

MSc Trauma Surgery Thoracolumbar Spinal Trauma

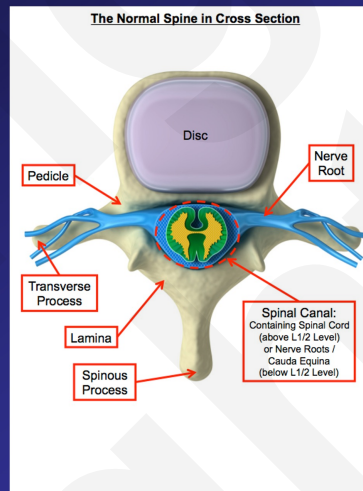
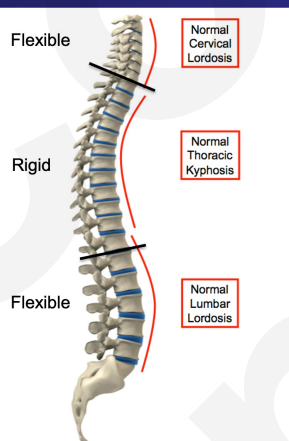
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No Disclosures No Conflicts of Interest



Thoracolumbar Fractures



ASIA INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI)

Examiner Name: _____ Date/Time of Exam: _____

Examiner Signature: _____

RIGHT **LEFT**

MOTOR KEY MUSCLES

RIGHT

C2 Neck flexion

C3 Neck extension

C4 Elbow flexion

C5 Elbow extension

C6 Wrist flexion

C7 Wrist extension

C8 Finger flexion

T1 Finger abduction (pinch)

T2 Elbow flexion

T3 Elbow extension

T4 Wrist flexion

T5 Wrist extension

T6 Forearm pronation

T7 Forearm supination

T8 Forearm pronation

T9 Forearm supination

T10 Forearm pronation

T11 Forearm supination

T12 Forearm pronation

L1 Hip flexion

L2 Hip extension

L3 Knee flexion

L4 Knee extension

L5 Long toe extension

S1 Ankle plantar flexion

S2 Ankle dorsiflexion

S3 Ankle inversion

S4 Ankle eversion

S5 Ankle inversion

S6 Ankle eversion

LEFT

C2 Neck flexion

C3 Neck extension

C4 Elbow flexion

C5 Elbow extension

C6 Wrist flexion

C7 Wrist extension

C8 Finger flexion

T1 Finger abduction (pinch)

T2 Elbow flexion

T3 Elbow extension

T4 Wrist flexion

T5 Wrist extension

T6 Forearm pronation

T7 Forearm supination

T8 Forearm pronation

T9 Forearm supination

T10 Forearm pronation

T11 Forearm supination

T12 Forearm pronation

L1 Hip flexion

L2 Hip extension

L3 Knee flexion

L4 Knee extension

L5 Long toe extension

S1 Ankle plantar flexion

S2 Ankle dorsiflexion

S3 Ankle inversion

S4 Ankle eversion

S5 Ankle inversion

S6 Ankle eversion

Reflexes

1/2

3/4

5/6

7/8

Key Sensory Points

C2 Neck

C3 Neck

C4 Elbow

C5 Elbow

C6 Wrist

C7 Wrist

C8 Finger

T1 Finger

T2 Elbow

T3 Elbow

T4 Wrist

T5 Wrist

T6 Forearm

T7 Forearm

T8 Forearm

T9 Forearm

T10 Forearm

T11 Forearm

T12 Forearm

L1 Hip

L2 Hip

L3 Knee

L4 Knee

L5 Long toe

S1 Ankle

S2 Ankle

S3 Ankle

S4 Ankle

S5 Ankle

S6 Ankle

Neurological Levels

1. SENSORY

2. MOTOR

Neurological Level of Injury (NLI)

ASIA Impairment Scale (AIS)

Steps in Classification

1. Determine sensory levels for right and left sides.

2. Determine motor levels for right and left sides.

3. Determine the neurological level of injury (NLI).

4. Determine whether the injury is Complete or Incomplete.

5. Determine AIS Impairment Scale (AIS) Grade.

6. Determine ASIA Motor Scale (AMS) Grade.

7. Determine ASIA Sensory Scale (ASS) Grade.

8. Determine ASIA Ankle Scale (AAS) Grade.

9. Determine ASIA Hip Scale (AHS) Grade.

10. Determine ASIA Knee Scale (AKS) Grade.

11. Determine ASIA Long toe Scale (ALTS) Grade.

12. Determine ASIA Ankle plantar flexion Scale (APFS) Grade.

13. Determine ASIA Ankle dorsiflexion Scale (ADS) Grade.

14. Determine ASIA Ankle inversion Scale (AIS) Grade.

15. Determine ASIA Ankle eversion Scale (AES) Grade.

16. Determine ASIA Ankle inversion/eversion Scale (AIES) Grade.

17. Determine ASIA Ankle inversion/eversion Scale (AIES) Grade.

18. Determine ASIA Ankle inversion/eversion Scale (AIES) Grade.

19. Determine ASIA Ankle inversion/eversion Scale (AIES) Grade.

20. Determine ASIA Ankle inversion/eversion Scale (AIES) Grade.

Muscle Function Grading

0 = total paralysis

1 = palpable or visible contraction

2 = active movement, full range of motion (ROM) with gravity eliminated

3 = active movement, full ROM against gravity

4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position

5 = (normal) active movement, full ROM against gravity and full resistance in a functional muscle position except from an otherwise unimpaired person

5+ = normal, active movement, full ROM against gravity and sufficient resistance to be considered normal (identified inhibiting factors (ie pain, shock) were not present)

NT = not testable (ie due to intractable, severe pain such that the patient cannot be graded; amplitude of limb or contraction of > 50% of the normal range of motion)

Sensory Grading

0 = Absent

1 = Altered, other decreased/impaired sensation or hypersensitivity

2 = Normal

NT = Not testable

Non Key Muscle Functions (optional)

May be used to assign a motor level to differentiate AIS B vs C.

Shoulder: Flexion, extension, abduction, adduction, internal and external rotation

Elbow: Supination

Forearm: Pronation

Wrist: Flexion, extension, abduction, adduction, internal and external rotation

Hand: Flexion, extension, abduction, adduction, internal and external rotation

Thumb: Flexion, extension, abduction, adduction, internal and external rotation

Index: Flexion, extension, abduction, adduction, internal and external rotation

Long toe: Flexion, extension, abduction, adduction, internal and external rotation

Plantar: Flexion, extension, abduction, adduction, internal and external rotation

ASIA Impairment Scale (AIS)

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

B = Sensory incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5 (light touch or pin prick at S4-S5 or deep and pressure ASIS to motor function is preserved more than three levels below the motor level on either side of the body).

C = Motor incomplete. Motor function is preserved below the neurological level, and more than half of key muscle functions below the NLI have a muscle grade of 3.

D = Motor incomplete. Motor function is preserved below the neurological level, and at least half of key muscle functions below the NLI have a muscle grade of 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an AIS does not receive an AIS grade.

Steps in Classification

1. Determine sensory levels for right and left sides.

2. Determine motor levels for right and left sides.

3. Determine the neurological level of injury (NLI).

4. Determine whether the injury is Complete or Incomplete.

5. Determine AIS Impairment Scale (AIS) Grade.

6. Determine ASIA Motor Scale (AMS) Grade.

7. Determine ASIA Sensory Scale (ASS) Grade.

8. Determine ASIA Ankle Scale (AAS) Grade.

9. Determine ASIA Hip Scale (AHS) Grade.

10. Determine ASIA Knee Scale (AKS) Grade.

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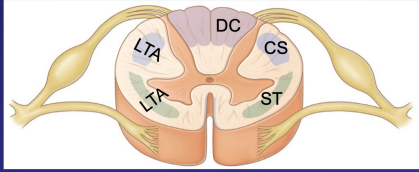
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Spinal Cord



Spine Function - PMS

- Protection
- Movement
- Support



Suspecting a Spinal Injury

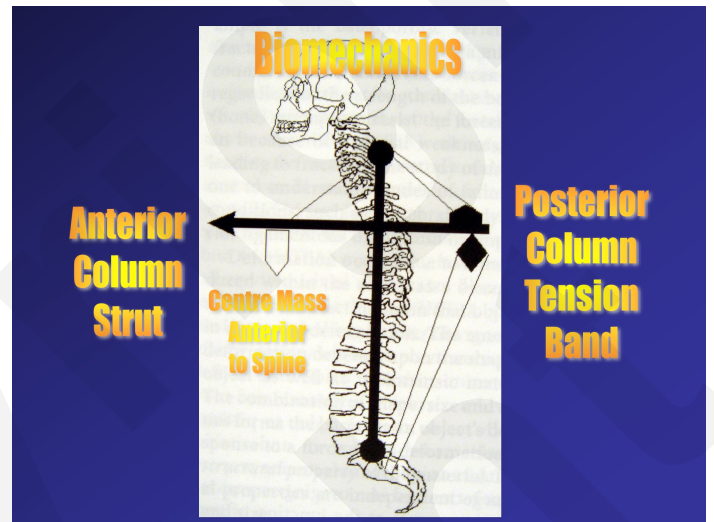
- Mechanism of Injury
- Unconscious
- Neurological Deficit
- Spinal Pain / Tenderness

Goals of Spine Trauma Care

- Protection
- Detection
- Optimize conditions for neuro recovery
- Maintain / restore spinal alignment
- Minimize loss of spinal mobility
- Obtain healed and stable spinal column
- Rehabilitation
- #s = Manage the ass soft tissue injury

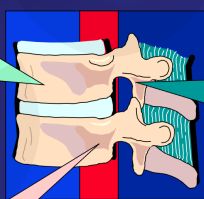
Management of Spinal Injury

- ABCDE / ATLS Approach
- Protection - **THINK SPINAL CORD INJURY**
 - Maintain airway with spine control
 - Always aim to have a team of 6 for transfers (min 4 for log rolls)
- Detection
 - Level of injury
 - Complete or Incomplete cord injury
 - Spinal or Neurogenic shock
- Management
 - Conservative or Surgical treatment



The column theory THREE COLUMNS

- ANTERIOR COLUMN**
- anterior longitudinal ligament
 - anterior half of vertebral body
 - anterior part of annulus fibrosis



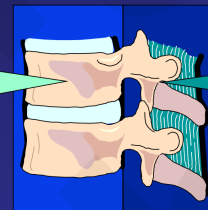
- POSTERIOR COLUMN**
- neural arch
 - ligamentum flavum
 - facet joint capsules
 - interspinous ligament

- MIDDLE COLUMN**
- posterior longitudinal ligament
 - posterior half of vertebral body
 - posterior part of annulus fibrosis

- Denis 1983
- conceptual rather than anatomical
- based on biomechanical studies

The column theory TWO COLUMNS

- ANTERIOR COLUMN**
- solid column of vertebral bodies
 - compression-resistant



- POSTERIOR COLUMN**
- hollow column of neural canal
 - tension-resistant

- AO Magerl 1993
- anatomically based concept

AO CLASSIFICATION OF THORACOLUMBAR FRACTURES

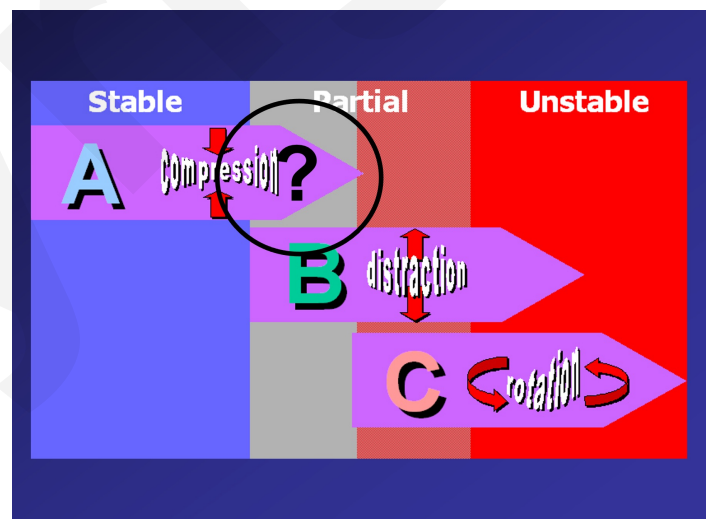


Table 2

Thoracolumbar Injury Classification and Severity Score

Injury Characteristic	Qualifier	Points
Injury morphology		
Compression	—	1
	Burst	+1
Rotation/translation	—	3
Distraction	—	4
Neurologic status		
Intact	—	0
Nerve root	—	2
Spinal cord, conus medullaris	Incomplete	3
	Complete	2
Cauda equina	—	3
Posterior ligamentous complex integrity		
Intact	—	0
Suspected/Indeterminate	—	2
Disrupted	—	3

+ = 1 additional point given to the morphology

≤ 3 = non op
4 = grey
≥ 5 = op

Load-sharing classification

McCormack, Gaines et al
(Spine 1994)

28 pts

COMMINUTION



1. Little
< 30% comminution



2. More
30-60% comminution



3. Gross
> 60% comminution

on sagittal CT

APPOSITION



1. Minimal
minimal spread



2. Spread
< 2mm of < 50%



3. Wide
> 2mm of > 50%

on axial CT

KYPHOSIS



1. Little
< 4° correction



2. More
4-9° correction



3. Most
> 9° correction

on lateral x-ray - POST OP

score from 3 to 9

≤ 6 = posterior surgery

> 6 = anterior surgery

Lying vs standing
Prediction of correction

Old Instrumentation
Not Externally Validated

New AO Classification

Spine

SPINE Volume 38, Number 23, pp 2028-2037
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DIAGNOSTICS

AOSpine Thoracolumbar Spine Injury Classification System

Fracture Description, Neurological Status, and Key Modifiers

1. Morphologic classification of the fracture
2. Neurological status
3. Clinical modifiers

1. Morphological Classification

- **Type A:** Compression
- **Type B:** Failure of posterior or anterior tension band **without** evidence of either gross translation or the potential for gross translation
- **Type C:** Failure of all elements leading to dislocation or displacement in any plane or complete disruption of a soft-tissue hinge even in the absence of translation

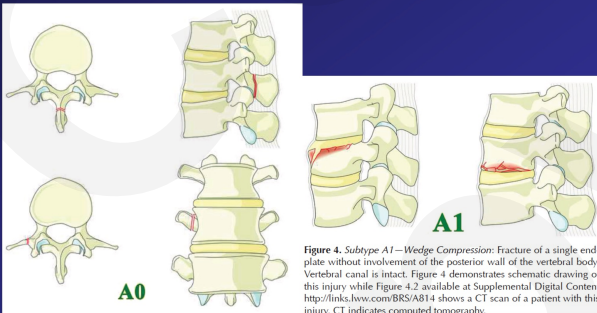


Figure 3. Subtype A0—Minor injuries: Injuries such as transverse process or spinous process fractures, which do not compromise the mechanical integrity of the spinal column. Figure 3 demonstrates schematic drawing of this injury while Figure 3.2 available at Supplemental Digital Content <http://links.lww.com/BRS/A813> shows a CT scan of a patient with this injury. CT indicates computed tomography.

Figure 4. Subtype A1—Wedge Compression: Fracture of a single endplate without involvement of the posterior wall of the vertebral body. Vertebral canal is intact. Figure 4 demonstrates schematic drawing of this injury while Figure 4.2 available at Supplemental Digital Content <http://links.lww.com/BRS/A814> shows a CT scan of a patient with this injury. CT indicates computed tomography.

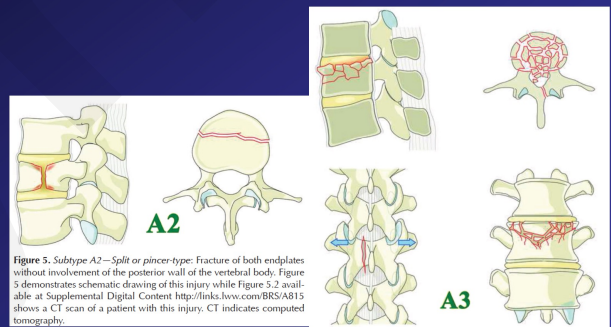


Figure 5. Subtype A2—Split or pincer-type: Fracture of both endplates without involvement of the posterior wall of the vertebral body. Figure 5 demonstrates schematic drawing of this injury while Figure 5.2 available at Supplemental Digital Content <http://links.lww.com/BRS/A815> shows a CT scan of a patient with this injury. CT indicates computed tomography.

Figure 6. Subtype A3—Incomplete burst: Fracture with any involvement of the posterior wall of the vertebral body. Only a single endplate fractured. Vertical fracture of the lamina is usually present and does not indicate a tension band failure. Figure 6 demonstrates schematic drawing of this injury while Figure 6.2 available at Supplemental Digital Content <http://links.lww.com/BRS/A816> shows a CT scan of a patient with this injury. CT indicates computed tomography.

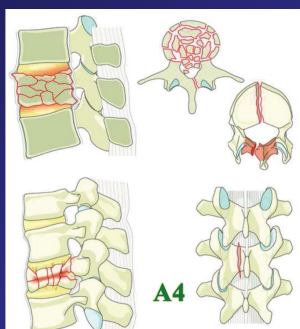


Figure 7. Subtype A4—Complete burst: Fracture with any involvement of the posterior wall of the vertebral body and both endplates. Vertical fracture of the lamina is usually present and does not indicate a tension band failure. Figure 7 demonstrates schematic drawing of this injury while Figure 7.2 available at Supplemental Digital Content <http://links.lww.com/BRS/AB17> shows a CT scan of a patient with this injury. CT indicates computed tomography.

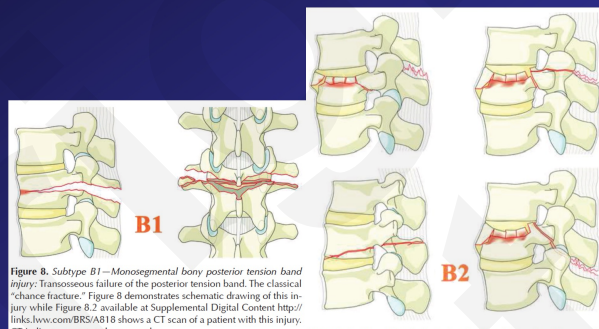


Figure 8. Subtype B1—Monosegmental bony posterior tension band injury: Transosseous failure of the posterior tension band. The classical "chance fracture." Figure 8 demonstrates schematic drawing of this injury while Figure 8.2 available at Supplemental Digital Content <http://links.lww.com/BRS/AB18> shows a CT scan of a patient with this injury. CT indicates computed tomography.

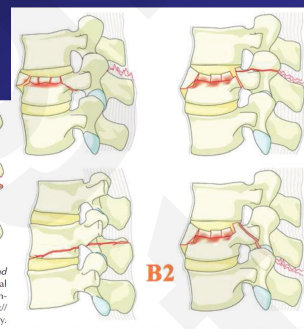


Figure 9. Subtype B2—Posterior tension band disruption: Bony and/or ligamentary failure of the posterior tension band together with a type A fracture. Type A fracture should be classified separately. This example should be classified as T12-L1 "type B2" with T12 "A4" according to the combination rules. Figure 9 demonstrates schematic drawing of this injury while Figure 9.2 available at Supplemental Digital Content <http://links.lww.com/BRS/AB19> shows a CT scan of a patient with this injury. CT indicates computed tomography.

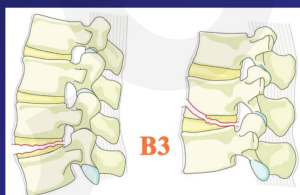


Figure 10. Subtype B3—Hyperextension injury: Injury through the disc or vertebral body leading to a hyperextended position of the spinal column, which is commonly seen in ankylosing disorders. Anterior tension band, notably the ALL, is ruptured but there is a posterior hinge preventing further displacement. Figure 10 demonstrates schematic drawing of this injury while Figure 10.2 available at Supplemental Digital Content <http://links.lww.com/BRS/AB20> shows a CT scan of a patient with this injury. CT indicates computed tomography. CT indicates computed tomography.

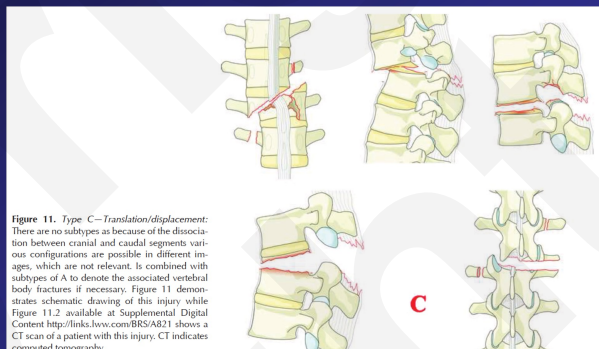


Figure 11. Type C—Translation/displacement: There are no subtypes as because of the dissociation between cranial and caudal segments various configurations are possible in different images, which are not relevant. Is combined with subtypes of A to denote the associated vertebral body fractures if necessary. Figure 11 demonstrates schematic drawing of this injury while Figure 11.2 available at Supplemental Digital Content <http://links.lww.com/BRS/AB21> shows a CT scan of a patient with this injury. CT indicates computed tomography.

2. Neurological Status

- N0: Intact
- N1: Transient deficit resolved
- N2: Symptoms / signs radiculopathy
- N3: Incomplete SCI / CES
- N4: Complete SCI (ASIA A)
- Nx: Unable to assess

3. Clinical Modifiers

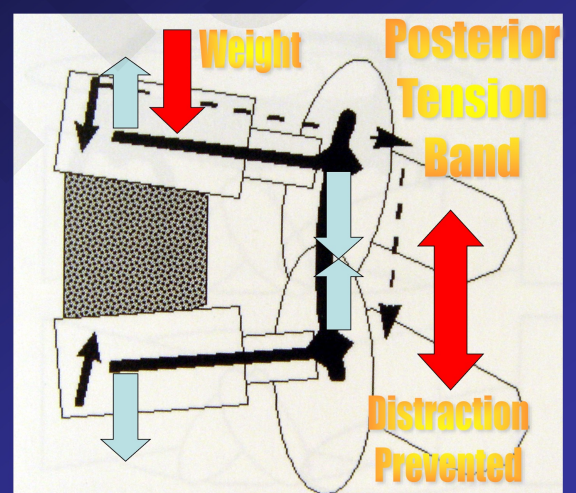
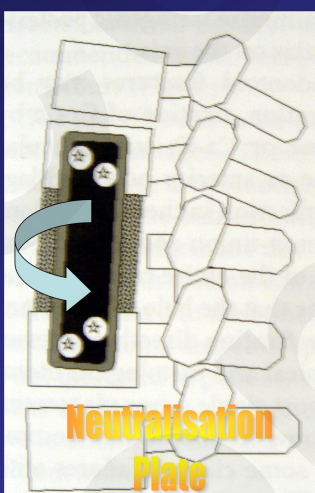
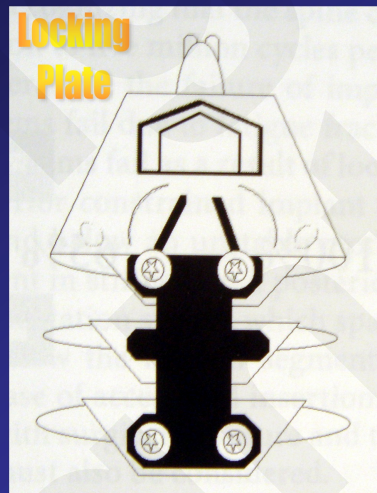
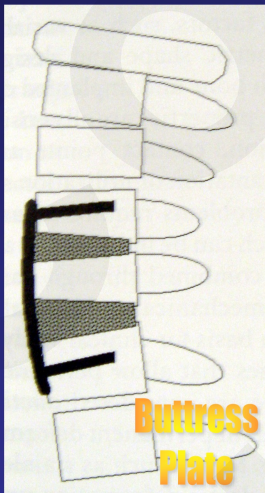
- M1: Indeterminate ligamentous injury
- M2: Patient specific comorbidity – AS, RA, DISH, OP, Burns

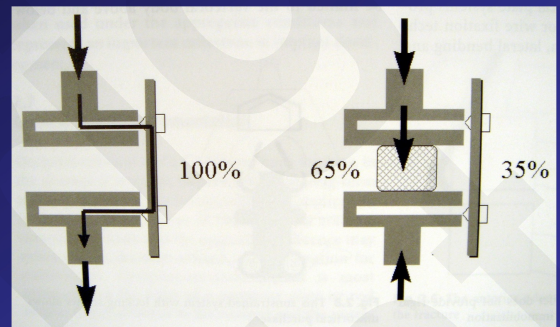
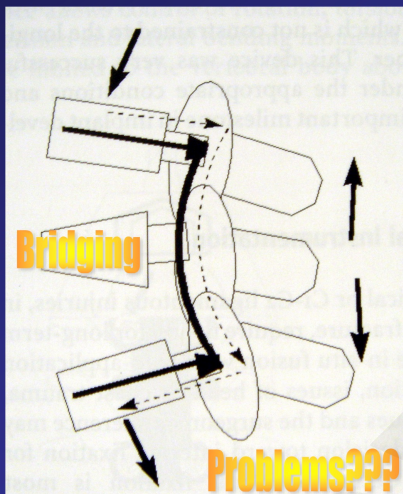
Thoracolumbar Instability

- Neurological deficit
- Clinical posterior tenderness or deformity
- > 20-30° kyphosis (segmental or combined)
- > 30% loss of vertebral height (thoracic)
- > 50% loss of vertebral height (lumbar)
- > 50% canal compromise
- Rotational malalignment
- Fracture dislocation
- Multiple adjacent fractures (combined height loss > 50%)
- Scoliosis > 10°

AO Principles

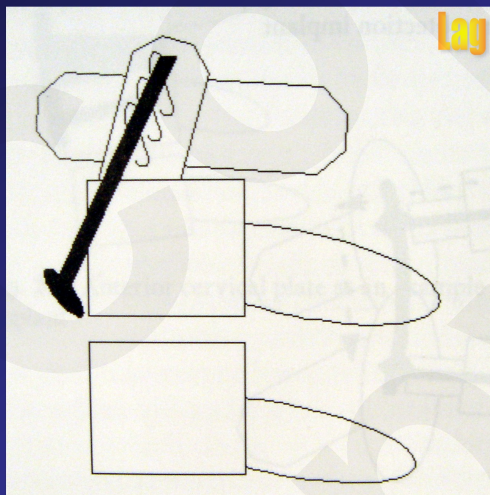
- Anatomic Reduction
- Stable Internal Fixation
- Atraumatic Technique
- Early Active Mobilisation





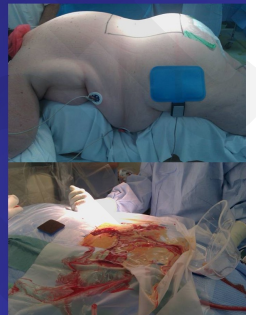
Failure

Success



The Personalities

- Personality of the patient
 - Age
 - Comorbidity
 - Bone stock
 - Energy of injury / other injuries
 - Time since injury



The Personalities

- Personality of the fracture
 - Canal compromise
 - Neurologic compromise
 - Kyphosis
 - Anterior collapse
 - Progression



Munted

The Personalities

- Personality of the surgeon



Indications for Surgery - DRS

- Decompression
 - Spinal cord / nerve roots
- Realignment
 - Correct deformity
- Stabilisation
 - Prevent / Treat
 - Neurological deficit / deformity / pain
 - (Non fusion technology form of "stabilisation")

All may require fusion

Require Instrumentation

Instrumentation increases fusion

Absolute Indications for Surgery

- Indications for decompression
 - Worsening neurological deficit in the presence of demonstrable neural compression despite attempts at postural reduction
- Indications for stabilisation
 - All cases requiring decompression
 - Complete ligamentous disruption associated with dislocation
- Open Thoracolumbar burst fractures
- Patient with complete neurological deficit
- Multiply injured patient

Relative Indications for Surgery

- Decompression surgery (+ stabilisation)
 - Dynamic neurology
 - Stable incomplete neurology in presence of demonstrable neural compression
- Stabilisation surgery
 - Loss of anterior body height >50%
 - Kyphosis >20-30 degrees
 - Canal stenosis >50%
 - Disruption of posterior ligamentous complex

"Accepted" Indications for Surgery Thoracolumbar Burst Fractures

- Progressive neurologic deficit
- Progressive kyphosis ass. with neurologic deficit
- CT evidence of spinal canal compromise associated with an incomplete neurologic deficit
- Greater than 50% loss of vertebral body height
- Kyphosis greater than 30 degrees at level of #
- Spinal canal compromise greater than 50%

J Spinal Disord. 1990 Mar;3(1):39-46.

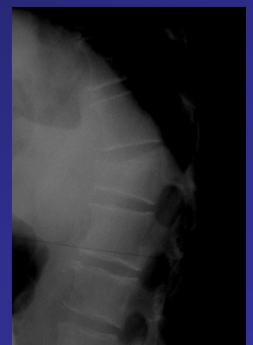
Compression / A1 Impaction

- Primarily involve anterior column in flexion
- Cause RTAs and Falls
- Most common thoracolumbar junction



Treatment

- Mobilise
- Pain Relief
- ? Brace
- ?????Operation

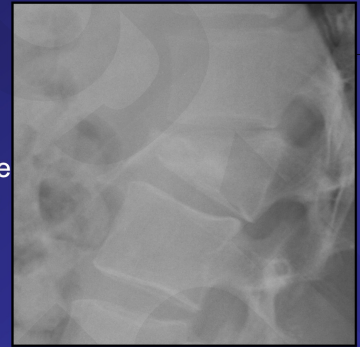


Outcome

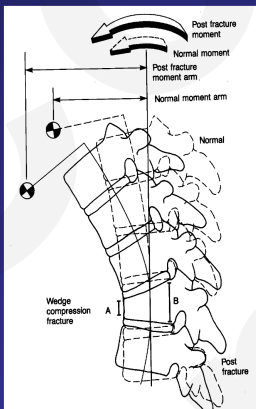
- Majority heal
- Low incidence of back pain
- Lumbar # more likely to be painful

Deformity – Standing Xrays

Gertsbein
>30 deg kyphosis
at union is associate
with increased pain



Post Traumatic Kyphosis



**Moment =
Force x
Distance**

*Goals for
Surgery*

Realign
Stabilize
Decompress
Prevent Late Pain / Deformity

Neurology

Biomechanics

clearance of
canal compromise

Maintain Function

Prevention of
neurological
deficit



Experimental Study of Thoracolumbar Burst Fractures

A Radiographic and Biomechanical Analysis of Anterior and Posterior Instrumentation Systems

Yasuhiro Shono, MD,* Paul C. McAfee, MD,† and Bryan W. Cunningham, BS‡

Anterior > Posterior

Biomechanical Evaluation of the Stability of Thoracolumbar Burst Fractures

Kenneth S. James, Karl H. Wenger, John D. Schlegel, and Harold K. Dunn

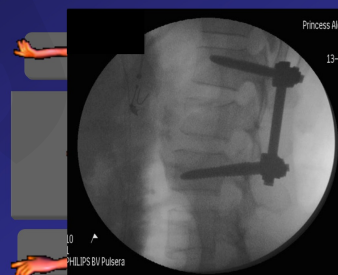
**Importance of Intact
Posterior Column**

*Anterior or
posterior surgery*

*posterior approach
technically easy
low morbidity*

Posterior surgery
is mainstay

*short segment
pedicle fixation
reduction of deformity
& canal compromise*



*posterior approach
Important for
dislocation / realign*

Dural laceration occurring with burst fractures and associated laminar fractures

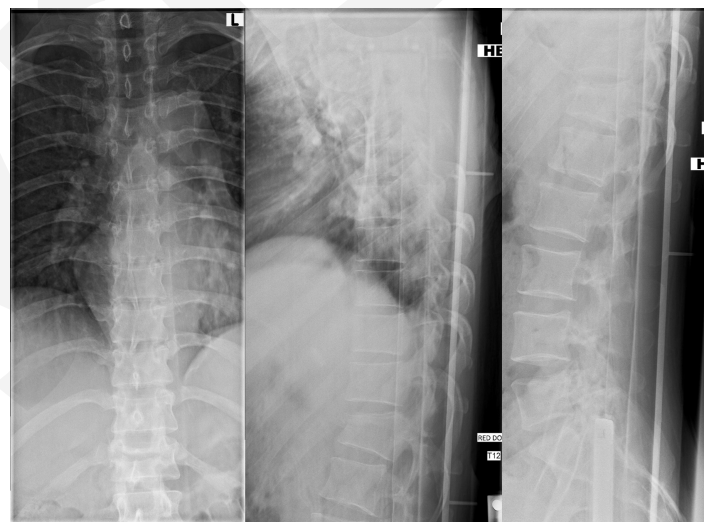
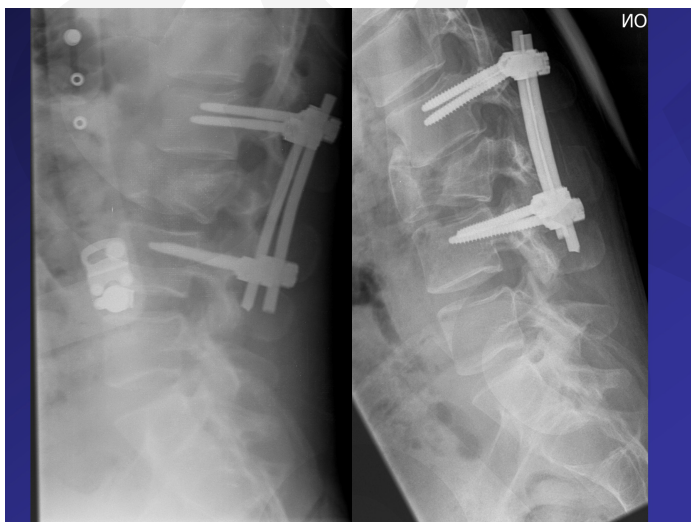
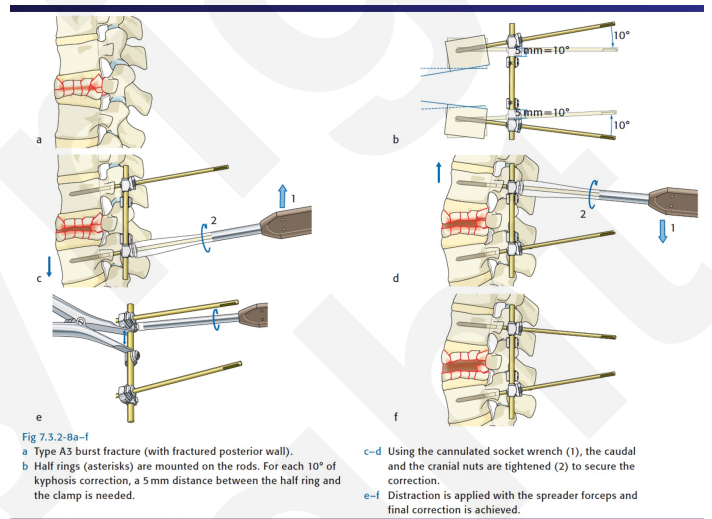
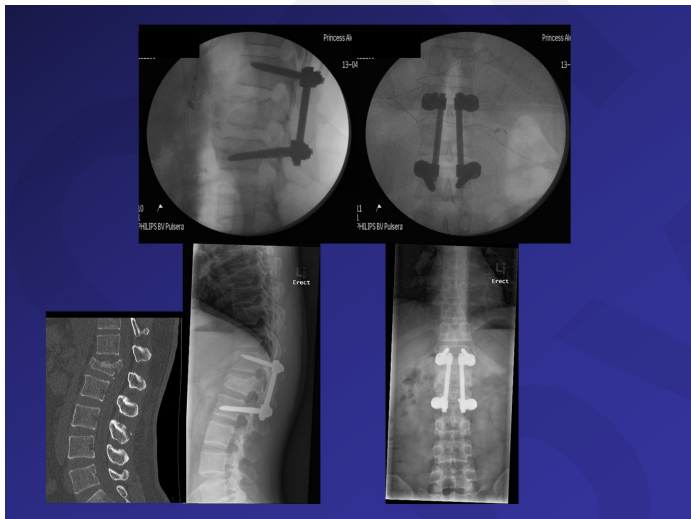
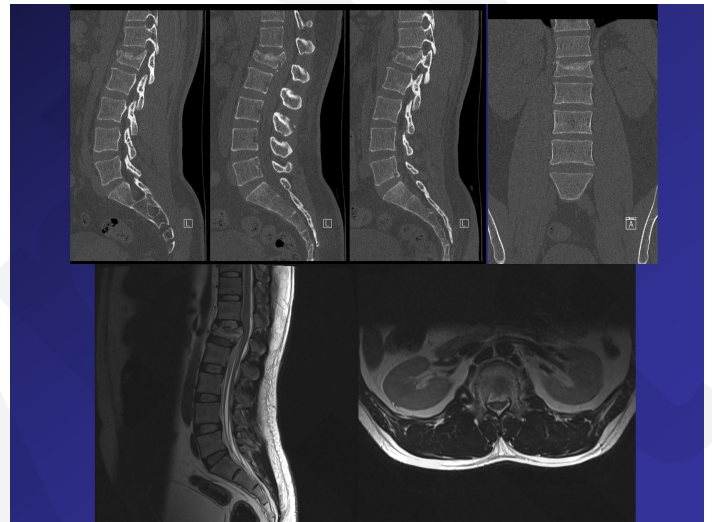
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J Bone Joint Surg Am. 1989;71:1044-1052.

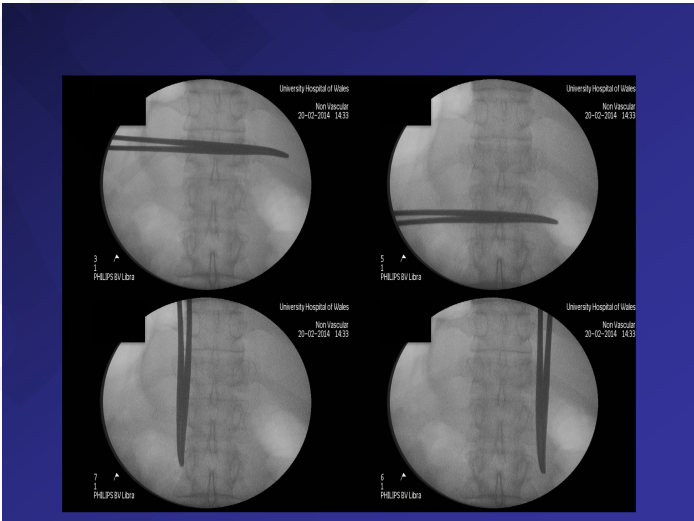
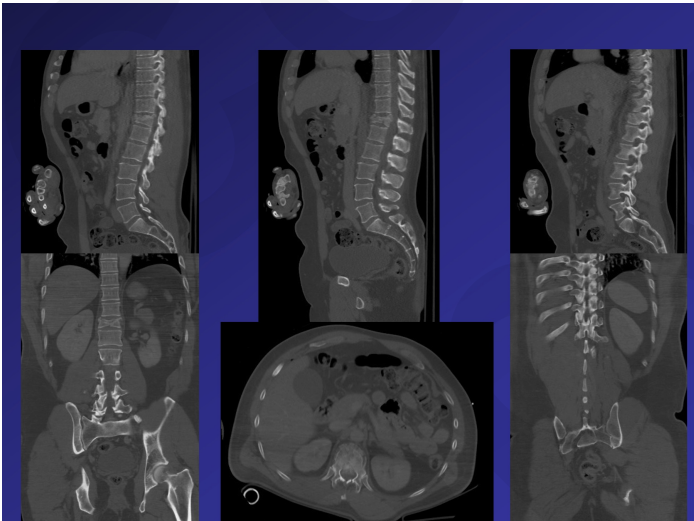
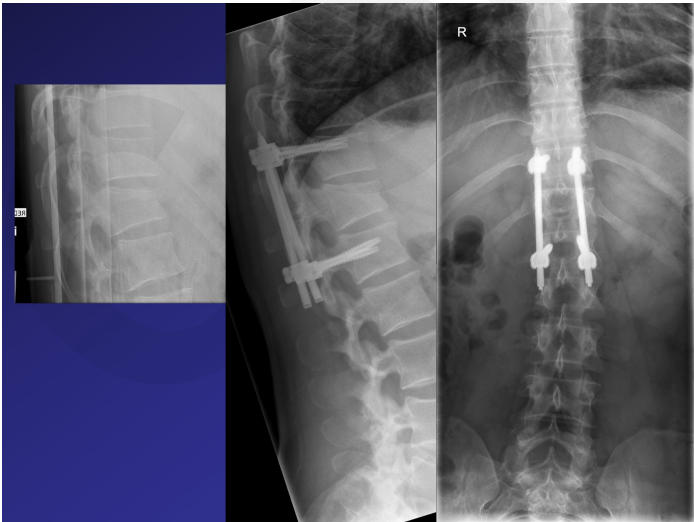
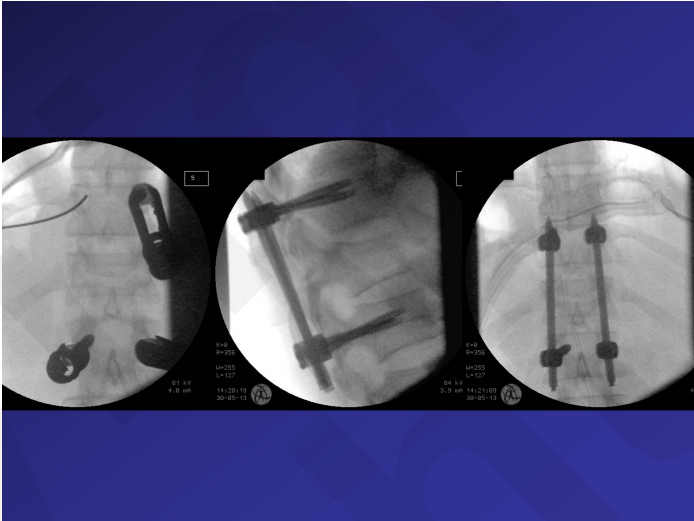
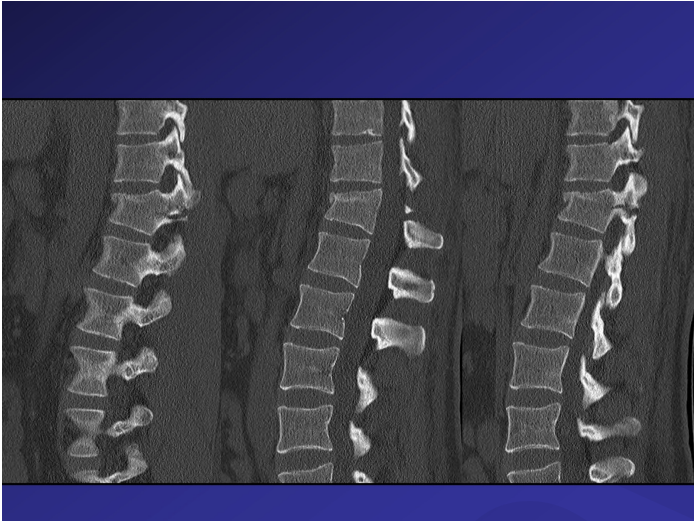
11/30 Dural Lacs

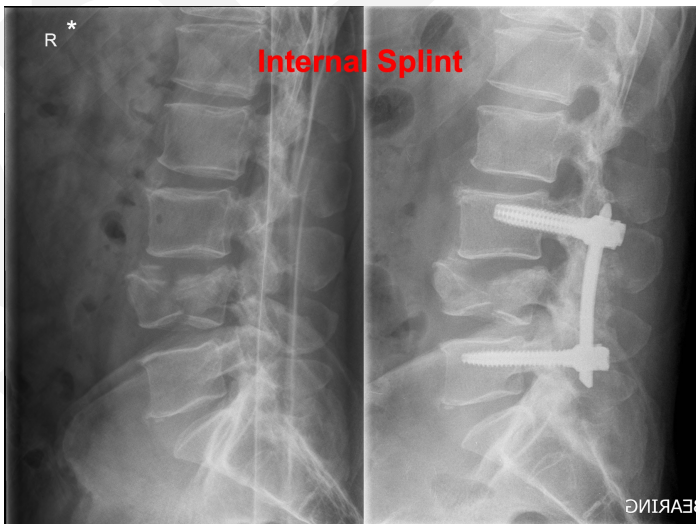
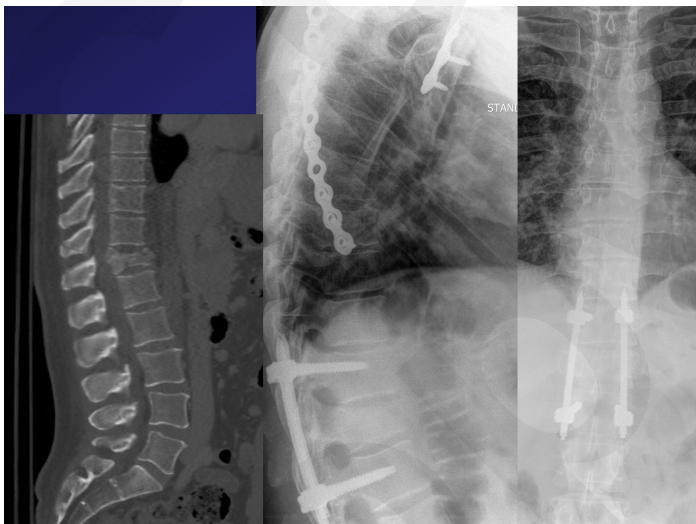
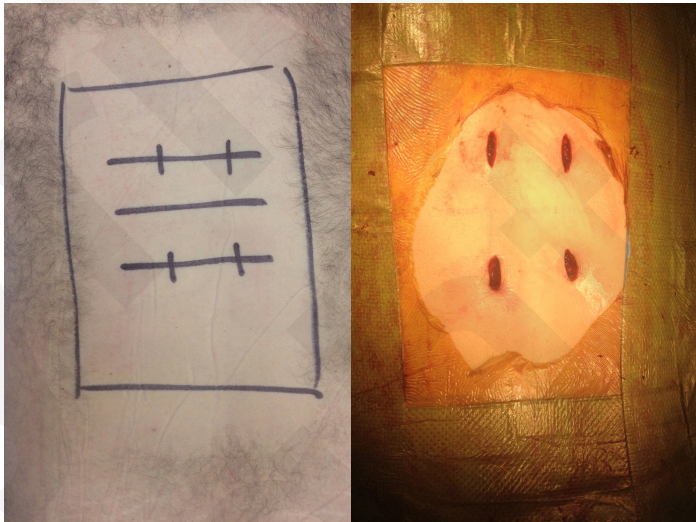
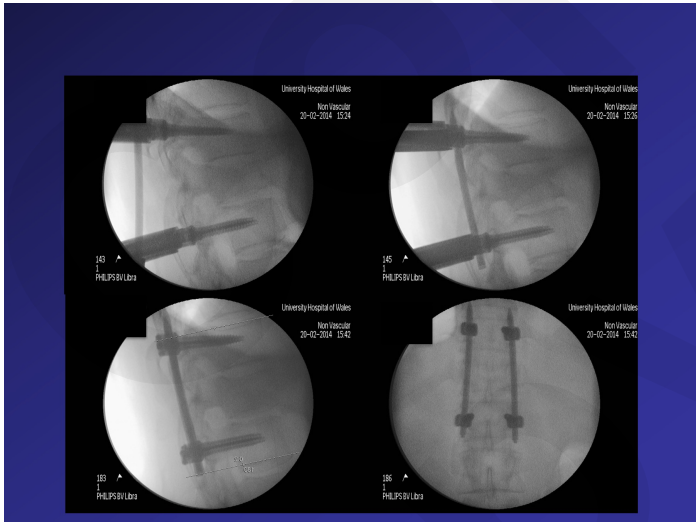
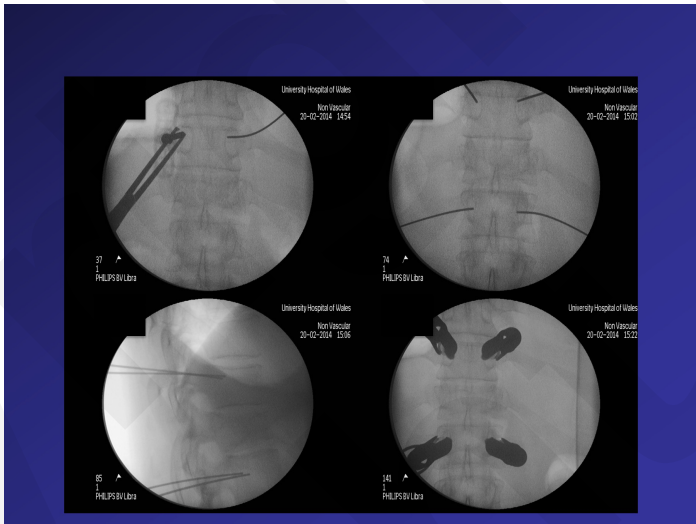
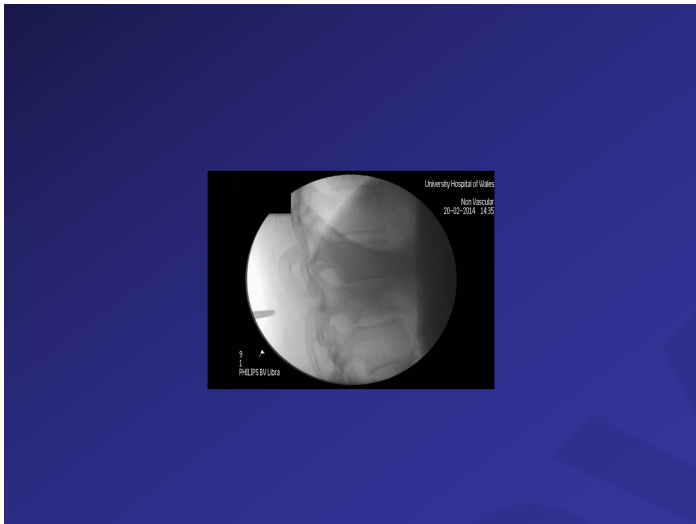
- Exception – facet fracture dislocations
– i.e. remove posterior compressive fragments from the back

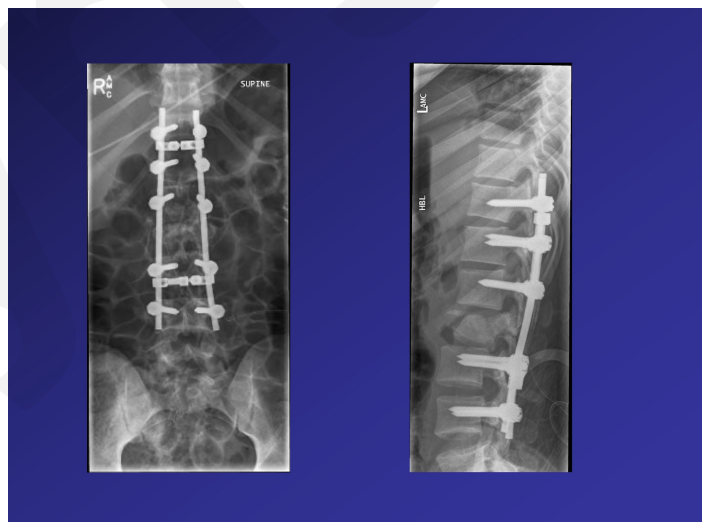
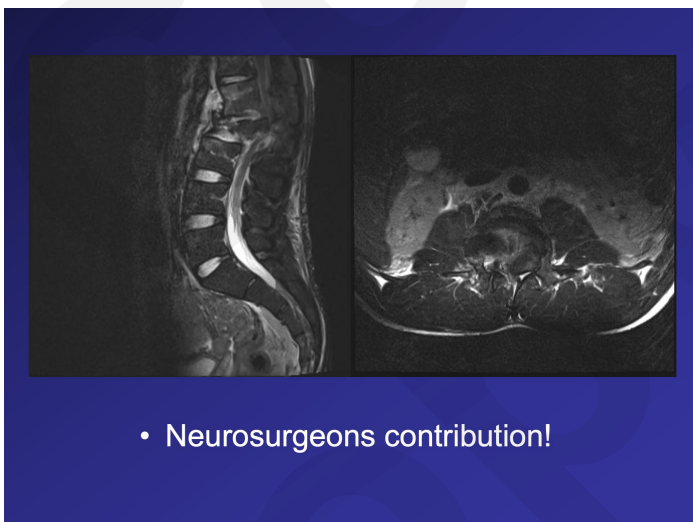
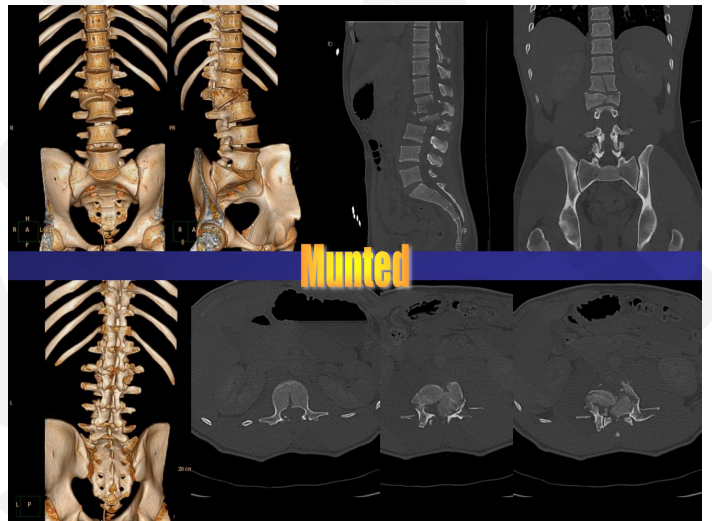
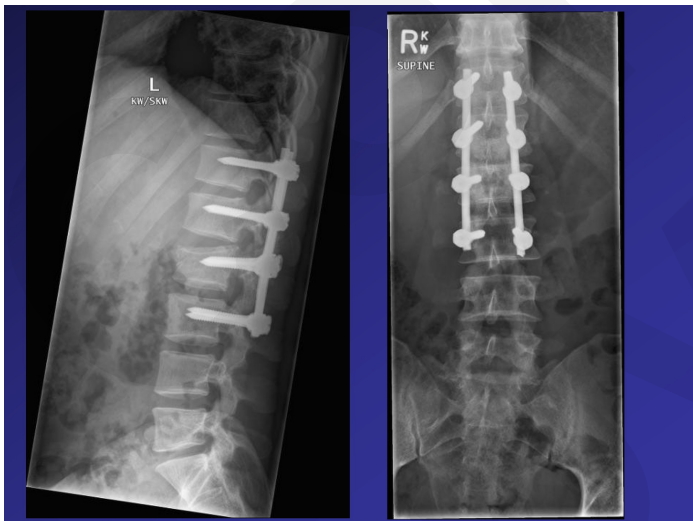
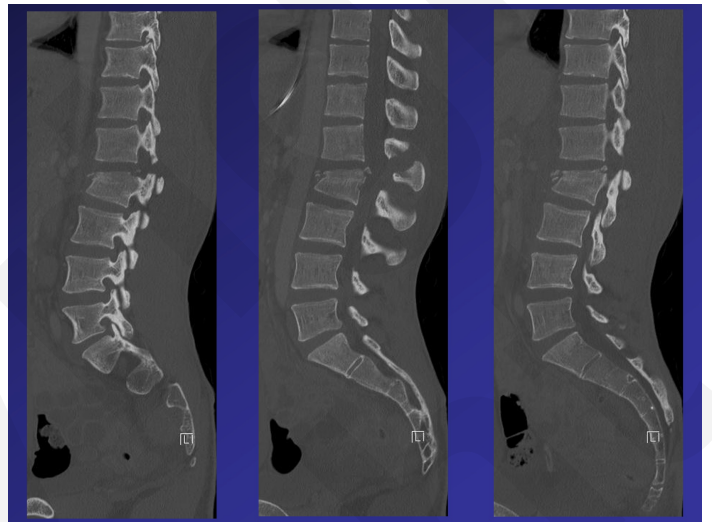
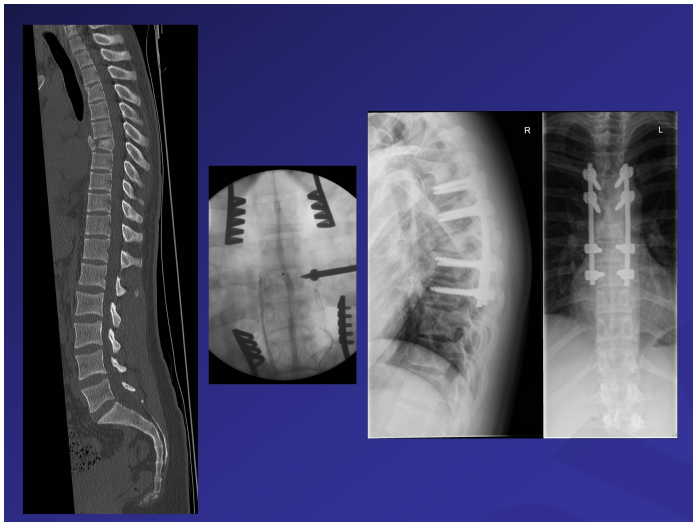
+ Posterior Fix +
Decompression =

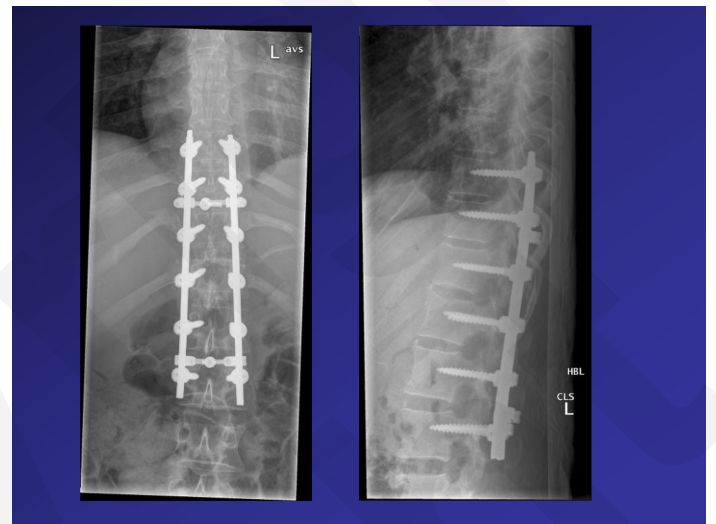
and destabilised!











Anterior or posterior surgery

posterior fixation cannot provide anterior column support

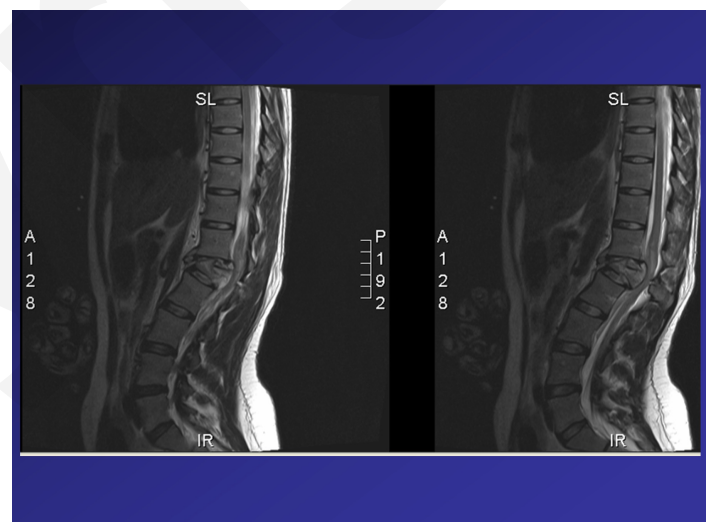
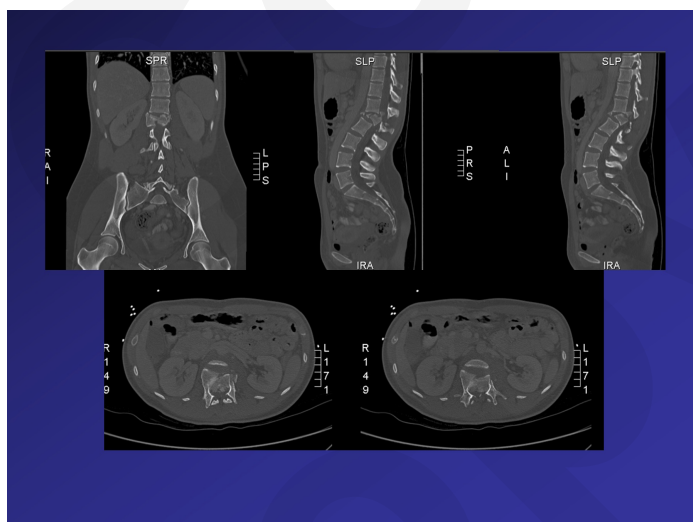
Corpectomy direct cord decompression vs. posterior indirect

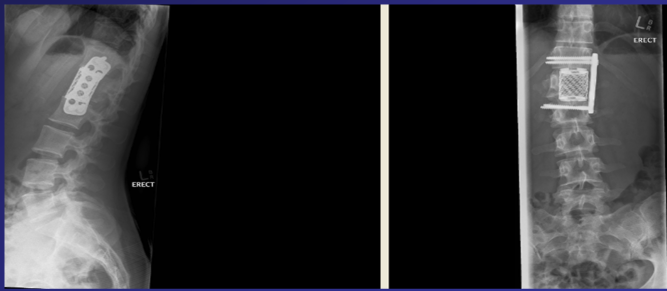
Cons:
Infrequent Specialist Training

Anterior surgery for significant anterior comminution

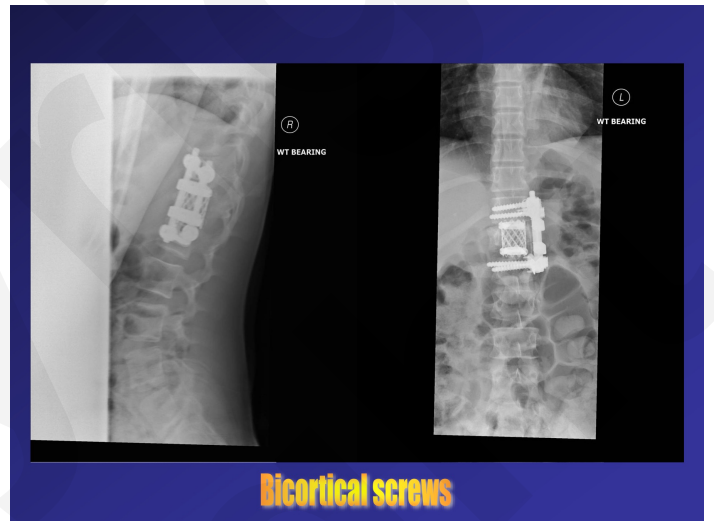
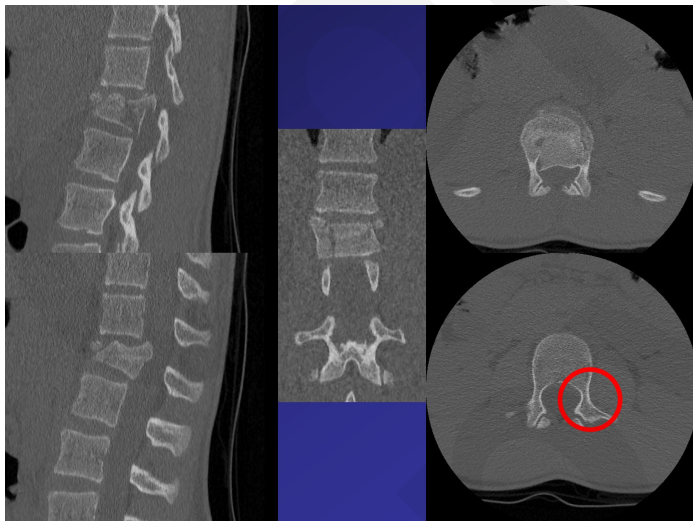
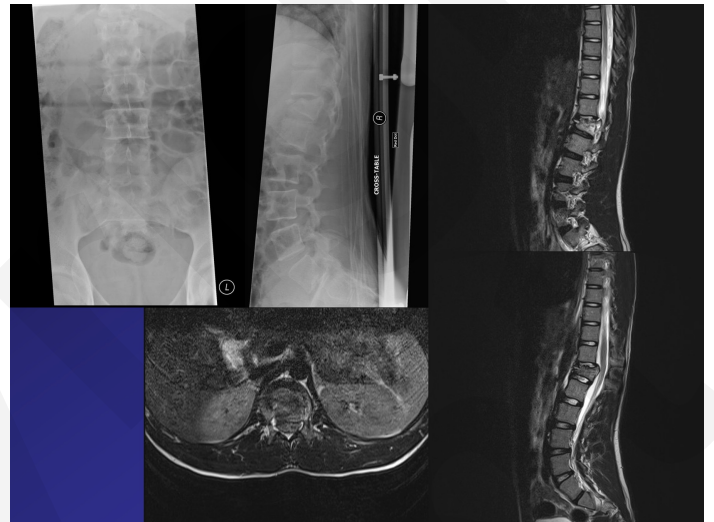
correction of deformity

stabilization of instability

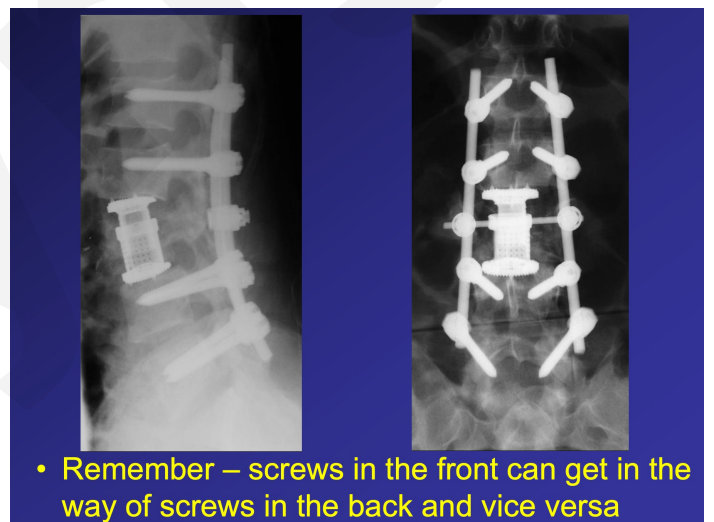
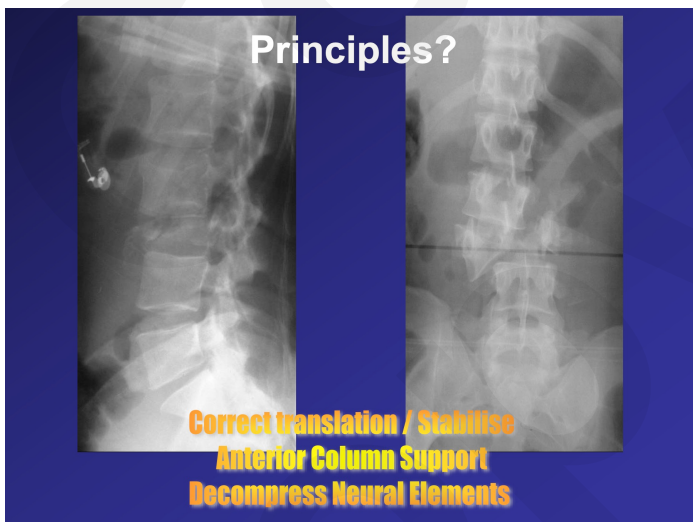




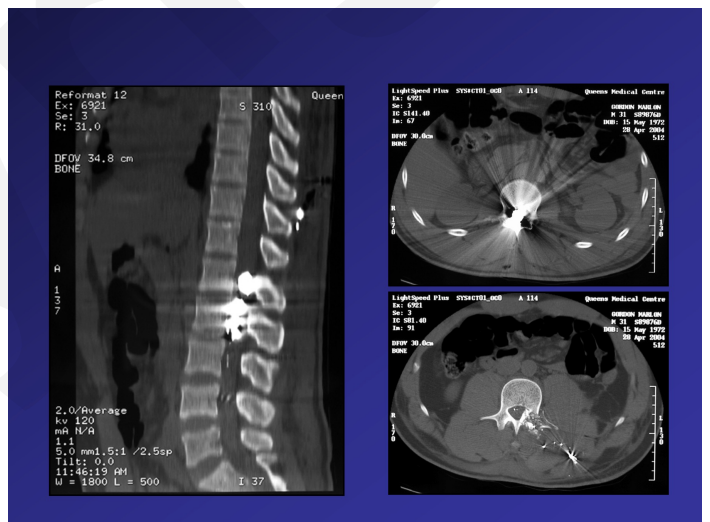
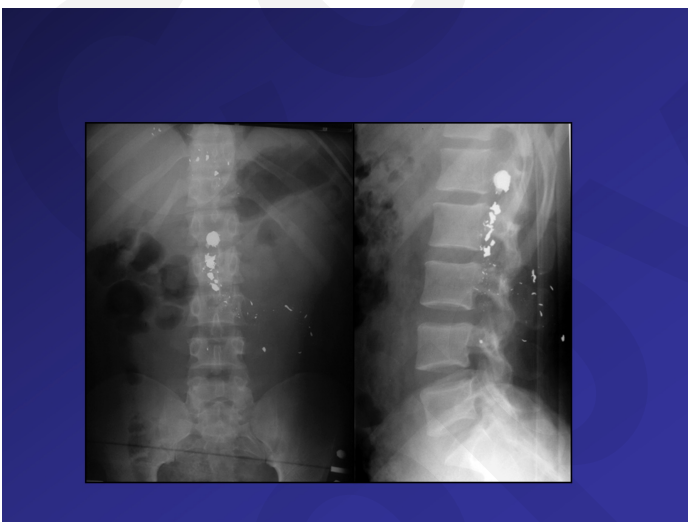
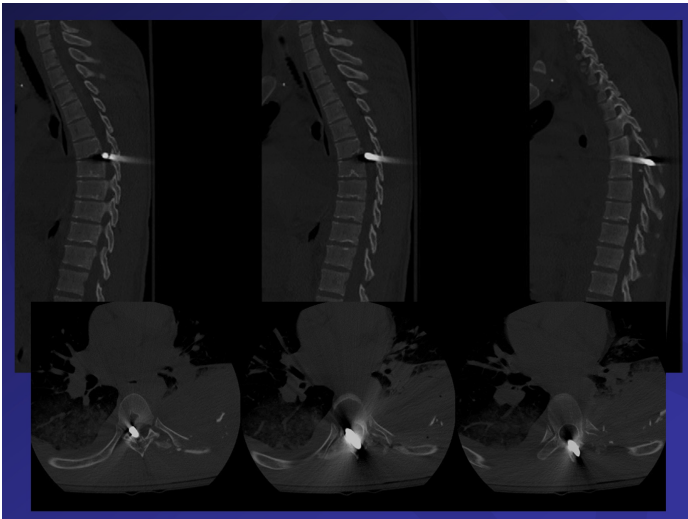
Bicortical screws

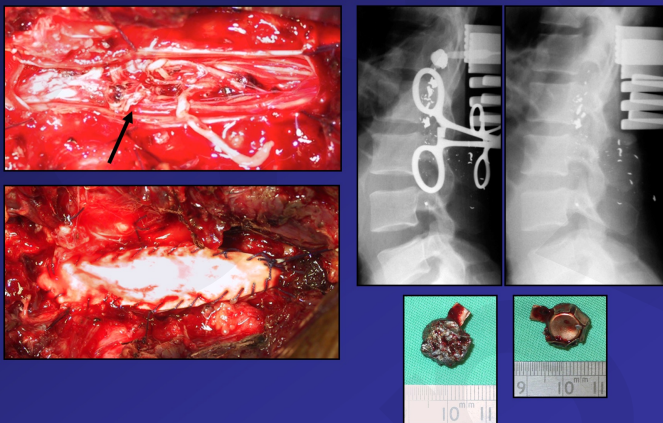
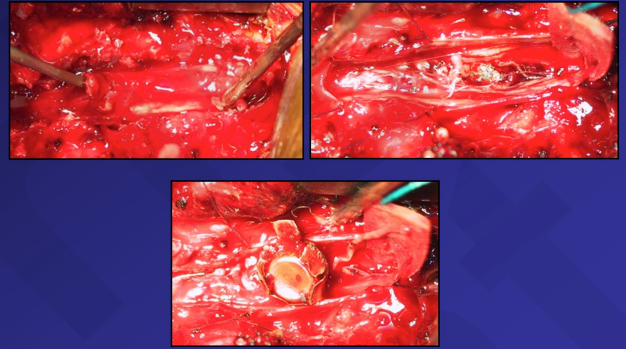
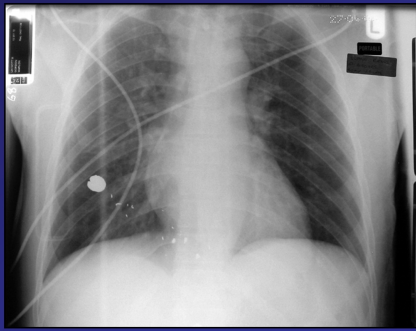


Bicortical screws



- Posterior
 - Realign
 - Restore Tension Band
 - Ligamentotaxis
 - Indirect Canal Decompression
- Anterior
 - Column support
 - Decompression
- Posterior Qs
 - Short or long
 - +/- Fracture screws
 - +/- Cross Links
 - Decompression
 - Fuse
- Anterior Qs
 - Structural Allograft
 - Cage Autograft
 - Expandable Cage
 - Rods or Plate





Timing of Surgery

Eur Spine J (2013) 22:2157–2166
DOI 10.1007/s00586-012-2624-1

REVIEW ARTICLE

A methodological systematic review of early versus late stabilization of thoracolumbar spine fractures

Fix Early

Complications / Outcomes TL

Stadhouder (Spine 2008)

- Thoracolumbar fractures
- Complications : 17% Nonop 21% Op (NS)
- Outcomes: VAS, ODI, GHQ similar at 2-6 years
- Employment: 88% Nonop, 83% op

Other Complications

- Pneumonia
- Postural Hypotension
- DVT / PE
- Autonomic Dysreflexia
- Renal Failure
- Pseudo-obstruction
- Sexual Dysfunction
- Pressure Sores
- Psychological Problems

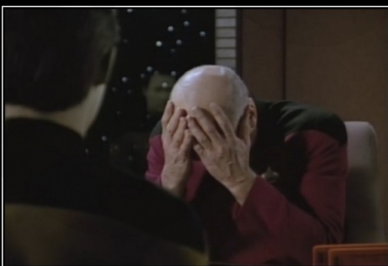
Outcomes Paralysis

- 25yr tetraplegic >60% normal life expectancy (level below C5)
- 25yr paraplegic >80% normal life expectancy
- 25yr partial paraplegic with mobility >85% normal life expectancy
- 90% of patients with complete tetraplegia will recover some level of function in the muscles below the neurologic level of injury
- MRC 1-2/5 at 30 days have 97% chance progressing to 3/5 at 1 year
- MRC 0/5 at 30 days only 57% recover to 1/5 and 27% to 3/5 at 1 year
- 80% of patients with incomplete paraplegia recover to grade 3/5 in their hip flexors and knee extensors at 1 year (enough to stand with aids)



Summary

- Remember ABCDE / ATLS
 - Treat life threatening injuries first
- Protect then Detect
- Think second injury



FACEPALM

When words fail to describe the dismay, there is always Facepalm.

