that surgery will be needed. Neurological assessment is crucial, as the presence of deficits such as paraplegia or altered sensation can impact the treatment approach. This integrated classification system thus aids in tailoring treatment plans to individual patient needs, balancing the risks and benefits of surgical versus conservative management strategies. This new method is similar to the SLIC (Subaxial Injury Classification and Scoring) system used for cervical spine injuries. It combines information about the injury and clinical factors to help with the best care.

3.1.1.Type A: Compression Injuries

Compression injuries are the most prevalent mechanism of injury in the thoracolumbar spine, resulting in a range of fracture morphologies. These include superior and inferior endplate impaction, varying degrees of anterior wedging, burst fractures, and sagittal splitting of the vertebral body. When a vertebra breaks in a compression fracture, the anterior vertebral height often goes down, the cortical bone buckles, and the endplate gets smaller. This causes band-like sclerosis to form next to the broken endplate. On CT scans, these injuries appear as arcs of irregular bony fragments displaced circumferentially around the endplate. Importantly, the height of the posterior vertebral body and intervertebral disk generally remain preserved, and there is usually no listhesis, which is the forward displacement of one vertebra over another.

Mild compression fractures frequently call for conservative management, but those that have more than 40% height loss, particularly when they come with numerous contiguous fractures and posterior ligament sprains, may require protracted bracing. This extended bracing helps in stabilizing the spine and promoting healing by reducing movement and stress on the injured vertebrae. [3] Severe compression fractures, characterized by more than 70% height loss, may need surgical intervention, such as posterior stabilization, to prevent the development of kyphotic deformity. Kyphotic deformity, or excessive forward curvature of the spine, can result in chronic pain and functional impairment, making timely and effective treatment essential.

Burst fractures are different from simple compression fractures because they damage the back of the vertebral body, causing the back of the vertebra to lose height and bone fragments to move back into the spinal canal. This displacement can potentially compress the spinal cord or nerve roots, leading to neurological deficits. The thoracolumbar region is particularly susceptible to burst fractures due to the high forces experienced in this transitional area of the spine, and these fractures account for approximately 16% of all spinal injuries encountered at trauma centers.

CT imaging is the preferred method for evaluating burst fractures due to its ability to provide detailed cross-sectional views of the bony structures. It efficiently characterizes the fracture pattern, identifies associated posterior element fractures, and assesses the extent of bony encroachment into the spinal canal. This information is critical for planning appropriate treatment and assessing the risk of neurological complications. Additionally, MRI may be employed to evaluate soft tissue damage, including spinal cord compression or contusion, and to further guide surgical planning if needed. The combination of CT and MRI provides a comprehensive assessment of the injury, facilitating accurate diagnosis and effective management strategies.

3.1.2. Type B: Distraction (Tension Band) Injuries

The main cause of distraction injuries in the thoracolumbar spine is flexion forces, which result in tensile stress and can cause a variety of injuries to the bones, ligaments, or both. These injuries typically initiate at the posterior aspect of the spine, causing separation between the posterior elements. This separation can then extend to involve anterior soft tissues or result in vertebral fractures. A classic example of a distraction injury is the Chance fracture, characterized by a horizontal fracture line through the vertebral body and posterior elements. However, distraction injuries are not limited to this pattern; they encompass a broad spectrum of variations depending on whether the primary damage is to the ligaments or bones and whether the distraction affects the entire spine or is localized to the posterior elements.

The severity of distraction injuries can vary significantly. Different levels of splaying can be seen in the back parts, like the spinous processes and laminae, but it can be hard to see on regular x-rays and CT scans, especially if the patient is lying on their back. [4] This difficulty in detection is due to the way these imaging modalities may not fully capture the three-dimensional nature of the injury, especially when soft tissue damage is involved. Consequently, posterior tension band injuries, which often accompany vertebral body fractures, can be misdiagnosed as simple compression or burst fractures if MR imaging is not performed. MRI is essential in these cases, as it provides detailed images of the soft tissues and ligaments, allowing for accurate diagnosis and better understanding of the extent of the injury.

In contrast to posterior distraction injuries, anterior tension band injuries due to hyperextension are less common. These injuries typically present as horizontal fractures through the vertebral body or through an ossified disk in older patients who have undergone degenerative spinal fusion. The increased stress on the anterior elements during hyperextension can lead to notable changes in vertebral height and alignment. This type of injury may result in an increase in vertebral or disk height and an abnormal increase in spinal lordosis, which is a condition where the spine curves excessively inward. Concurrent degenerative changes, such as disc degeneration or osteophyte formation, can also complicate hyperextension injuries, which further complicates the clinical presentation and management. [5]

To summarize, accurate assessment and management of distraction injuries require a thorough understanding of the injury mechanisms and patterns. Advanced imaging techniques, such as MRI, play a crucial role in identifying and characterizing these injuries, which helps guide appropriate treatment strategies. This comprehensive approach ensures that both the bony and soft tissue components of the injury are adequately addressed, improving patient outcomes and reducing the risk of long-term complications.

3.1.3Type C: Displacement/Dislocation

The most severe form of spinal injury involves displacement with translation and/or rotation, which is a result of complete disruption of all spinal ligaments. This catastrophic injury typically impacts both the anterior and posterior aspects of the vertebrae, leading to complex fracture patterns. In addition to the spinal injuries, these severe cases often involve associated rib fractures and costotransverse dislocations. Rib fractures can complicate the clinical picture, potentially leading to pneumothorax or hemothorax, while costotransverse dislocations can affect the stability of the thoracic spine and complicate overall treatment and recovery.

Thoracolumbar displacement or dislocation injuries are particularly concerning due to their high association with neurological deficits. The displacement and rotational forces involved in these injuries can significantly impact the spinal cord and nerve roots, leading to severe neurological outcomes. Studies have shown that between 50% and 90% of patients with such injuries develop permanent neurological deficits. These deficits can range from partial loss of sensation and motor function to complete paraplegia, depending on the severity and level of spinal cord involvement.

The management of these injuries is complex and requires a multidisciplinary approach, including urgent surgical intervention to stabilize the spine and decompress the spinal cord if necessary. Post-injury rehabilitation is crucial and often involves physical therapy, pain management, and psychological support to address the functional and emotional impacts of the injury. Additionally, elements like the speed of treatment, the degree of initial neurological damage, and the presence of associated injuries like rib fractures and lung complications can affect the prognosis. Thus, a comprehensive and timely treatment strategy is essential for optimizing recovery and improving long-term outcomes for patients with severe thoracolumbar spinal injuries.

4.1.Lower Lumbar

A pars interarticularis fracture, commonly referred to as spondylolysis, is a stress fracture that occurs in the bony arch connecting the upper and lower facet joints of a vertebra. This type of injury is most frequently seen at the L5 vertebra, accounting for 85–95% of cases, and less commonly at the L4 level, which accounts for 5–15% of instances. [6] The overall prevalence of spondylolysis in the general population is about 6%. Many individuals with spondylolysis do not experience any symptoms and may remain unaware of the condition. However, it can cause significant pain and discomfort, particularly in athletes who engage in activities that place substantial stress on the lower back. Sports such as football, wrestling, dance, and weightlifting are commonly associated with this condition, especially among adolescents and young adults whose spinal structures are still developing and may be more vulnerable to stress fractures. [7]

When diagnosing spondylolysis, radiographic imaging is often the first step. The oblique view of X-rays is particularly useful for visualizing the pars interarticularis and detecting fractures in this area. Nonetheless, traditional radiographs may have limited sensitivity and may not always reveal stress fractures or nondisplaced fractures effectively. [8] To assess the extent of spinal instability and motion, flexion and extension X-ray views are used. These views are valuable for detecting spondylolisthesis, a condition in which a vertebra slips forward over the one below it. This complication is found in 50–81% of individuals with spondylolysis and can exacerbate symptoms by contributing to spinal instability and potentially leading to further complications. [6, 7, 8]

Given the limitations of standard X-rays, advanced imaging techniques such as CT scans and MRI are recommended for a more comprehensive evaluation. CT scans are particularly adept at detecting fractures and providing detailed images of bony structures, making them highly effective for confirming the presence of spondylolysis. MRI, on the other hand, is invaluable for identifying edema and other soft tissue changes associated with early-stage injuries. [6] This capability of MRI helps in evaluating the severity of the injury and understanding the impact on surrounding soft tissues.

Early and accurate diagnosis is crucial as it enables timely and appropriate treatment, which usually starts with conservative measures. These include rest, physical therapy, and nonsteroidal anti-inflammatory drugs (NSAIDs) to manage pain and reduce inflammation. A carefully tailored physical therapy program may include exercises to strengthen the core muscles and improve spinal stability, helping to alleviate symptoms and prevent further injury.

In cases where conservative treatment does not provide adequate relief or where the condition is severe and persistent, surgical intervention might be considered. This typically involves procedures such as spinal fusion, which aims to stabilize the affected vertebrae and relieve pressure on the spinal nerves. Surgical options are generally reserved for the 9–15% of patients who do not respond to conservative management and continue to experience significant symptoms. [6]

To ensure precise diagnosis and appropriate management, diagnostic injections of steroids or local anesthetics may be utilized. These injections can help confirm that spondylolysis is indeed the source of the patient’s pain by temporarily alleviating symptoms and allowing clinicians to verify the diagnosis before proceeding with more invasive treatments. [9] Overall, a multidisciplinary approach involving imaging, conservative treatment, and, if necessary, surgical intervention is essential for effectively managing spondylolysis and improving patient outcomes.

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