Thoracolumbar and Lumbar Burst Fractures

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Thoracolumbar/Lumbar Burst Fractures: Overview

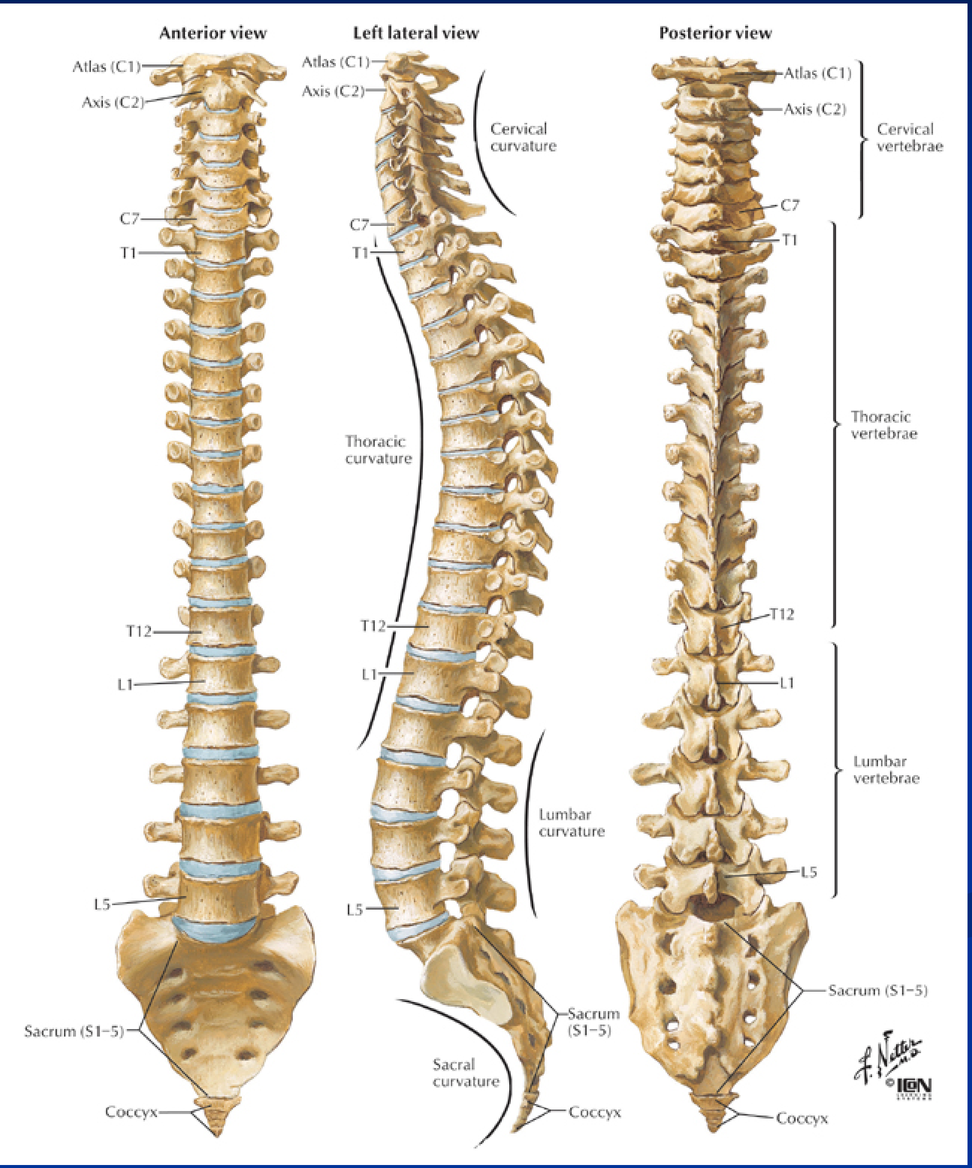
- Epidemiology
- Anatomy
- Initial Assessment
- Imaging
- Injury Mechanism/Biomechanics
- Fracture Classification
- Treatment Options: Operative vs. Non-operative Management

Epidemiology

- 79,000 spinal fractures in U.S. each year – 72.5% involve thoracic or lumbar spine [1,2]
- Most common site of injury is thoracolumbar junction
  - Mechanical transition zone between rigid thoracic and more mobile lumbar spine [3-5]
- Lumbar spine more prone to injury
  - Absence of ribs, transition from kyphotic to lordotic posture, sagitally oriented facet joints [6]
- Operative versus non-operative mgmt: controversy

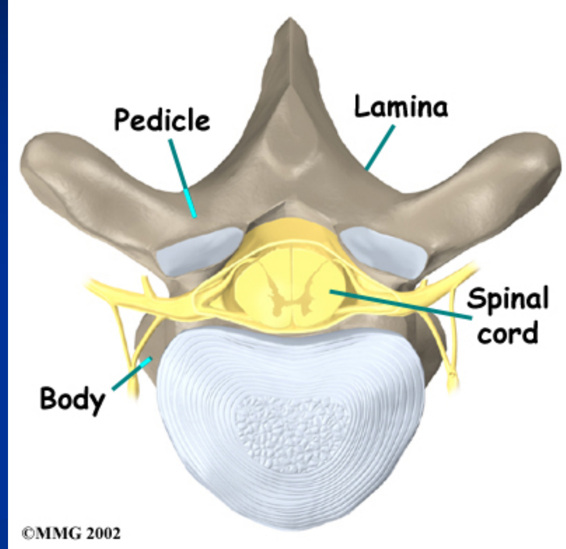
Anatomy

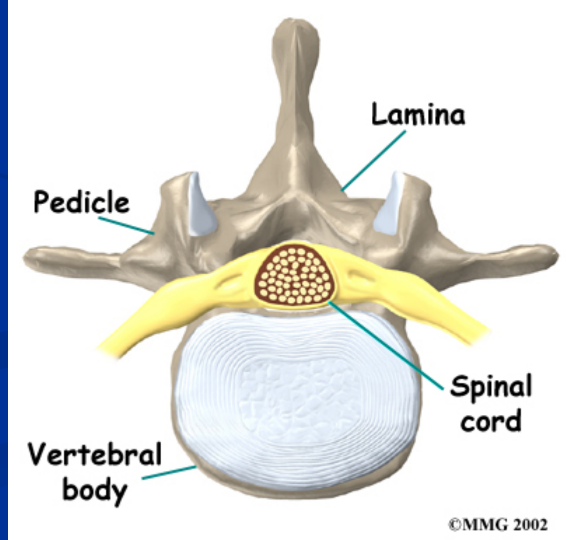
- Vertebral column: 29 vertebrae organized in 4 curves:
  - 2 primary curves present at birth: **thoracic** and **sacral (kyphosis)**
  - 2 compensatory curves - result of adaptation to upright posture: **cervical** and **lumbar (lordosis)**



Anatomy

- **T spine**: made rigid by ribcage articulations (ligamentous support); facet joints in coronal plane limit flexion/extension
- **L spine**: facet joints in sagittal plane increase flexion/extension but decrease lateral bending/rotation
- **TL junction**: facet joints in oblique orientation; provide support and resistance to 35-45% of torsional and shear forces on spine



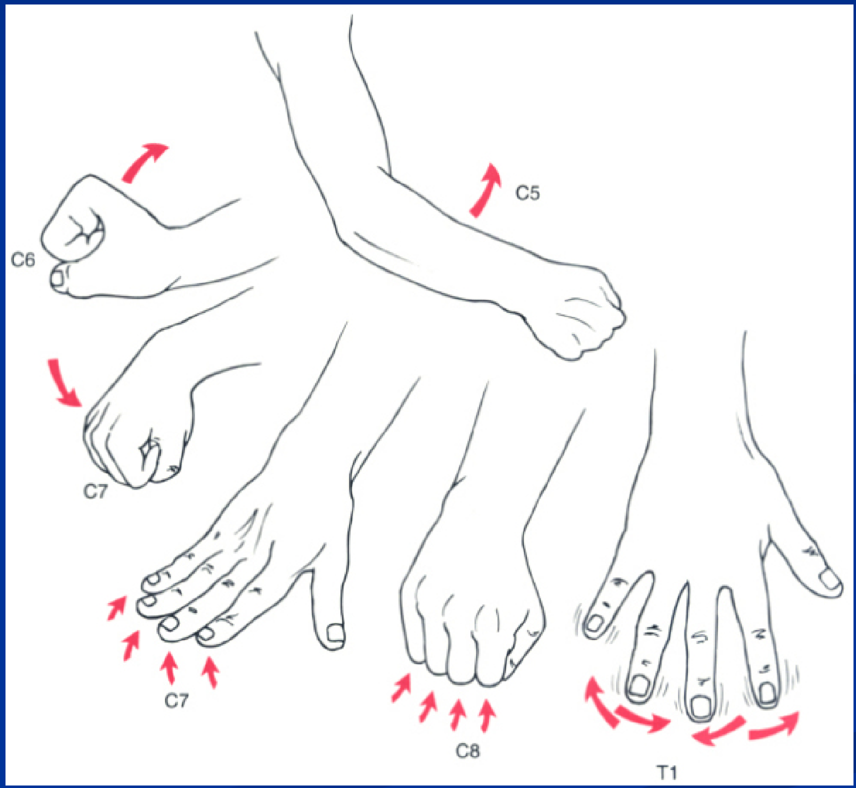


Initial Assessment

- **ABCs & Immobilization**: patients should be immobilized until stability of fracture can be assessed adequately – avoid loss/worsening of neurological deficits [4]
- **Neurological exam**: performed as soon as the patient is hemodynamically stable: motor, sensation, DTRs, digital rectal exam [10]
- Neurologic deficits from TL fxs can involve spinal cord or cauda equina
- 70% of thoracolumbar injuries do not have associated neurologic deficits [2]

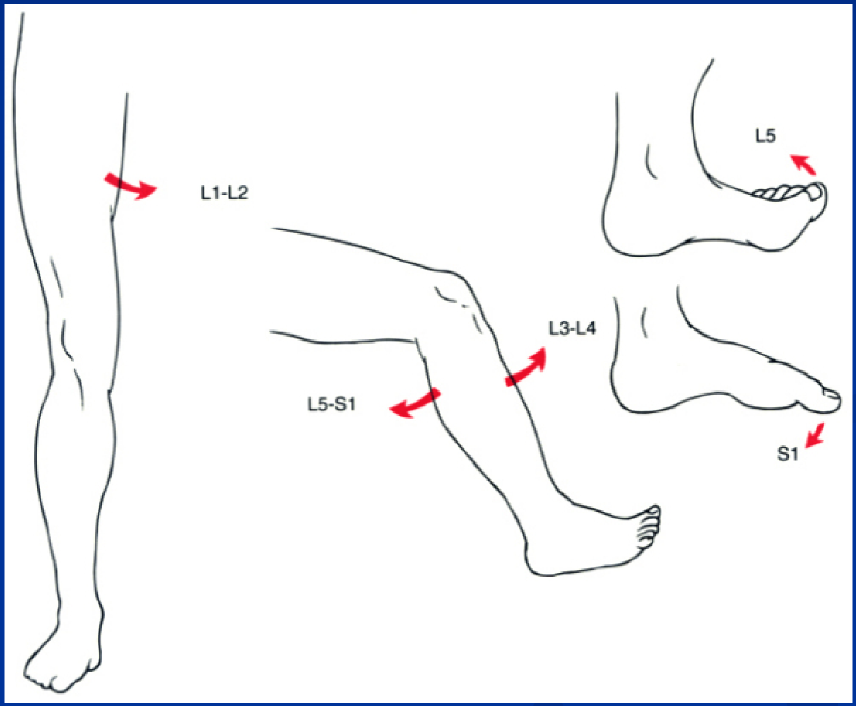
Initial Assessment: Motor Examination

- Upper extremity
  - C5-shoulder abduction
  - C6-wrist extension
  - C7-wrist flexion
  - C8-finger flexion
  - T1-finger abduction

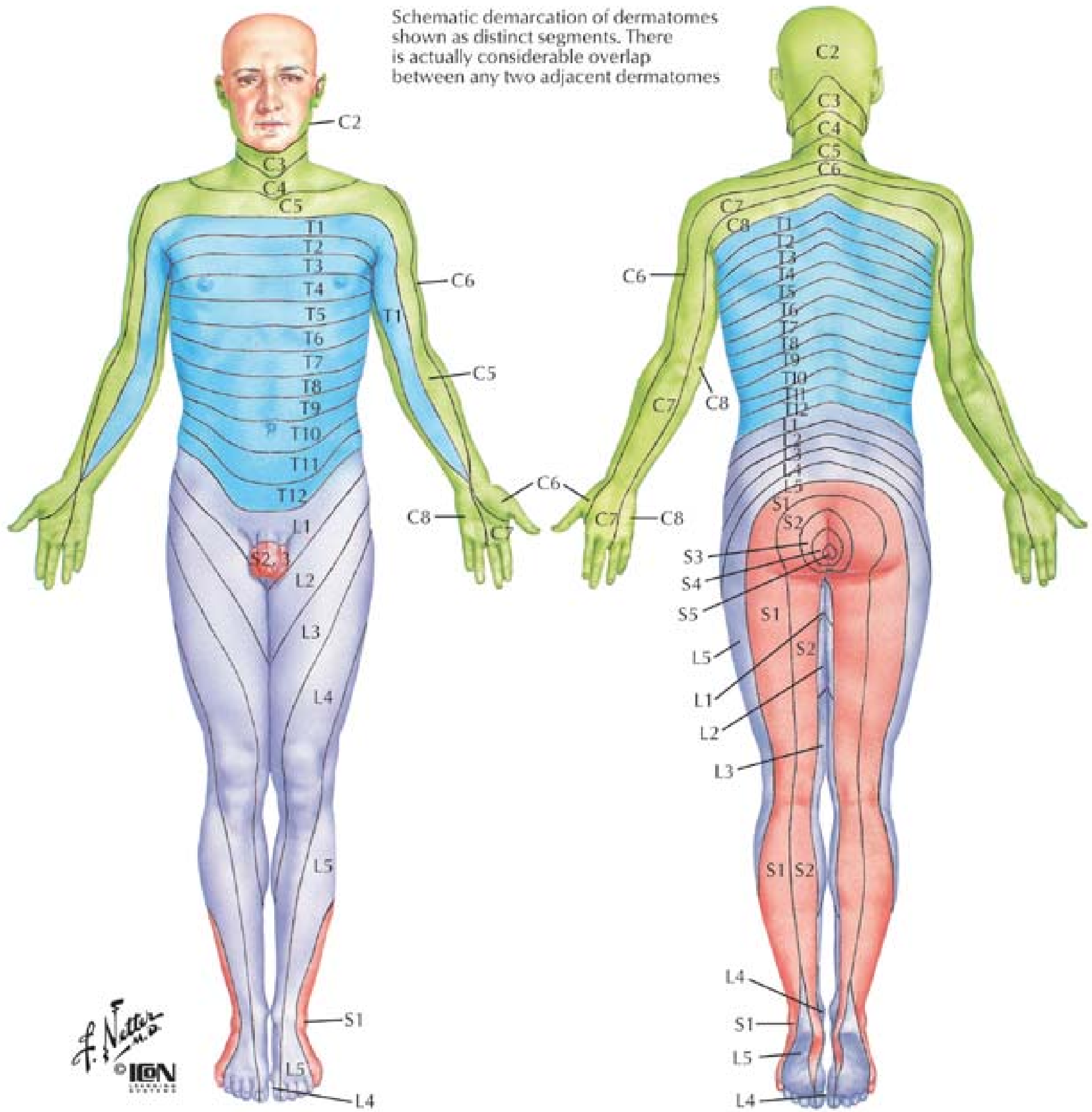


Initial Assessment: Motor Examination

- Lower extremity
  - L1-hip flexion
  - L2-hip adduction
  - L3-knee extension
  - L4-ankle dorsiflexion
  - L5-toe extension



Initial Assessment: Dermatomes



Levels of principal dermatomes

C5	Clavicles
C5, 6, 7	Lateral parts of upper limbs
C8, T1	Medial sides of upper limbs
C6	Thumb
C6, 7, 8	Hand
C8	Ring and little fingers
T4	Level of nipples
T10	Level of umbilicus
T12	Inguinal or groin regions
L1, 2, 3, 4	Anterior and inner surfaces of lower limbs
L4, 5, S1	Foot
L4	Medial side of great toe
S1, 2, L5	Posterior and outer surfaces of lower limbs
S1	Lateral margin of foot and little toe
S2, 3, 4	Perineum

Initial Assessment: Classification of injury

- **American Spinal Injury Association (ASIA)**
  - A = Complete – No Sacral Motor / Sensory
  - B = Incomplete – Sacral sensory sparing
  - C = Incomplete – Motor Sparing (<3)
  - D = Incomplete – Motor Sparing (>3)
  - E = Normal Motor & Sensory

ASIA

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR

KEY MUSCLES

	R	L	Key muscles
C2			
C3			
C4			
C5			Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)
T2			
T3			
T4			
T5			
T6			
T7			
T8			
T9			
T10			
T11			
T12			
L1			
L2			Hip flexors
L3			Knee extensors
L4			Ankle dorsiflexors
L5			Long toe extensors
S1			Ankle plantar flexors
S2			
S3			
S4-5			Voluntary anal contraction (Yes/No)

0 = total paralysis
1 = palpable or visible contraction
2 = active movement, gravity eliminated
3 = active movement, against gravity
4 = active movement, against some resistance
5 = active movement, against full resistance
NT = not testable

TOTALS ☐ + ☐ = ☐ **MOTOR SCORE**

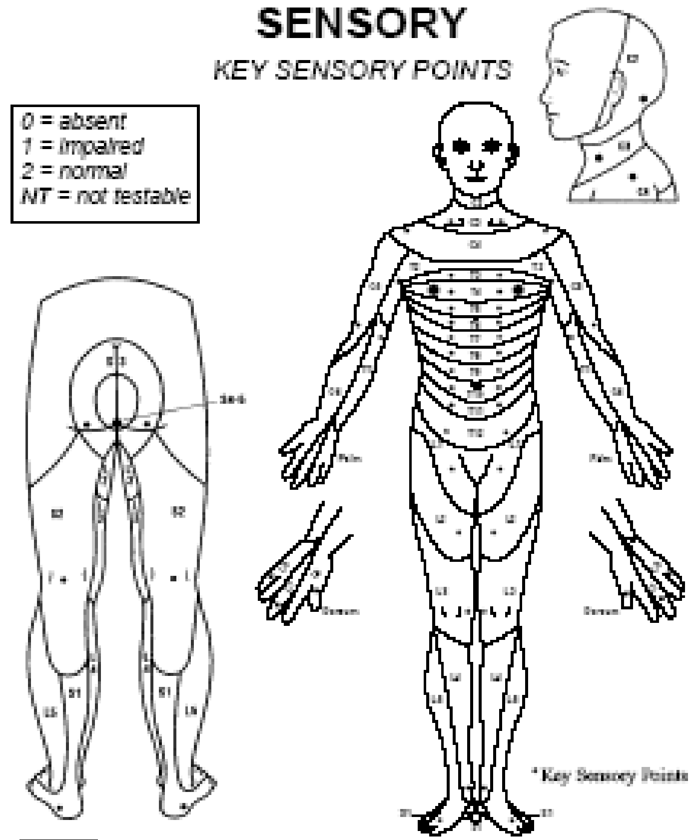
(MAXIMUM) (50) (50) (100)

SENSORY

KEY SENSORY POINTS

	Light Touch R	Light Touch L	Pin Prick R	Pin Prick L
C2				
C3				
C4				
C5				
C6				
C7				
C8				
T1				
T2				
T3				
T4				
T5				
T6				
T7				
T8				
T9				
T10				
T11				
T12				
L1				
L2				
L3				
L4				
L5				
S1				
S2				
S3				
S4-5				

0 = absent
1 = impaired
2 = normal
NT = not testable



☐ Any anal sensation (Yes/No)

TOTALS { ☐ + ☐ = ☐ **PIN PRICK SCORE** (max: 112)
☐ + ☐ = ☐ **LIGHT TOUCH SCORE** (max: 112)

(MAXIMUM) (56) (56) (56) (56)

NEUROLOGICAL LEVEL *The most caudal segment with normal function*		R	L	**COMPLETE OR INCOMPLETE?** ☐ *Incomplete = Any sensory or motor function in S4-S5*	**ZONE OF PARTIAL PRESERVATION** *Caudal extent of partially innervated segments*		R	L
	SENSORY	☐	☐			SENSORY	☐	☐
	MOTOR	☐	☐	**ASIA IMPAIRMENT SCALE** ☐		MOTOR	☐	☐

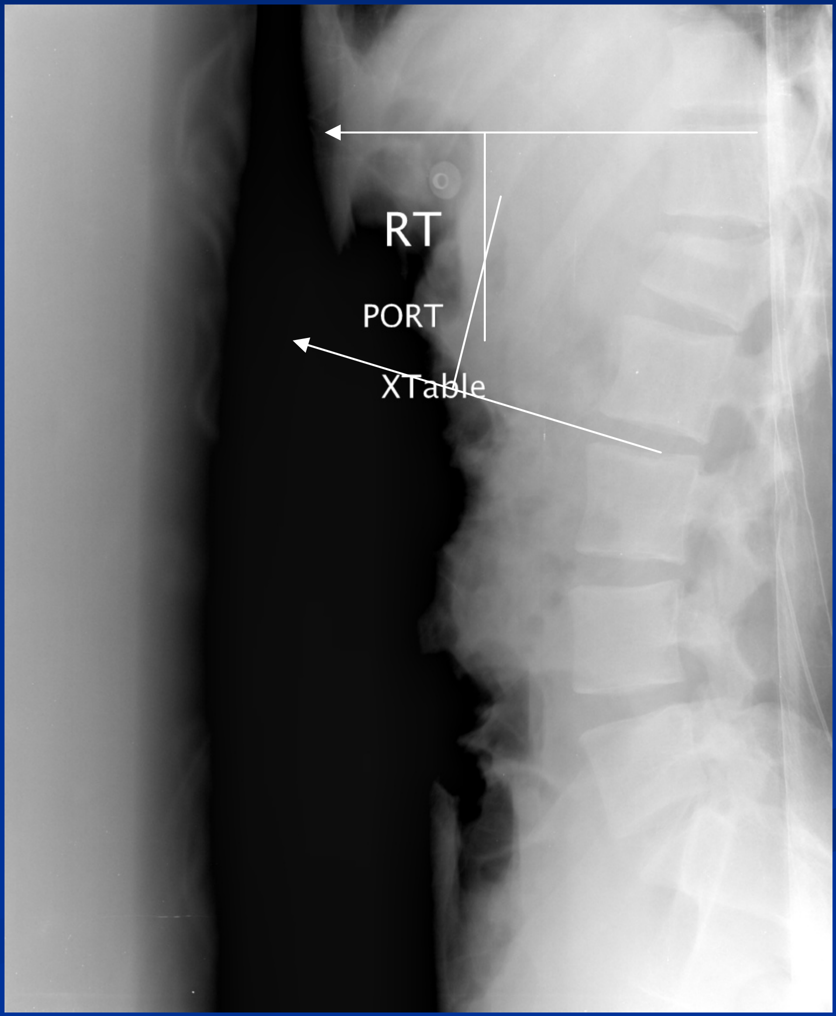
2000 Rev.

Imaging: X-Rays

- AP and lateral:
  - AP view: pedicles, VBs, disc spaces, spinous processes
  - Lateral view: VB heights, disc space relations, VB alignment, paraspinal swelling

Imaging: X-ray

- In the presence of injury, the entire spine should be imaged to rule out noncontiguous injuries
- Degree of kyphosis can be measured using **Cobb Measurement.**



Imaging: CT

- CT yields more diagnostic information than plain radiographs regarding extent of bony injury [6,12]

Imaging: MRI

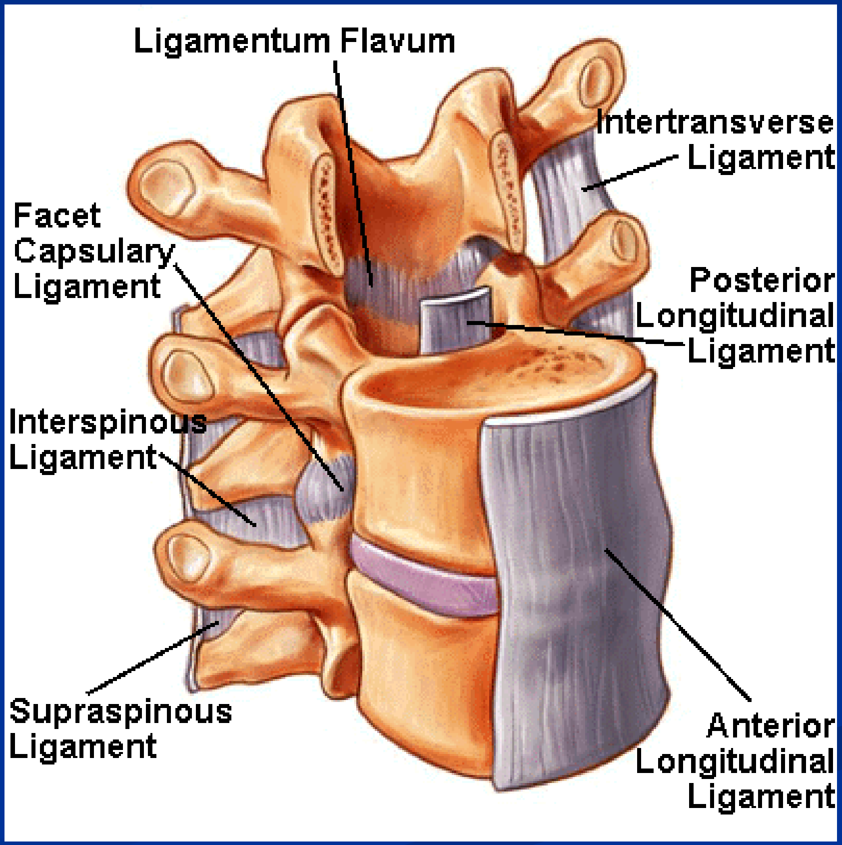
- MRI allows visualization of soft tissue components of spinal injuries [6]
- Useful at thoraco-lumbar junction due to variable location of conus medullaris

Injury Mechanism/Biomechanics

- Gravity exerts continual axial load on the vertebral column
- Body's center of gravity is approx 4cm anterior to first sacral vertebra – results in ventral bending vector acting on spinal column
- **Posterior ligamentous complex** acts as dorsal tension band to counteract these forces - net sum of vectors acting on spine equal zero
- Essential to prevent change in spine's sagittal alignment

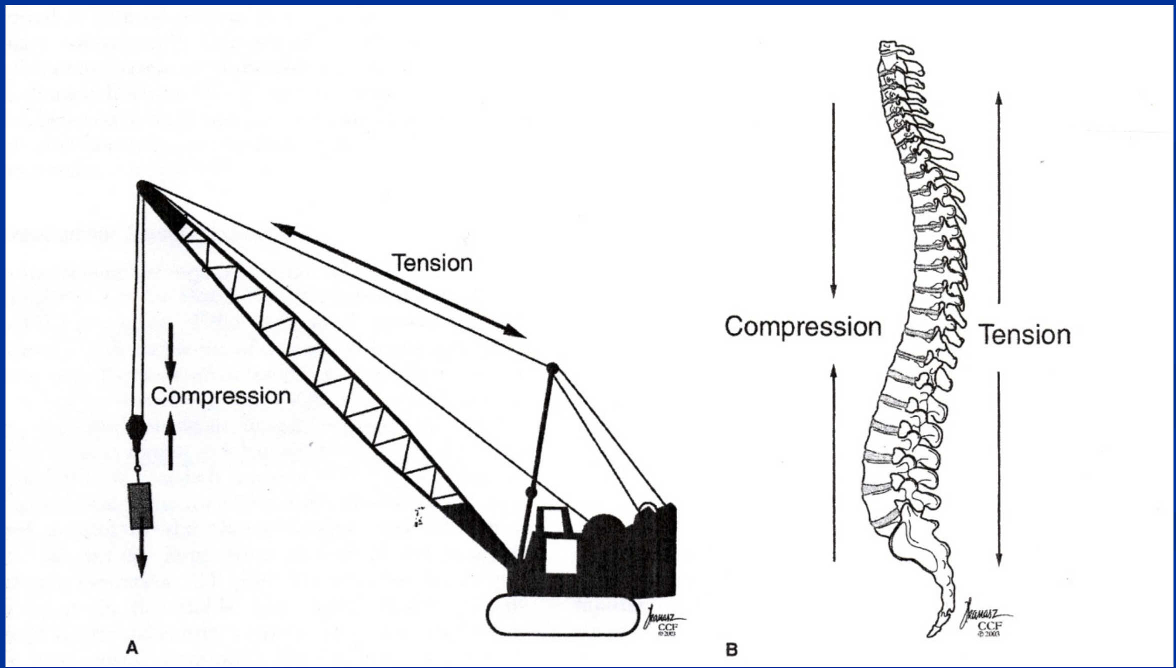
Injury Mechanism/Biomechanics

- **PLC**: interspinous ligaments and ligamentum flavum
- Trauma resulting in spinal ligament/osseous structure disruption may change net vector sum acting on spine from zero, resulting in potential for spinal imbalance



Injury Mechanism/Biomechanics

- Whiteside [9]: analogy of construction crane
- Failure of the cable leads to the crane falling forward – in spine, illustrated by characteristic kyphotic deformity seen with unstable burst fxs

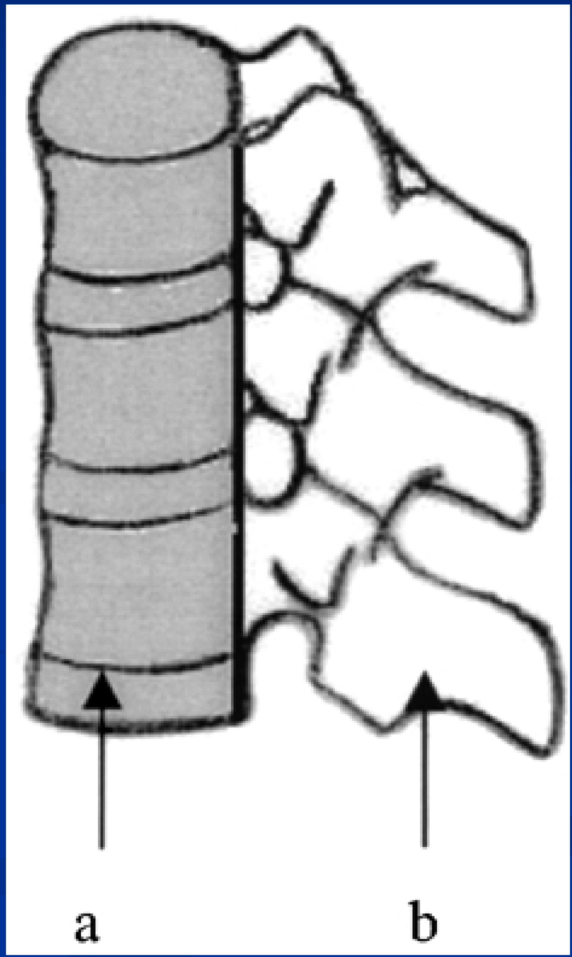


Fracture Classification

- Fracture classification allows organization and treatment of fractures through protocols developed to maximize patient outcomes
- Most classification schemes based on criteria for describing **stability**

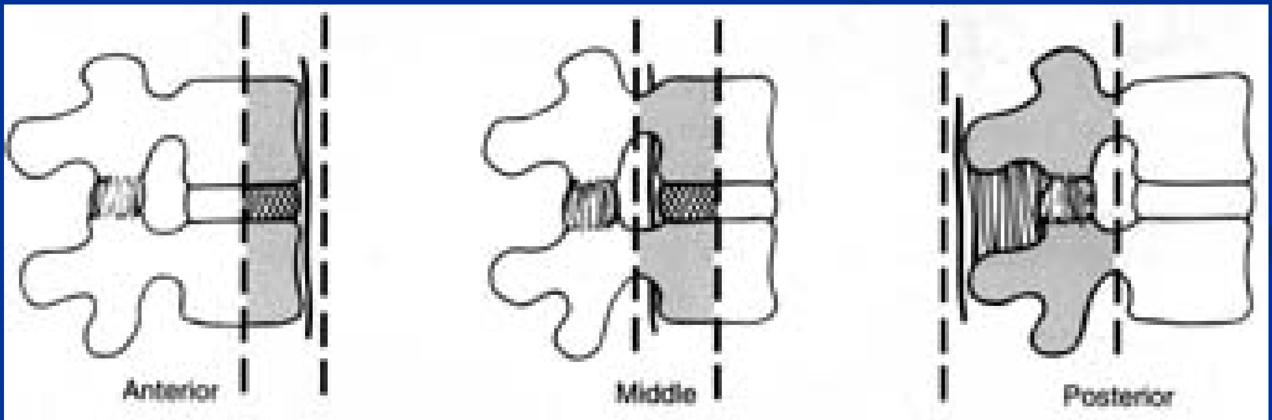
Fracture Classification: Holdsworth

- Holdsworth [15]: two-column model of spine stability (1960s). Separated spine into anterior weight-bearing column (a) and posterior tension-bearing column (b)
- Burst fractures unstable if PLC is disrupted



Fracture Classification: Denis

- Denis [3]: three-column classification of spinal fractures (1980s). Injury to middle column was necessary and sufficient to create instability
- Based classification on results of biomechanical studies demonstrating that isolated rupture of PLC is insufficient to create instability



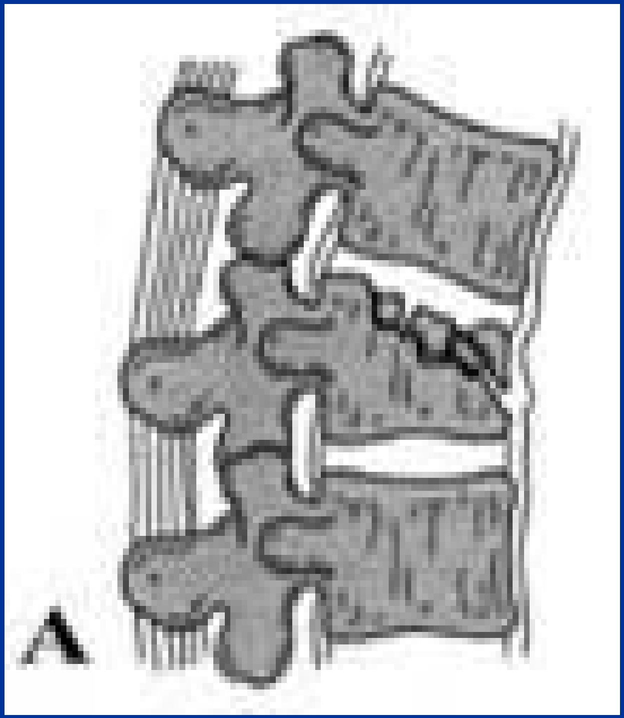
Fracture Classification: Denis

- Divides spinal fractures into minor and major injuries
  - Minor injuries: fractures of transverse process, pars interarticularis, spinous process
  - Major injuries:

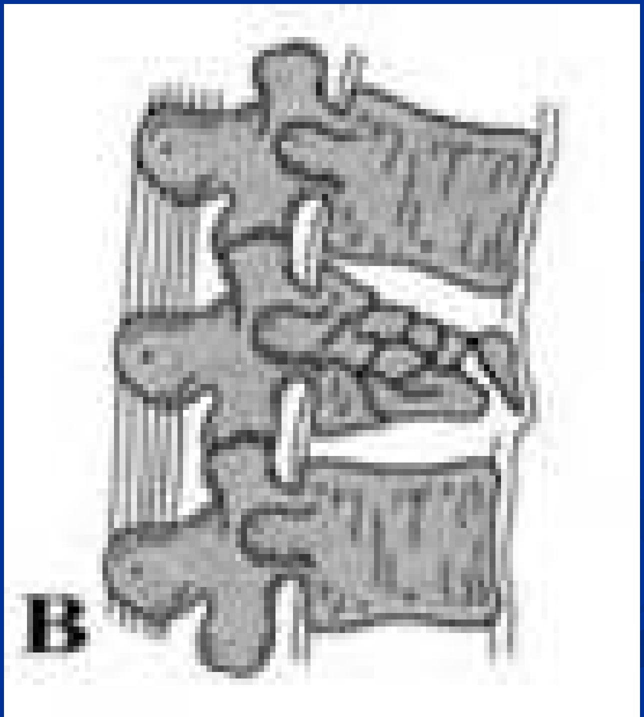
Fracture type	**Column**		
	Anterior	**Middle**	**Posterior**
Compression	Compression	Intact	Intact , or distraction
Burst	Compression	Compression	Intact
Seat-belt type	Intact	Distraction	
Fracture dislocation	Compression, rotation , shear	Distraction , rotation , shear	

Fracture Classification: Denis

- Compression Fracture

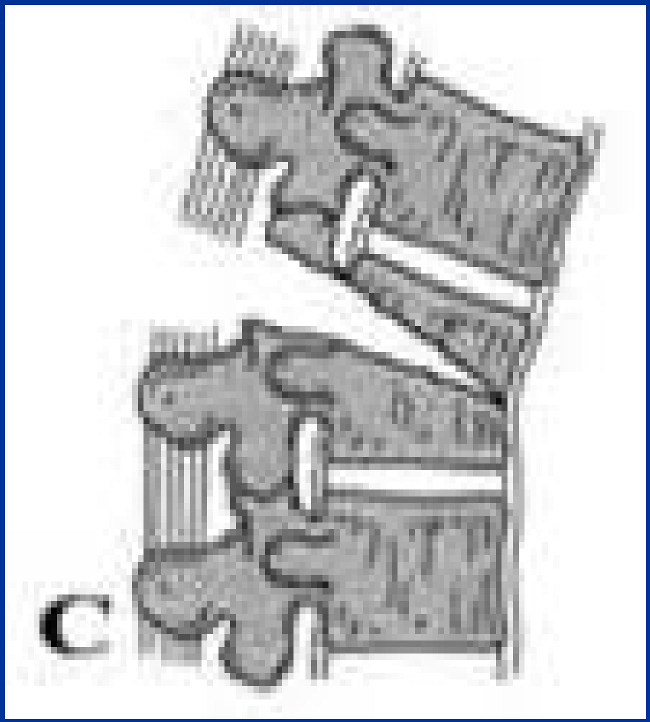


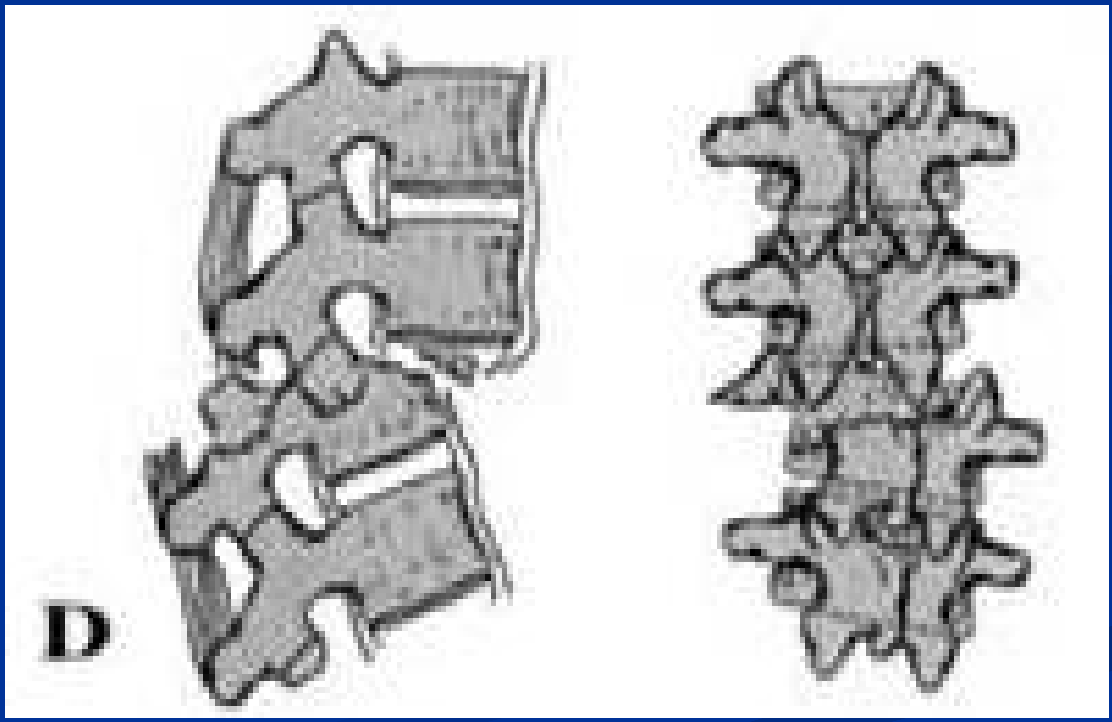
- Burst Fracture



Fracture Classification: Denis

- Seat-belt type
- Fracture dislocation





Fracture Classification: Denis

- Denis' 3 types of instability:
  - Mechanical (1st degree) – may result in late kyphotic deformity. Require external or operative stabilization.
  - Neurologic (2nd degree) – retropulsion of bone fragments predispose patients to increased risk for neurologic injury. Controversy re: operative stabilization.
  - Mechanical/neurologic (3rd degree) – develop after burst fx w/neuro deficit or fracture/dislocation. Highly unstable > require operative decompression and stabilization.

Fracture Classification: McCormack

- McCormack [17]: load-sharing classification, designed specifically for thoracolumbar burst fxs (1994)
- Uses point system: grades amount of VB comminution, displacement of fracture fragments, degree of kyphosis (1-9 points)

Score	1 point	2 points	3 points
Sagittal collapse	30%	>30%	60%
Shift	1mm	2mm	>2mm
Correction	3 degrees	9 degrees	10 degrees

Fracture Classification: McCormack

- With McCormack, patients with >6 points have a large void or gap, resulting in least supportive anterior and middle columns and predisposing posterior instrumentation for failure
- Original goal was to predict failure of short-segment posterior fixation for burst fxs – prescribes that injuries with high scores should undergo supplemental anterior column support

Fracture Classification: TLICS

- TLICS system [13] designed by the Spine Trauma Study Group (2008). Based on 3 aspects:
  - morphology of the injury
  - integrity of the PLC
  - neurological status of the patient

Injury morphology	
Compression	1
Burst	1
Translation rotation	3
Distraction	4
PLC integrity	
Intact	0
Indeterminate	2
Disrupted	3
Neurological status	
Intact	0
Nerve root injury	2
Complete	2
Incomplete	3

Fracture Classification: TLICS

- TLICS determination for surgery:
  - <3 points can be treated non-operatively
  - >5 points usually require surgical intervention
  - = 4 points can be treated w/or w/o surgery
- TLICS determination of surgical approach:
  - Incomplete + anterior compression = ANT
  - Incompetent PLC = POST
  - Neurological deficit + incompetent PLC = ANT + POST

Treatment Options

- Controversy regarding operative vs. non-operative management, surgical approach
- Treatment based on maximizing neurologic recovery and preventing neurologic decline – identify **unstable fractures**

Non-operative Management

- Most fractures in thoracolumbar/lumbar region consist of compression, burst fractures, and isolated dorsal column fractures – stable fxs
- Compression fxs: stable if PLC, along with dorsal vertebral body, is not disrupted (Denis) – bracing
- Burst fxs: stable if no PLC injury/dorsal element fx. Neurologically intact patient > bracing

Non-operative Management

SPINE Volume 18, Number 8, pp 955–970

Thoracolumbar Burst Fractures

The Clinical Efficacy and Outcome of Nonoperative Management

Joe Mumford, MD, James N. Weinstein, DO, Kevin F. Spratt, PhD, and Vijay K. Goel, PhD

Mumford et al

- 41 pts with thoraco-lumbar burst fxs w/o neurological deficit treated conservatively
- At injury, canal compromise averaged 37% - at 2 years f/u, 2/3 resolution of fragments occluding canal
- Outcome evaluation: 49% patients reported excellent outcomes relative to pain and function
- Progression of body collapse on imaging averaged 8%
- 1 pt developed neurologic deterioration prompting surgery – all other pts remained neurologically intact

Non-operative Management

SPINE Volume 18, Number 8, pp 971–976

Nonoperative Management of Stable Thoracolumbar Burst Fractures With Early Ambulation and Bracing

Jeffrey B. Cantor, MD, Nathan H. Lebwohl, MD,
Timothy Garvey, MD, and Frank J. Eismont, MD

Cantor et al

- 18 **neurologically intact** patients with burst fxs w/o PLC disruption – treated with early ambulation w/bracing
- Kyphosis: 19 degrees at time of injury, 20 degrees at f/u
- VB height loss: 36% on presentation, max change 5% at f/u
- At f/u15 pts rated their pain as little or none, 17 pts had little or no restriction of activity.
- CT scan 1 yr after injury in 8 pts showed >50% resorption of retropulsed bone
- No patient had deterioration of neurological function.

Surgical Treatment

- Surgical Treatment – 3 components:
  - Neural Decompression
  - Stabilization
  - Fusion

Surgical treatment: Decompression

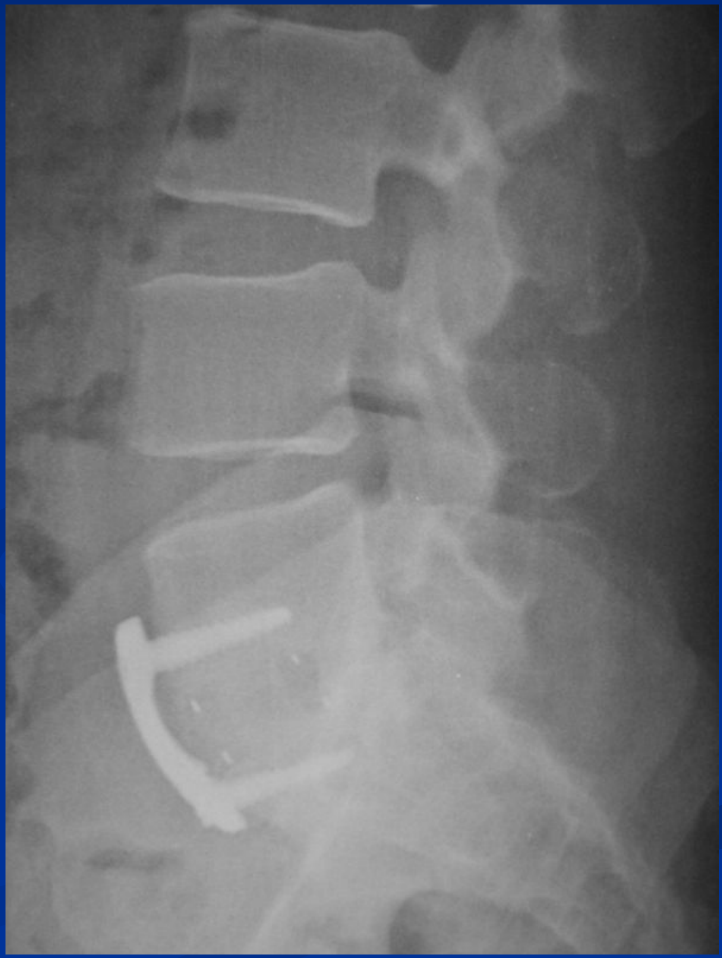
- TL and Lspine fx w/ neuro deficit have significantly higher recovery rate when treated with surgery. Primary goal: decompression of the spinal canal [4,7]
- Anterior, compared to posterior and posterolateral decompression has a higher rate of neurologic improvement (88% vs. 64%) and recovery of B&B function (69% vs. 33%).[8,18]
- Anterior decompression via corpectomy: maximal degree of canal decompression
- Treatment of low lumbar (L3-5) burst fx require posterior approach

Surgical treatment: Decompression

- Timing of surgery in patients w/burst fxs w/neurologic deficit is unclear
  - Most clinical studies have shown no correlation b/w timing and amount of neurologic recovery [7,11]
  - One study (Mirza et al, 1999) showed improved neurologic recovery w/surgery within 72 hrs vs. 10-14 days [16]
- Patients w/progressive deficit need **emergent decompression**

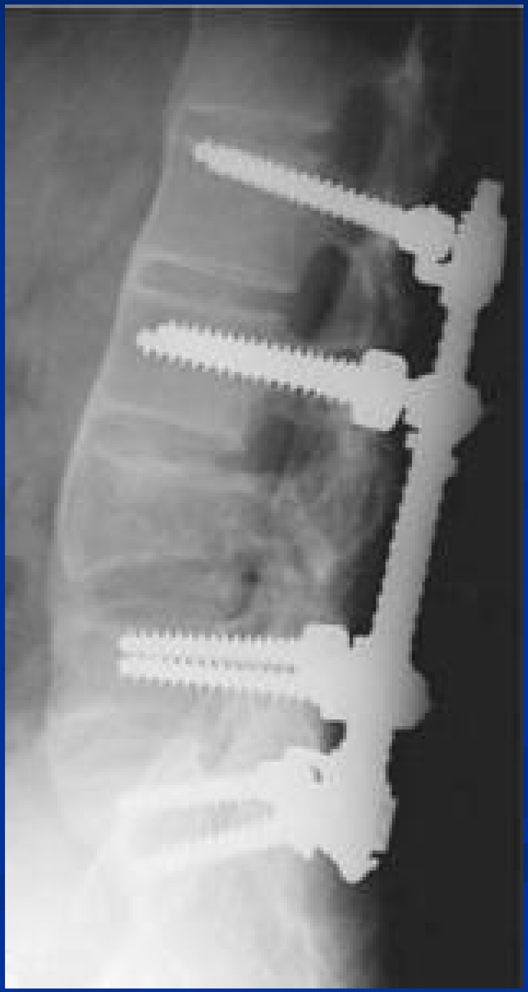
Surgical Treatment: Stabilization

- Primary role of surgical instrumentation: restore immediate stability and correct acute deformities
- Anterior stabilization:
  - Advantage: limits fusion to level above and below injury
  - Disadvantage: risk of vascular and visceral injury



Surgical Treatment: Stabilization

- Options for posterior stabilization: rods secured by screws, hooks, or wires
- Pedicle screw system: instrument two levels above and below injury
- Short segment stabilization (one level above and below) has high rate of construct failure. If spinal flexibility is priority, can be combined w/anterior instrumentation [17,19]



Surgical Treatment: Fusion

- Long term goal of instrumentation: maintain proper spinal alignment and stability until bone fusion occurs [9,19]
- Without solid fusion, metallic implants eventually break
- In order for fusion to occur, bone graft or graft replacement must have:
  - Osteogenicity
  - Osteoinductivity
  - Osteoconductivity

Surgical Treatment: Fusion

- Anterior fusion:
  - Autograft (Iliac crest)
  - Allograft (Femoral or humeral shaft)
  - Synthetic cage
- Posterior fusion:
  - Decortication of exposed bone elements
  - Implantation of bone fragment or bone matrix

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References

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