

# Spine Fractures.

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Lyon, France: 11-13 June 2025



# Spinal Cord Injury

- Neurological status must be always documented

**ASIA**

**STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY**

**MOTOR**

KEY MUSCLES

C2	R	L
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		

Elbow flexors  
Wrist extensors  
Elbow extensors  
Finger flexors (distal phalanx of middle finger)  
Finger abductors (little finger)

Hip flexors  
Knee extensors  
Ankle dorsiflexors  
Long toe extensors  
Ankle plantar flexors

Voluntary anal contraction (Yes/No)

**SENSORY**

KEY SENSORY POINTS

C2	R	L
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		

Any anal sensation (Yes/No)

**ASIA IMPAIRMENT SCALE**

**A = Complete:** No motor or sensory function is preserved in the sacral segments S4-S5.

**B = Incomplete:** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.

**C = Incomplete:** Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.

**D = Incomplete:** Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.

**E = Normal:** motor and sensory function are normal

TOTALS  +  =  **MOTOR SCORE** (MAXIMUM) (50) (50) (100)

TOTALS  +  =  **PIN PRICK SCORE** (MAXIMUM) (56) (56) (112)

TOTALS  +  =  **LIGHT TOUCH SCORE** (MAXIMUM) (56) (56) (112)

**NEUROLOGICAL LEVEL** The most caudal segment with normal function

SENSORY  R  L

MOTOR  R  L

**COMPLETE OR INCOMPLETE?**  **COMPLETE**  **INCOMPLETE**

Incomplete = Any sensory or motor function in S4-S5

**ASIA IMPAIRMENT SCALE**  **A**  **B**  **C**  **D**  **E**

**ZONE OF PARTIAL PRESERVATION** Caudal extent of partially innervated segments

SENSORY  R  L

MOTOR  R  L

**CLINICAL SYNDROMES**

Central Cord

Brown-Sequard

Anterior Cord

Conus Medullaris

Cauda Equina

This form may be copied freely but should not be altered without permission from the American Spinal Injury Association. 2000 Rev.

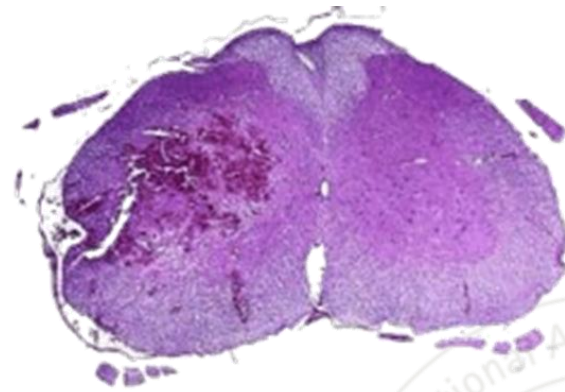
Level of lesion  
Essential for following  
improvement or  
deterioration

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# Spinal Cord Injury



Concepts:

## Spinal shock:

- Transient flaccid paralysis
- Abdominal breathing.
- Priapism.
- Areflexia (including lack of bulbocavernosus reflex).
- While spinal shock is present (usu <48 h), unable to predict recovery.

## Neurogenic Shock:

- Caused by an interruption of the sympathetic output to the heart and peripheral vasculature.
- Hypotension w/o tachycardia.

	Spinal shock	Neurogenic shock
<b>Definition</b>	Immediate temporary loss of total power, sensation and reflexes below the level of injury	Sudden loss of the sympathetic nervous system signals
<b>BP</b>	Hypotension	Hypotension
<b>Pulse</b>	Bradycardia	Bradycardia
<b>Bulbocavernosus reflex</b>	Absent	Variable
<b>Motor</b>	Flaccid paralysis	Variable
<b>Time</b>	48-72 hrs immediate after SCI	
<b>Mechanism</b>	Peripheral neurons become temporarily unresponsive to brain stimuli	Disruption of autonomic pathways → loss of sympathetic tone and vasodilation

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# Spinal Cord Injury

Incomplete or complete cord injury.

- **Incomplete:**
  - When there is evidence of sacral sensory sparing.
  - If there is voluntary contraction of the sacrally innervated muscles, the prognosis for recovery of motor function is better.
- **Complete:**
  - When it's no possible to detect any motor or sensory function below the level of injury after spinal shock ends.

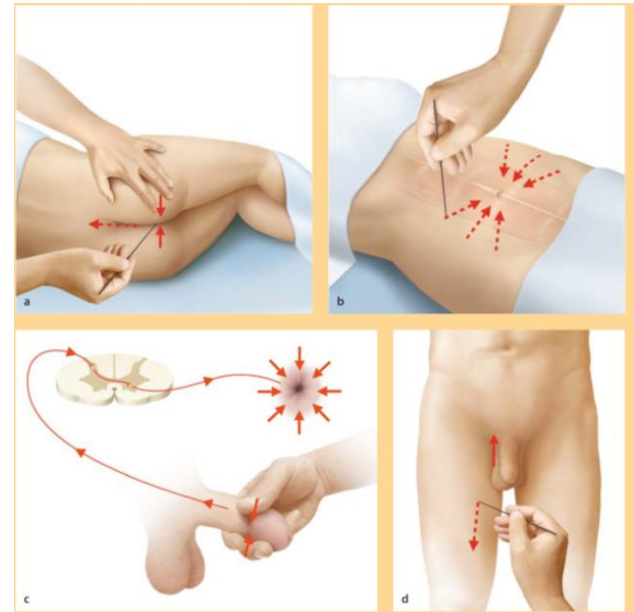


Figure 4. Polysynaptic reflexes

a The absence of the anal reflex indicates a lesion at S3 – 5. b Absence of the abdominal reflex indicates a lesion at T7 – 12 (screening test for patients with putative idiopathic scoliosis). c Absence of the bulbocavernosus reflex indicates a conus medullaris injury. After acute spinal cord injury, the bulbocavernosus reflex can be elicited within 72 h even in spinal shock in contrast to the lower limb tendon reflexes. Recovery of the bulbocavernosus reflex without sensory or motor function indicates a complete spinal cord lesion. d Absence of the cremaster reflex indicates a lesion at the level of L1/2.

025

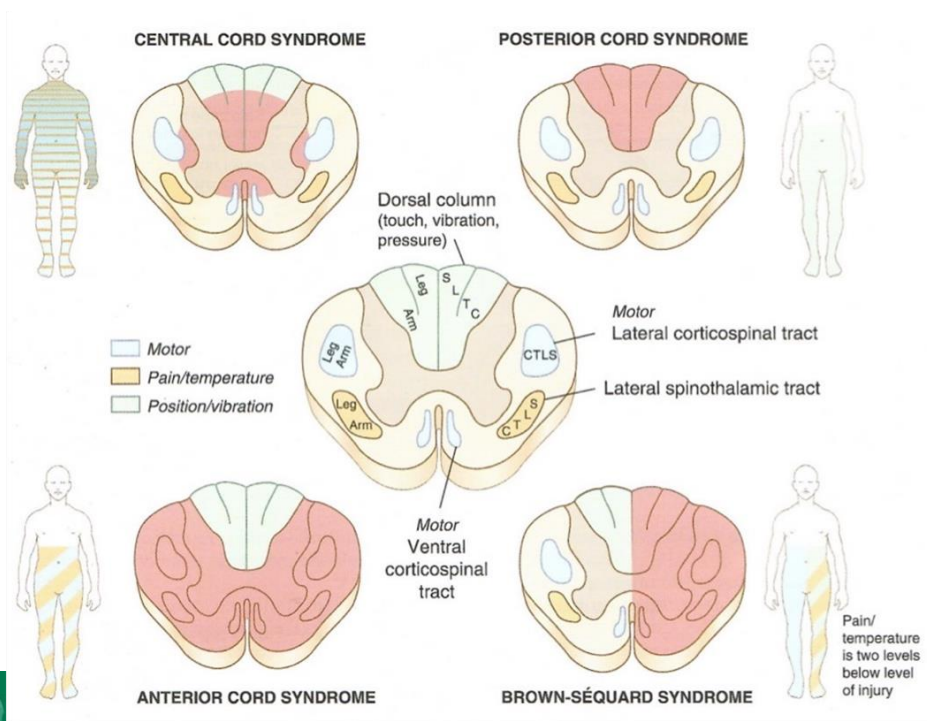


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# Spinal Cord Injury

patterns of incomplete neurological deficits



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# Spinal Cord Injury treatment



Cochrane  
Library

Cochrane Database of Systematic Reviews

Systolic blood pressure >90 mmHg, oxygen saturation 100%, reduction, immobilization, decompression.

## Pharmacology of spinal cord injury:

- There exists literature to suggest that high-dose steroids may have an effect on facilitating recovery. (*Eck JC, Spine 2006 ; Kasper C, J Bone Miner Res 2005*)
- Methylprednisolone 30 mg/Kg MP ( 1 hour) + 5,4 mg/Kg/h for next 23h ( if started < 3 h )

### however , the literature is somewhat controversial:

- MP treated patients, have an increase in respiratory tracts infections and total infections, compared with those without MP. (*Suberviola B, Injury 2008*).
- Nowadays, routine use currently is not uniformly accepted.

## Steroids for acute spinal cord injury (Review)

Bracken MB

### AUTHORS' CONCLUSIONS

#### Implications for practice

Methylprednisolone sodium succinate has been shown to enhance sustained neurologic recovery in a phase three randomized trial, and to have been replicated in a second trial. Therapy must be started within eight hours of injury using an initial bolus of 30 mg/kg by IV for 15 minutes followed 45 minutes later by a continuous infusion of 5.4mg/kg/hour for 24 hours. Further improvement in motor function recovery has been shown to occur when the maintenance therapy is extended for 48 hours. This is particularly evident when the initial bolus dose could only be administered three to eight hours after injury.

Updated Review: The Steroid Controversy for Management of Spinal Cord Injury

Jose A. Camacho<sup>1</sup>, Brian A. Karamian<sup>1</sup>, Daniel R. Bowles<sup>1</sup>, Michael P. Markowitz<sup>2</sup>, Stephen L. DiMaria<sup>3</sup>, Nicholas C. Semenza<sup>4</sup>, Mark R. Leibensperger<sup>5</sup>, Michael L. Smith<sup>6</sup>, Alexander R. Vaccaro<sup>7</sup>

■ CONCLUSIONS: At present, evidence regarding use of dexamethasone for MSCC is contentious, especially regarding dose regimens. Ultimately, further investigation into the use of steroids is required to determine its utility in treating patients with spinal cord pathology.

World neurosurgery 150: 1-8, june 2021

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# Characterize the fracture

## 1. X-Ray.

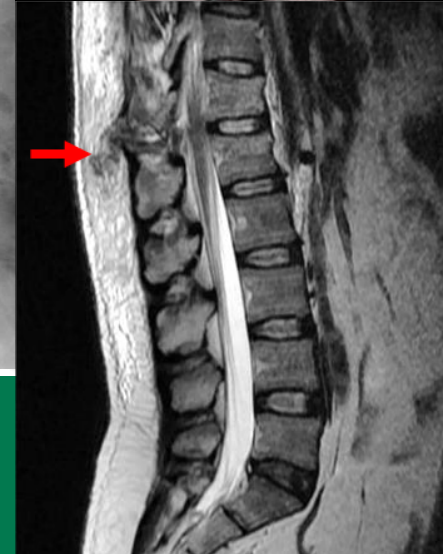
- Low quality in emergency room, but is the first image!!
- Unconscious patients, should be studied radiographically
- Be careful in evaluation the transition area ( CT, TL and LS).
- 25% of patients with TL fractures have fractures elsewhere.

## 2. CT.

- CT seems the most effective and cost-efficient manner to identify fractures of the spine especially bony details.
- Helical CT is faster and no much more radiation than Xray.

## 3. MRI.

- The best image of soft tissue:
  - Neural elements.
  - Ligaments,
  - Intervertebral discs
  - Epidural space.



# Case example

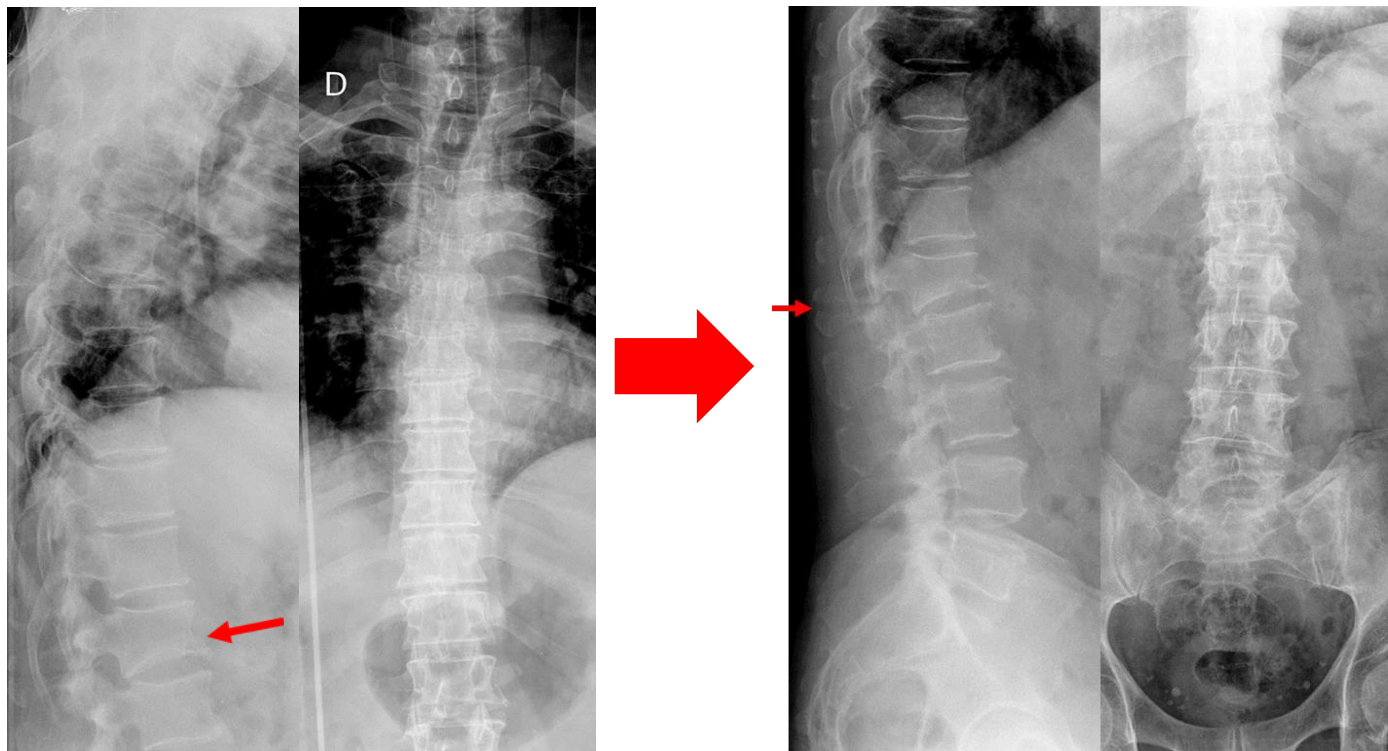
61 year-old male.

Car accident.

Pain in thoracolumbar area.

Initially evaluated in the emergency room as a compression fracture of L1 lower endplate.

Conservative treatment.



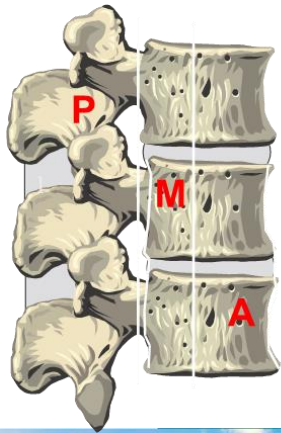
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# Denis Classification (1983).

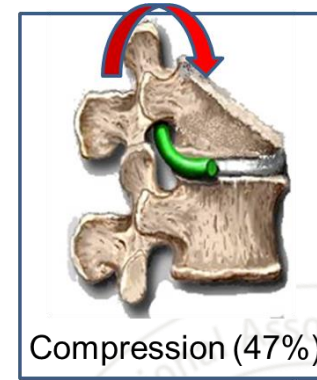
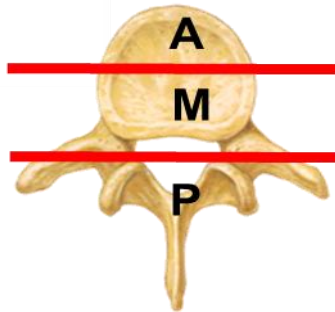
- Still in use in many centers.
- Based on mechanism of injury.
- Supported the three-column theory and found that the middle column is the main determinant of mechanical stability of the thoracolumbar region of the spine.

SPINE - VOLUME 8 - NUMBER 8 - 1983



The Three Column Spine  
and Its Significance in the  
Classification of  
Acute Thoracolumbar  
Spinal Injuries

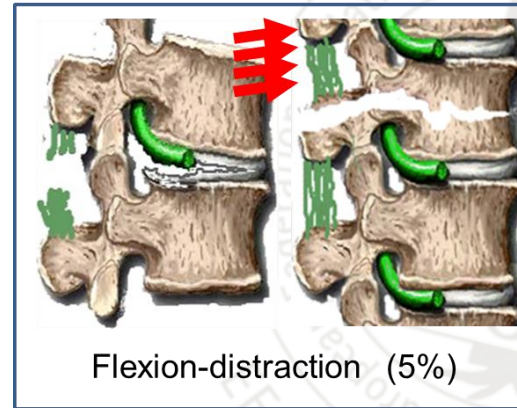
FRANCIS DENIS, MD, FRCS(C)



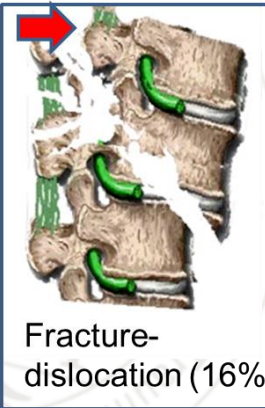
Compression (47%)



Burst (15%)



Flexion-distraction (5%)



Fracture-dislocation (16%)

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# Magerl/AO Classification (1994/2016)

- Based in pathomorphological criteria of injury and instability

- Three groups:

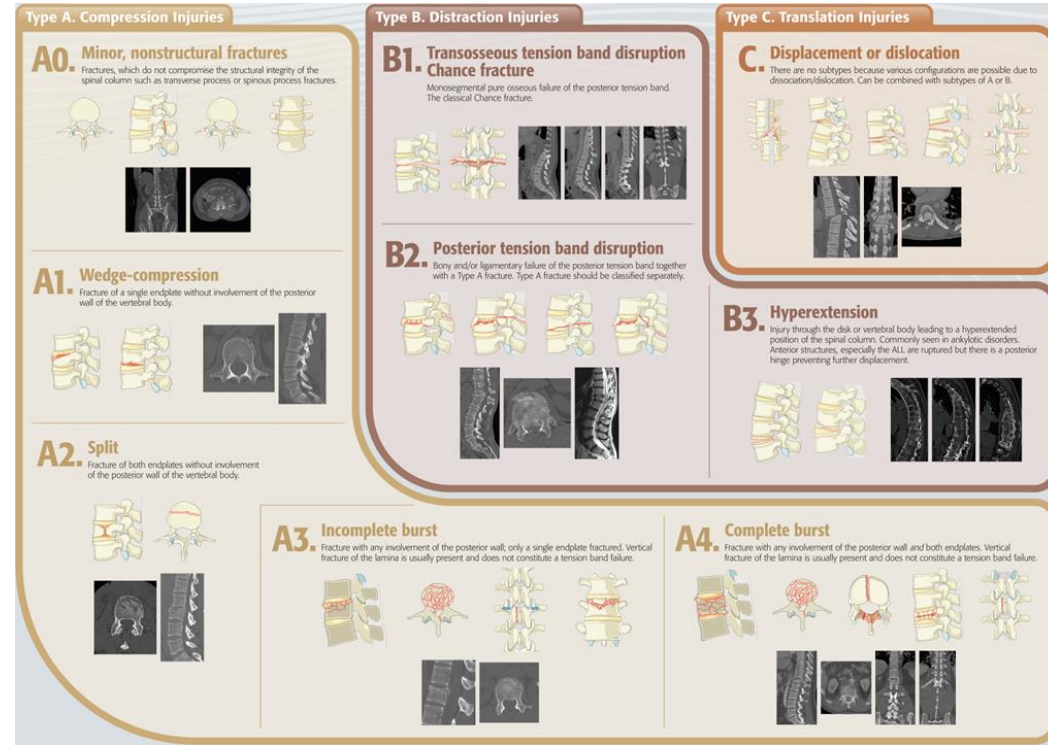
A: Compression (66%)

B: Distraction

C: Fractures-dislocation or traslation

Magerl et al. Eur Spine J. 1994.

- Revised 2016 adding neurological status and modifiers.
- Describes more than 50 subgroups of fractures.
- Their complexity has yielded low inter-and intraobserver agreement.
- Difficult to use in daily clinical practice.



Eur Spine J (2002) 11 :235–245  
DOI 10.1007/s00586-001-0364-8

ORIGINAL ARTICLE

E. C. Oner  
L. M. P. Ramos  
R. K. J. Stimmermacher  
P. E. D. Kingma  
C. H. Diekerhof  
W. J. A. Dhert  
A. J. Verbout

**Classification of thoracic and lumbar spine fractures: problems of reproducibility**  
A study of 53 patients using CT and MRI



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# TLICS Classification (2005)

SPINE, Volume 30, Number 20, pp 2325-2333  
©2005, Lippincott Williams & Wilkins, Inc.

## ■ A New Classification of Thoracolumbar Injuries

The Importance of Injury Morphology, the Integrity of the Posterior Ligamentous Complex, and Neurologic Status

Alexander R. Vaccaro, MD,\* Ronald A. Lehman, Jr., MD,† R. John Hurlbert, MD, PhD,‡  
Paul A. Anderson, MD,§ Mitchel Harris, MD,|| Rune Hedlund, MD,¶ James Harrop, MD,‡  
Marcel Dvorak, MD,\*\* Kirkham Wood, MD,†† Michael G. Fehlings, MD, PhD,‡‡  
Charles Fisher, MD, MHS,‡‡ Steven C. Zeiller, MD,\* D. Greg Anderson, MD,\*  
Christopher M. Bono, MD,§§ Gordon H. Stock, MD,\* Andrew K. Brown, MD,\*  
Timothy Kuklo, MD,† and F. C. Öner, MD, PhD,|||

Spinal Trauma Study Group (STSG)

Based on 3 parameters

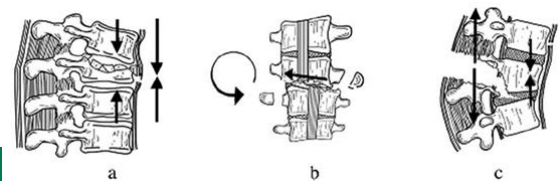
- Injury morphology
- Neurological status
- Integrity of the posterior ligamentous complex (fundamental for clinical decision making in Th-L trauma).

By Consensus: < = 3 Conservative treatment  
 = 4,5 **grey area “ treating physician’s discretion”**  
 = > 5 surgical treatment

## Thoracolumbar Injury Classification and Severity Score

Mechanism type	Qualifier	Points
Compression	Lateral angulation > 15°	1
	Burst	1
Translational/rotational		3
Distraction		4
Neurologic involvement		
Intact		0
Nerve root		2
Cord, conus medullaris	Incomplete	3
	Cord	2
Cauda equina		3
PLC		
Intact		0
Injury suspected/indeterminate		2
Injured		3

PLC, posterior ligamentous complex.



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# Case example.

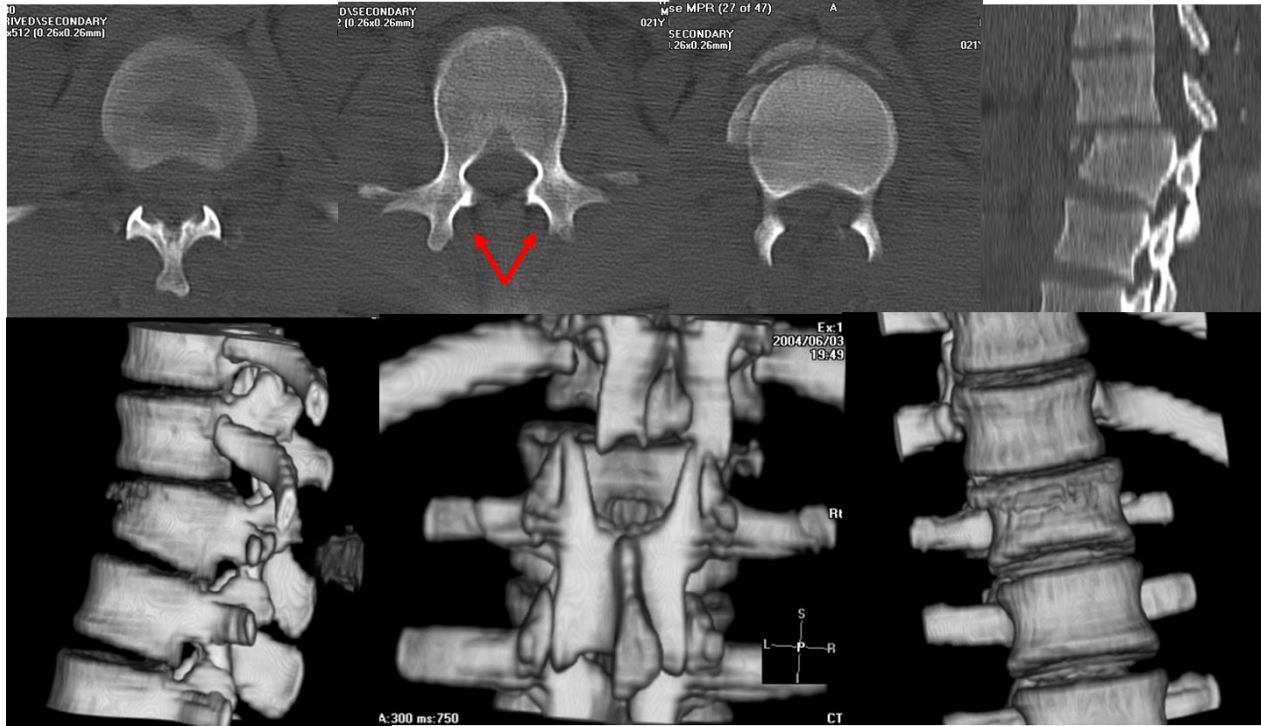
- 22 year-old male.
- Mountain-Bike accident.
- Thoracolumbar pain.
- Frankel/ASIA impairment scale: E.



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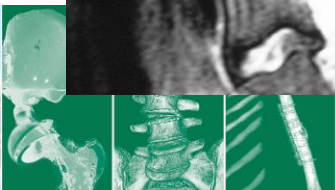
# Case example.



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# Case example.



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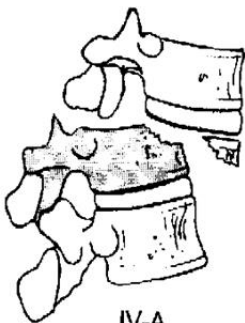


# Case example.

Denis classification:

**VI-A**

(Fracture dislocation by flexion-rotation injury)



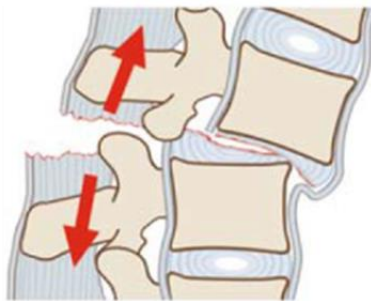
IV-A

Denis F. Spine. 1983

AO/Magerl classification:

**C.2.1.**

(Rotation + type B.1)



with post. lig. disruption

Magerl et al. Eur Spine J. 1994.

TLICS classification:

**7 points**

Thoracolumbar Injury Classification and Severity Score

Mechanism type	Qualifier	Points
Compression	Lateral angulation >15°	1
	Burst	1
Translational/rotational		3
Distraction		4
Neurologic involvement		0
	Intact	2
	Nerve root	3
	Cord, conus medullaris	3
	Incomplete	2
	Cord	3
Cauda equina		3
PLC		0
	Intact	0
	Injury suspected/indeterminate	2
Injured		3

PLC, posterior ligamentous complex.

Vaccaro A. Spine. 2005

- Treatment for this fracture?
- Needs surgery ?Timing ?
- Possible complications?

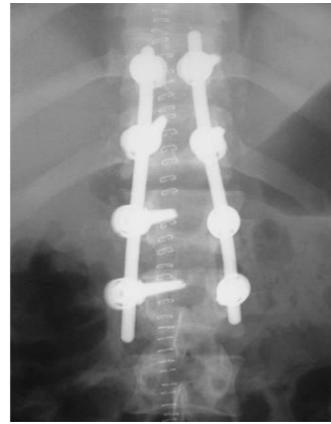
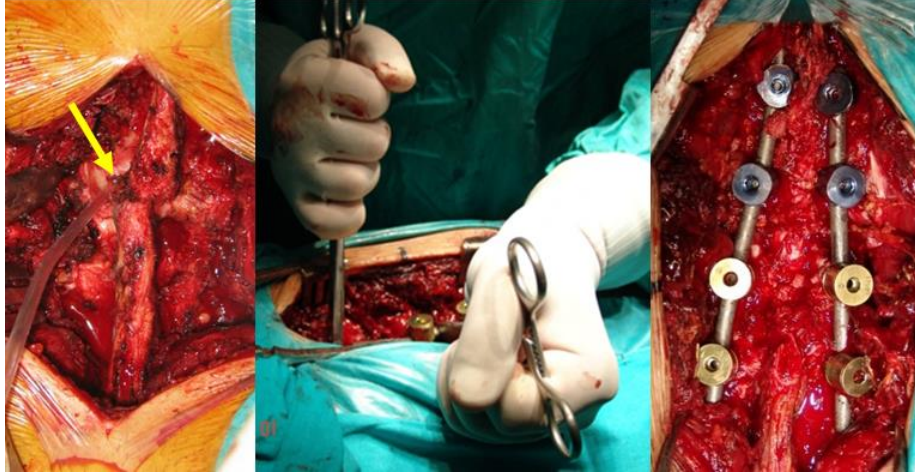
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# Case example.



5 years follow-up

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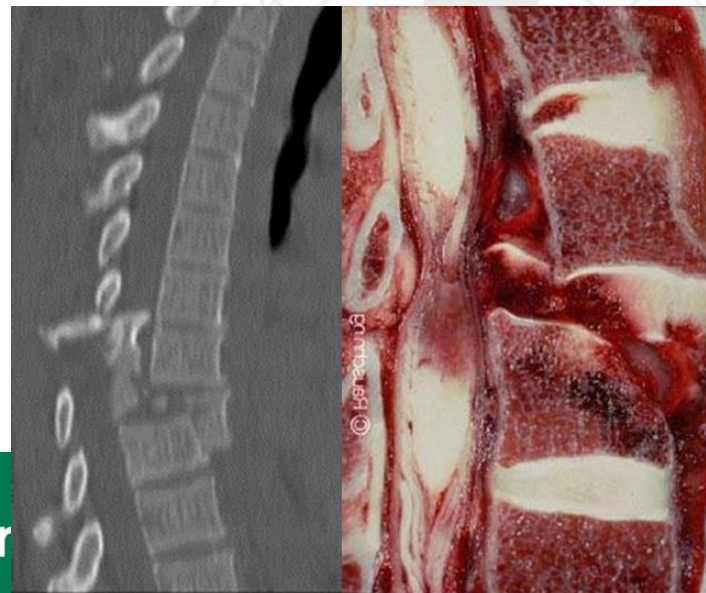
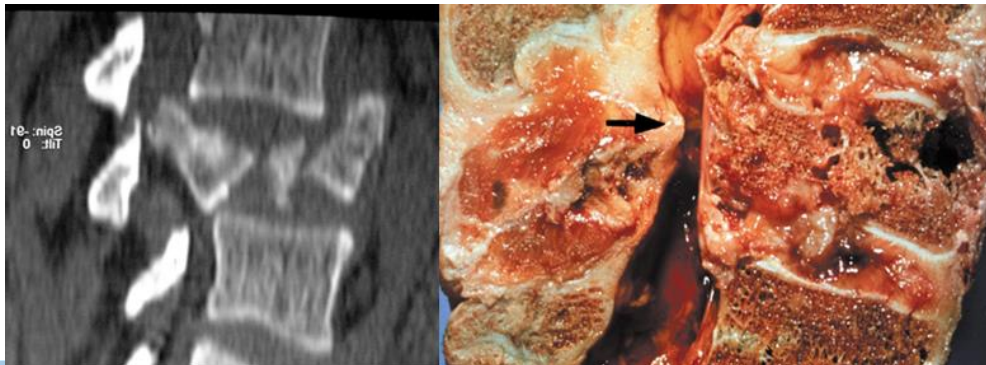
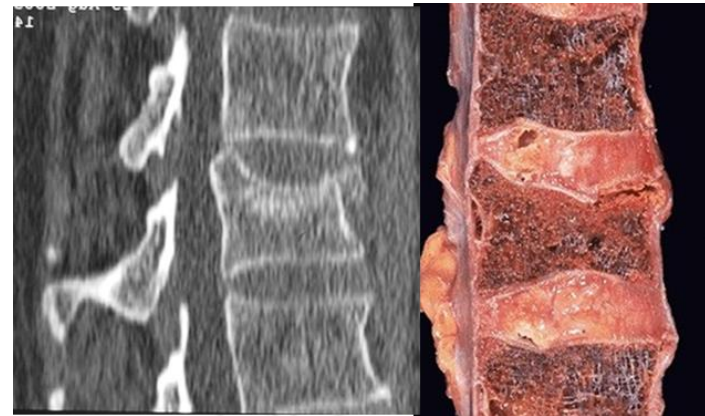


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# Surgical Treatment

- **Which fractures need surgery ?**
  - **Flexion-Distraction fracture** (three columns injury)
  - **Fractures dislocations** (bony and ligamentous injury, three columns)
    - **Burst fracture** (disruption posterior osteoligamentous complex, loss of 50% height, canal occupied > 50% )



# Treatment: Stabilization

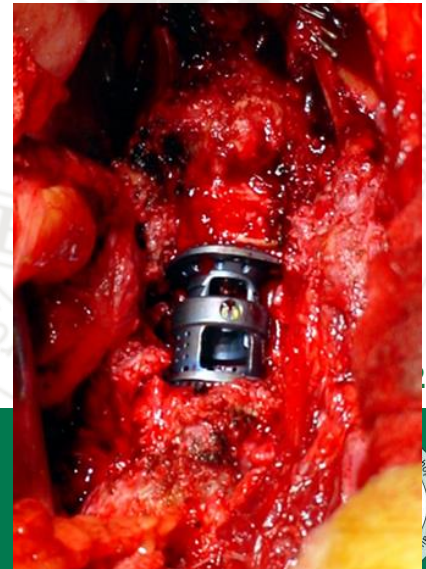
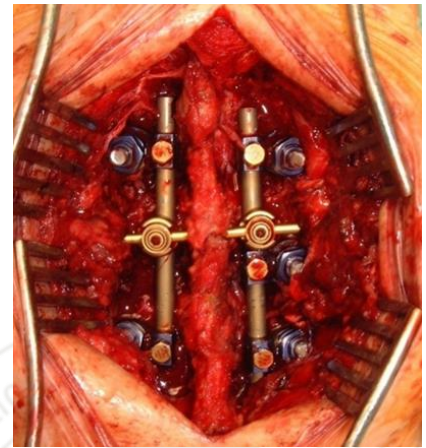
## ➤ How do we stabilize the fracture?

### 1- posterior instrumentation :

- Posterior pedicle screw fixation (most popular technique )
- The number of levels depends of severity injury

### 2- anterior reconstruction ??????

- Strongly considered in comminute or fragmented anterior column unable to load sharing.
- In TL or lower lumbar spine due to the need to maintain biomechanical integrity and normal sagittal alignment.
- To prevent instrumentation failure (pull-out), loosening or breakage.

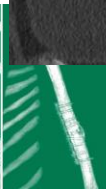
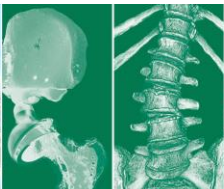
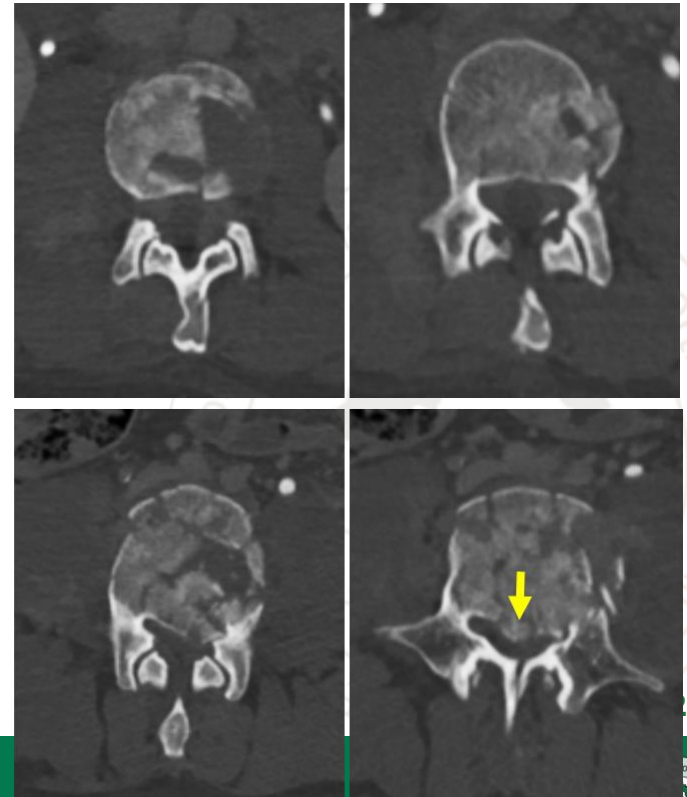
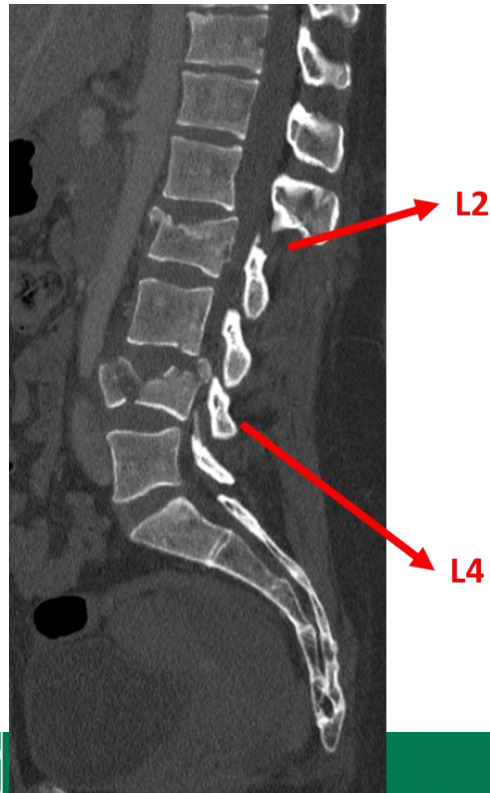


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# Case Example

37-year-old woman. High energy car accident. Normal neurological evaluation.

How can we decide if these fractures need an ANTERIOR SUPPORT?



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# Case Example

## The Load Sharing Classification of Spine Fractures

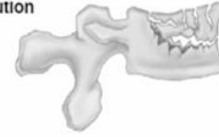
Thomas McCormack, MD, Eldin Karaikovic, MD, and Robert W. Gaines, MD

	Grade-1 (mild)	Grade-2 (moderate)	Grade-3 (severe)
<b>Comminution</b> (sagittal CT scan)	<30%	30%–60%	>60%
<b>Apposition of fragment</b> (axial CT scan)	Minimal displacement	2 mm displacement <50% cross section	2 mm displacement >50% cross section
<b>Kyphosis correction</b> (lateral X-ray)	≤3° or less	4°–9°	≥10°

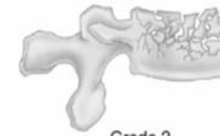
↓ Calculate the score

Score (3 to 9)	Suggested surgical plan
<6	Short segment posterior stabilization
≥7 without translation	Anterior instrument and strut-graft
≥7 with fracture-dislocation	Staged surgery; posterior SSPS followed by anterior column support. or Long segment posterior stabilization

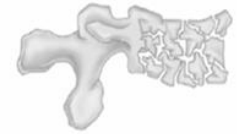
Comminution



Grade 1  
<30% comminution



Grade 2  
30% – 60% comminution



Grade 3  
>60% comminution

Apposition



Grade 1  
Minimal displacement  
axial CT



Grade 2  
At least 2 mm  
displacement of <50%  
cross-section of body

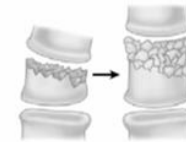


Grade 3  
At least 2 mm  
displacement of >50%  
cross section of the body.

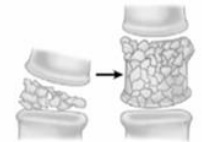
Kyphosis



Grade 1  
Kyphotic correction



Grade 2  
Kyphotic correction



Grade 3  
Kyphotic correction

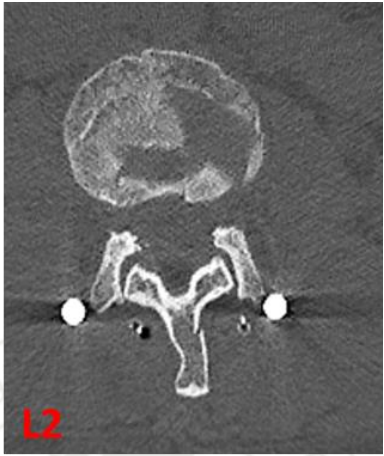
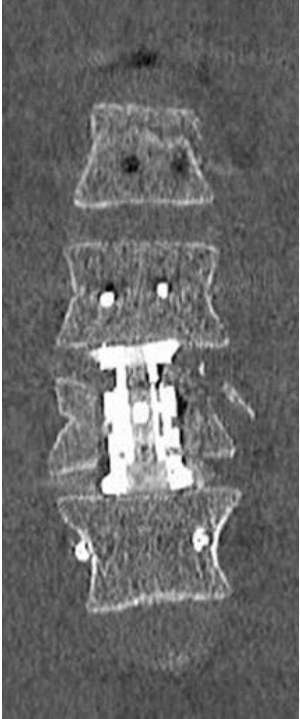
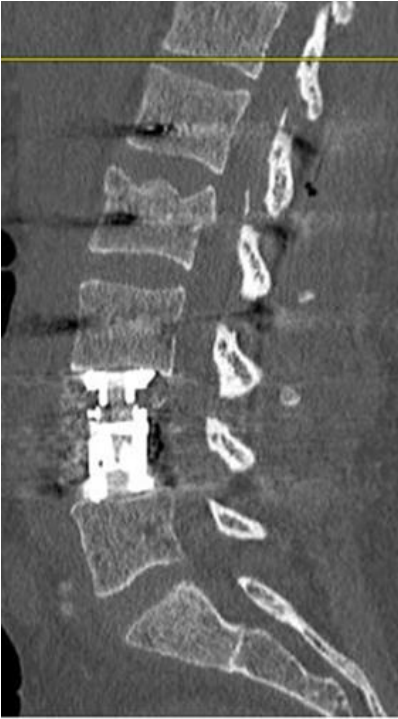
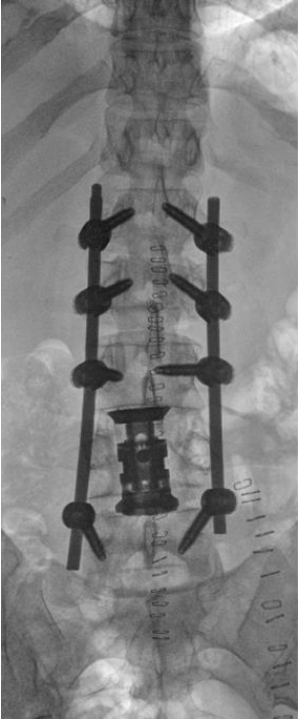


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Orthopaedics 2025

# Case Example



L2



L4



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# Treatment: decompression

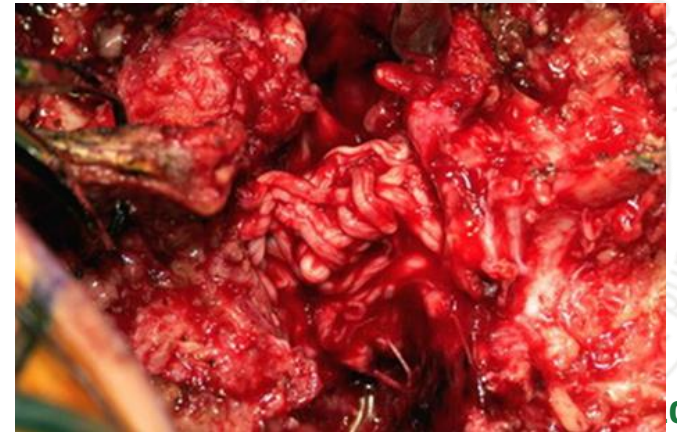
The degree of canal compromise has been shown to correlate poorly with neurological deficits.

- **Incomplete** neurological injury
- **Progressive** neurological injury
- Complete neurological damage: No decompression

## Recommended approach for decompression:

Above L2 → anterior approach

Below L2 → posterior approach



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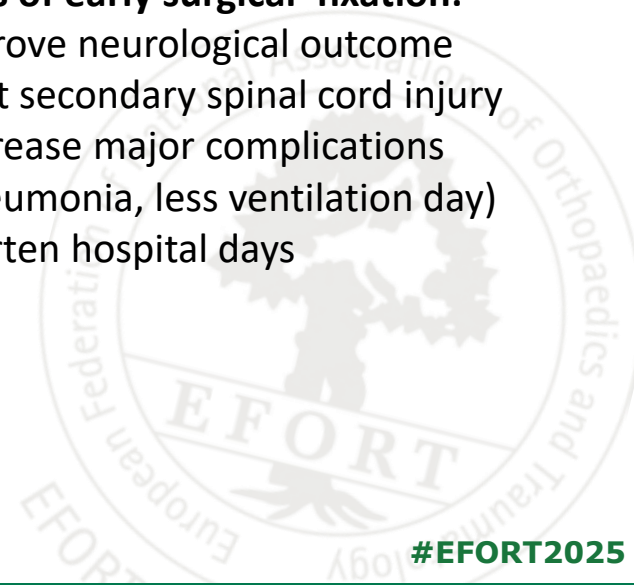


# Treatment: Timing

- **Urgent < 24 h**
  - progressive neurological deficit
  - unreduced spinal dislocation with SCI
  - severe deformity limiting position or care
- **Early 24-72 h**
  - ?????
- **Delayed > 72 h**

## Benefits of early surgical fixation:

- Improve neurological outcome
- Limit secondary spinal cord injury
- Decrease major complications (pneumonia, less ventilation day)
- Shorten hospital days



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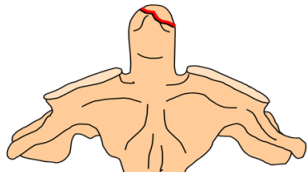
# Upper cervical Trauma

## 1. Atlas fractures (C1)

- Common and neurological injury is rare
- Classic Jefferson (burst fracture bilateral ant/post arch C1)
- Long term stability depends healing transverse ligament
- Unstable Jefferson # surgical option should be considered

## 2. Axis fractures (C2)

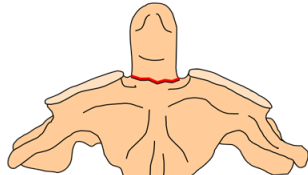
- Odontoid fractures are the most common C2#
- Anderson and d'Alonzo classification.



**Type 1**

C-Collar

beware unrecognized CCD



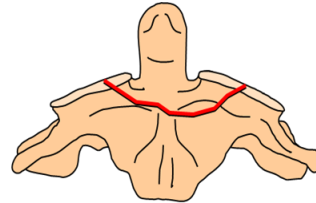
**Type 2**

SOMI / Minerva

Halo Vest

Odontoid Screw

C1-2 posterior fusion

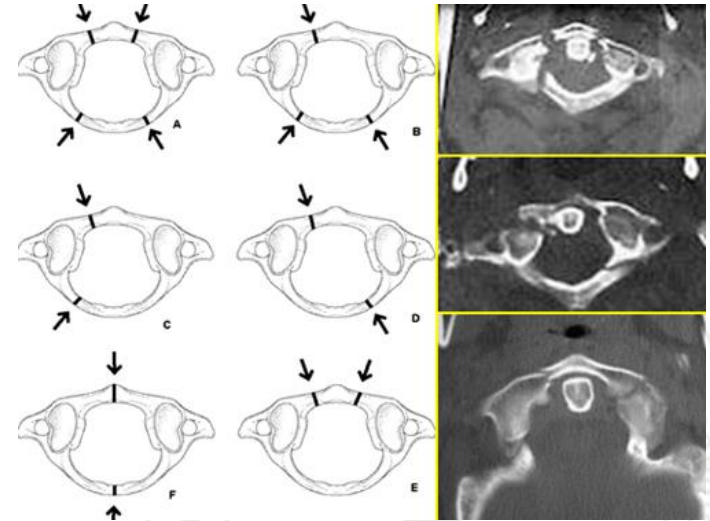


**Type 3**

C-Collar 10-15% nonunion

SOMI brace

Halo Vest



Fractures of the odontoid process of the axis.

[Anderson, L.D.;](#) [D'Alonzo, R.T.J. Bone Joint Surg. Am.,](#)

1974, 56, 8, 1663-1674,

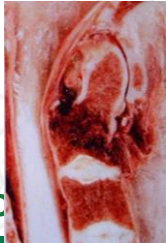
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# Upper cervical Trauma



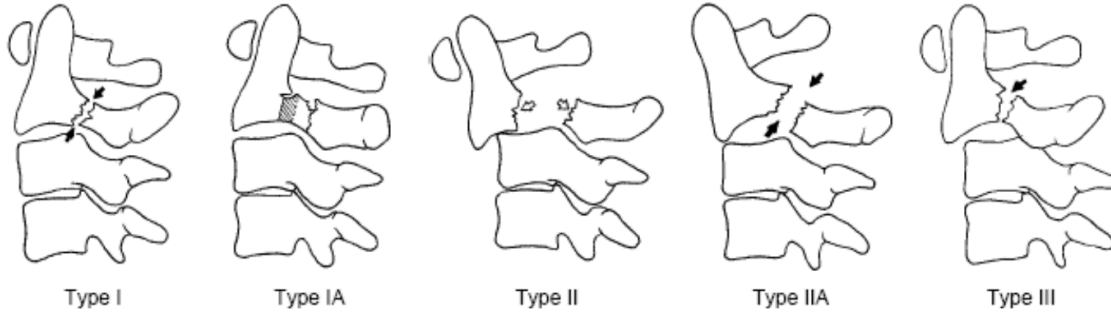
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FC



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Lyo

# Hangman's fracture



Levine AM, Edwards CC: The management of traumatic spondylolisthesis of the axis. *J Bone Joint Surg Am* 1985; 67:217-226

**Type I:** conservative C-collar.

**Type II and III:** posterior fusion

Open reduction and C1-C3 fusion

Direct pars repair and C2-C3 fusion



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# Hangman's fracture



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# Subaxial Cervical Fractures

- 1-Compression–flexion
- 2-Vertical compression
- 3.-Distraction-flexion
  - Stage I-facet subluxation
  - Stage II unilateral facet dislocation
  - Stage III bilateral facet dislocation <50%
  - Stage IV bilateral facet dislocation >50%



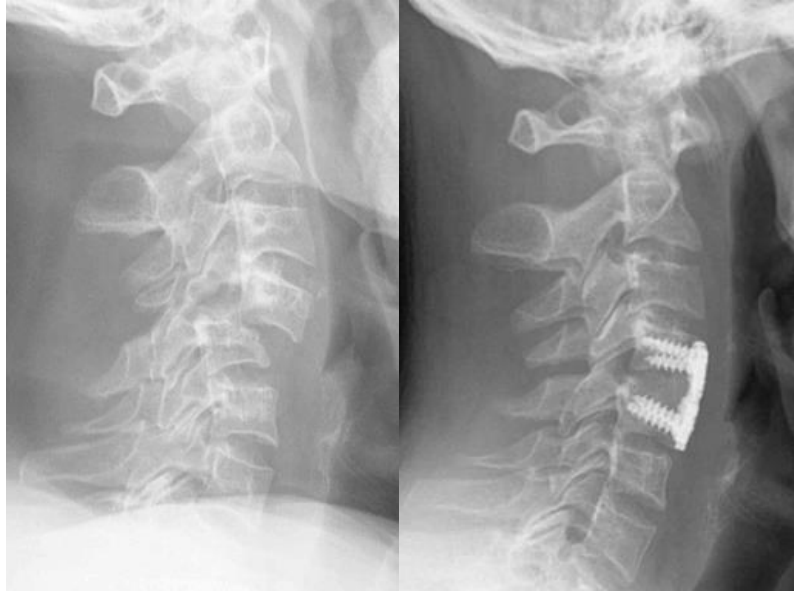
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# Subaxial Cervical Fractures



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