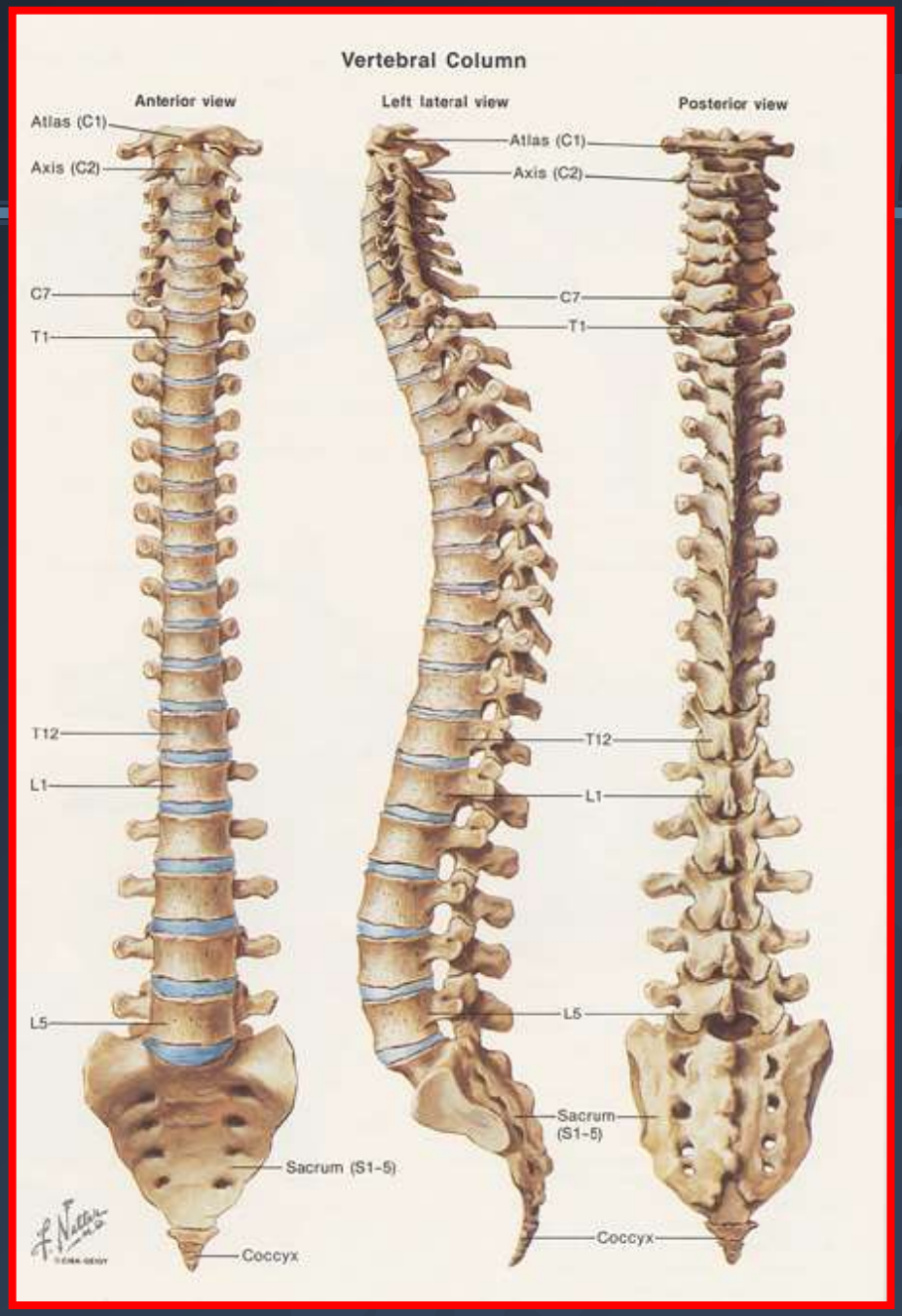
Spinal Cord Injury

Dr. Vetri


Vertebral Column
Anterior view
Left lateral view
Posterior view
Atlas (C1)
Axis (C2)
C7
T1
T12
L1
L5
Sacrum (S1–5)
Coccyx
Atlas (C1)
Axis (C2)
C7
T1
T12
L1
L5
Sacrum (S1–5)
Coccyx

General Principles of Spine Injuries

Epidemiology

- the fourth leading cause of death in the US
- C-spine injuries
  MVAs - 50%
  falls - 25%
  sports activities - 10%
- 60% of all spine injuries in children; upper cervical spine.
- C5-C6 is the most commonly injured level in adults.

Ranges of Motion (in degrees)

Level	Flexion/ Extension	Lateral Flexion	Rotation
O –C1	25	5	5
C1–C2	20	5	40
C2–C3	10	10	3
C3–C4	15	11	7
C4–C5	20	11	7
C5–C6	20	8	7
C6–C7	17	7	6
C7–T1	9	4	2

Stability

- *Definition*

1. The ability of the spine under physiologic loads to prevent displacements which would injure or irritate neural tissue.

2. Instability is the loss of the ability of the spine to tolerate physiological loading without incurring neurological deficit, pain, or progressive structural deficit.

Initial evaluation and treatment

- ABC's
- Stablization for transport
  - don't move patient before stabilization of cervical spine.
- In hospital
- Usual trauma protocol
- Traction
  - rule of thumb is 5 pounds per spinal level above the fracture/dislocation.
  - 60-80 pounds are usually the upper limit in any case.

Pharmacologic treatment of SCI

1. Hypertension
   adequate volume and normotension
2. Methylprednislone
   within 8 hours of the SCI protocol
   30mg/kg initial IV bolus over 15 minutes
   followed by a 45 minute pause,
   and then a 5.4 mg/kg/hr continuous infusion.
3. Naloxone
4. Triliazad

General Imaging Features and Determination of Instability

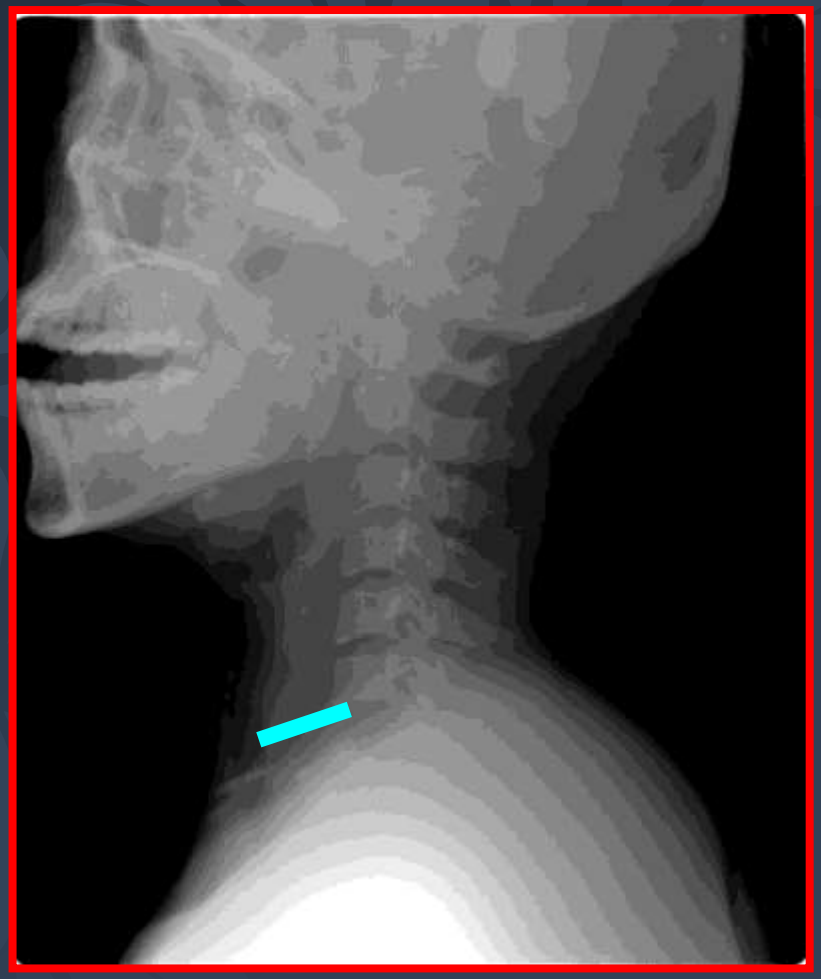
Plain Films

- AP, lateral, obliques
- open mouth
- Swimmer's view

Radiographic Criteria

Upper limits of prevertebral soft tissue

- level of C1: 10 mm
- level of C4: 7 mm
- level of C6-7: 20 mm



Inter-spinous process widening
(on AP radiographs)

More than 1.5 times the interspinous distance at the levels above and below is abnormal.

- C1-C2 distance between posterior cortex of C1 arch and odontoid is maximally 3 mm in adults and 4.5 mm in children.
- Normal spinal canal diameter is 17 ± 5 mm Stenosis is present if <13 mm.

- anterior subluxation of 3 mm of one body on another (or >20% of the AP distance) indicates instability.
- angulation greater than 11° is suggestive of instability.

Other Investigations

- flexion and extension views, tomograms
  CT, CT/myleogram, and MRI
- MRI essential for suspected spinal cord injury
  all soft tissues (disk and ligamentous structures) are shown in much better detail.

Injuries of the Upper Cervical Spine

Odontoid Anatomy

- Steele's rule of thirds

  The dens, subarachnoid space, and spinal cord each occupy 1/3 of the area of the canal at the level of the atlas.

Ligaments

External

1. posterior occipito-atlantal ligament (ligamentum flavum ends at C1).
2. anterior occipito-atlantal ligament.
3. ligamentum nuchae.
4. anterior longitudinal ligament.

Internal

1. cruciform ligament(transverse ligament)
2. accessory ligaments
3. apical ligament
4. alar ligaments
5. posterior longitudinal ligament
   (tectorial membane)

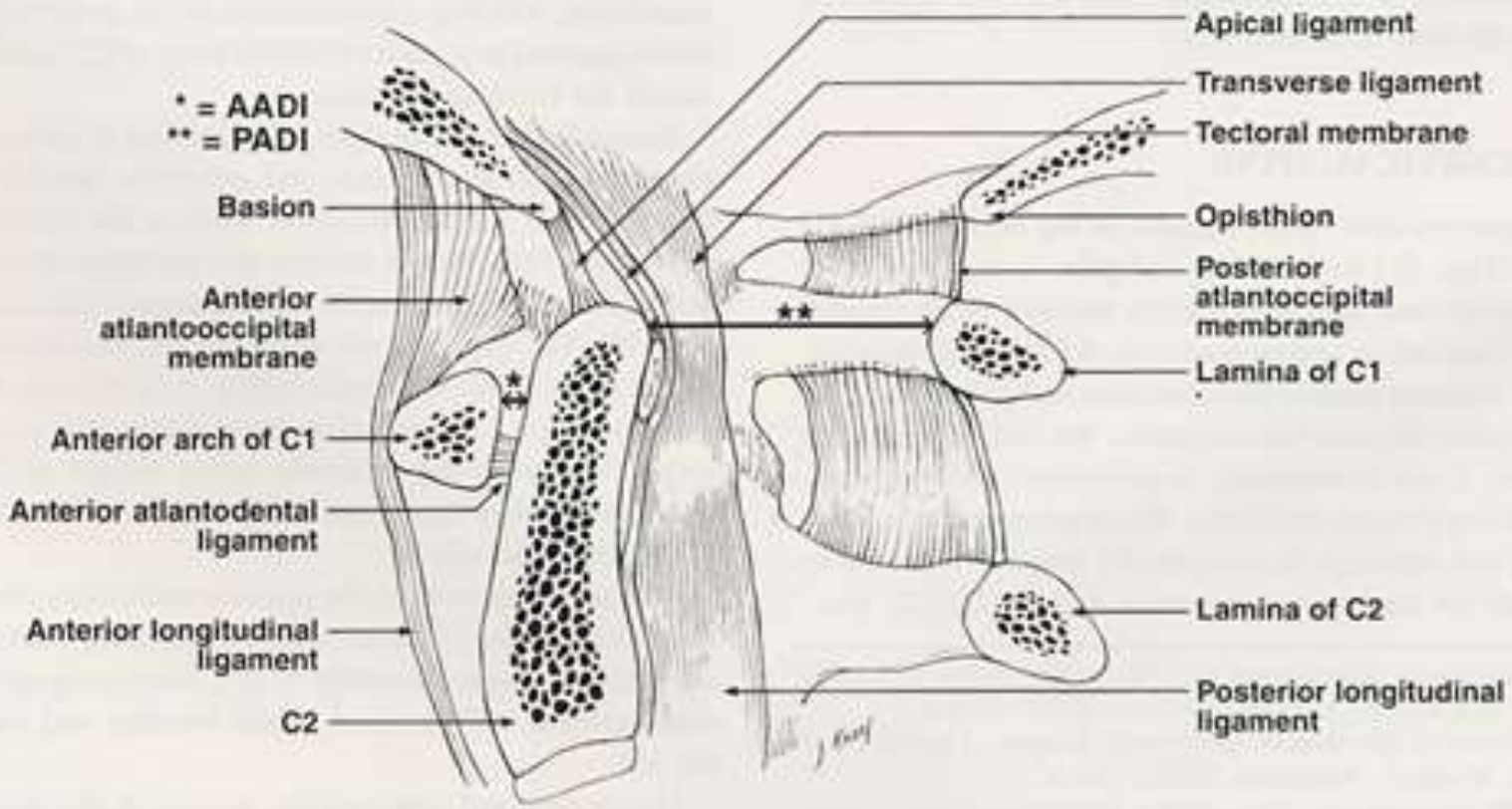


FIG. 3-2. Midsagittal section through the upper cervical spine.

Types of injuries

I. Atlanto-occipital dislocation.
II. Condylar fractures.
III. Atlanto-axial dislocation.
IV. Atlas fractures.
V. Odontoid fractures.
VI. Hangman's fractures.
VII. C3 fractures.

Atlas fractures

- cervicomedullary junction remains unchanged because of capacity of spinal canal.
- Jefferson's fracture

Clinical Features

- isolated C1 fractures rarely have associated cord injury.
- *symptoms*

  neck tenderness

  need neck support

  pharyngeal protuberance.

  dysphagia.

Imaging

- Spence's Rule

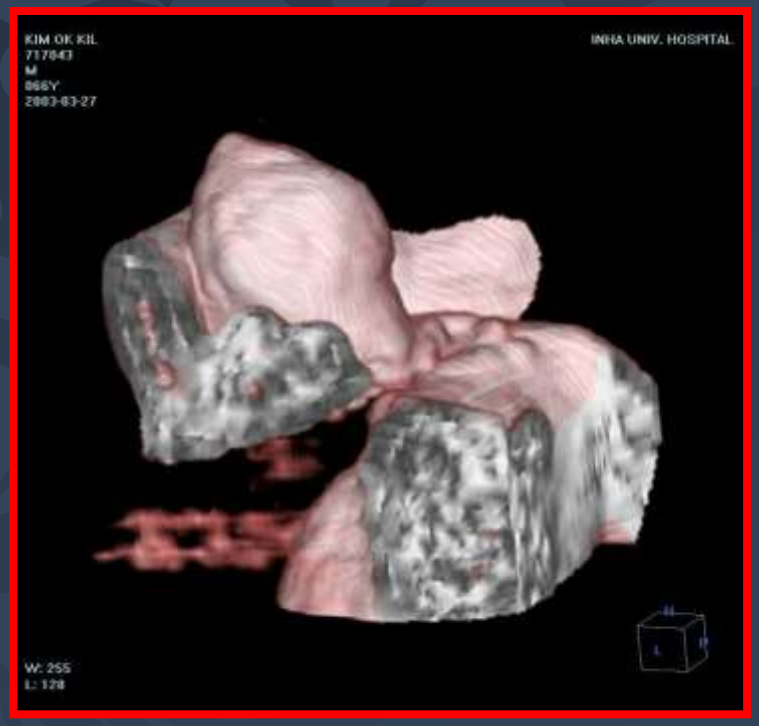
  If, on plain films, the distance of excursion of lateral masses is 7 mm or more, there is a transverse ligament rupture.

Treatment

- Halo immobilization in virtually all cases except when Spence's rule exceeded

Odontoid Fractures

- Odontoid fractures are the M/C fractures of C2.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Classification

Type I	An oblique fracture line through the upper part of the odontoid process representing an avulsion fracture where the alar ligaments attach. Stable, high rate of fusion.
Type II	A fracture at the junction between the odontoid process and the body of the axis. Unstable, high rate malunion.
Type IIA	Similar to type II but with fragments of bone present at the fracture site.
Type III	A fracture that extends down into the cacellous bone of the body of the axis and in reality is a fracture of the body of C2. Stable, with high rate of fusion.

Epidemiology

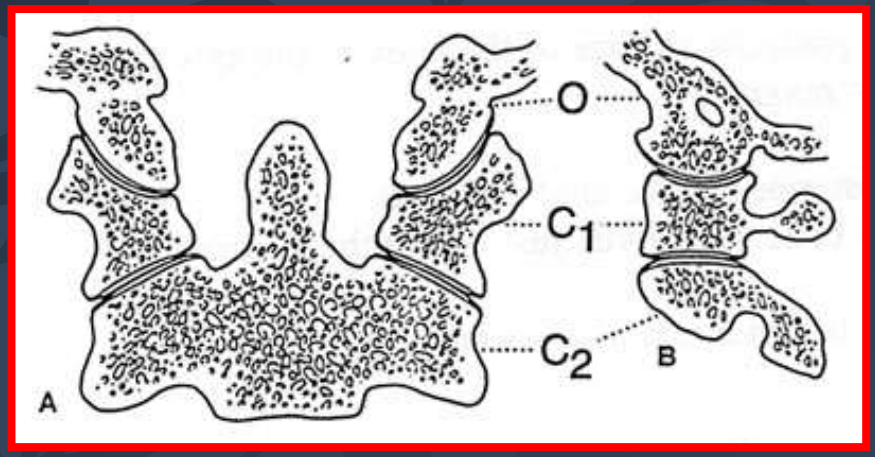
- about 10-15% of all cervical spine fractures.
- In children, these consitute about 75% of all C-spine injuries.

Clinical Features

- need high index of suspicion in all trauma patients
- many signs and symptoms are non-specific
- vertebral artery compression may cause brain stem ischemic symptoms.
- most patients unwilling to go from supine to sitting position without supporting their heads with their hands.

Imaging

- open mouth views
- tomography or CT
- saggital and coronal reconstructions have superseded tomography



Treatment and results

- Halo traction, maximum of 5-10 pounds to achieve reduction
- *Surgery*

  Type I : no fusion required

  Type III : no fusion required

  (>90% fuse with Halo immobilization)

  Type II : several factors important in decision making

1. Patient age.
   sixty years of age is the usually quoted cutoff for conservative management.
2. Displacement
   If >6 mm and >60 years, 85% nonunion rate.
3. Age of fracture
   greater than 2 weeks seems to be the cutoff for high union rate

Techniques for C1/C2 Fusion

- C1/C2 fusions can be considered even if there is a unilateral fracture of the atlas ring, or unilateral fracture of the lateral mass of the atlas.

Hangman's Fracture

- When submental knots with a measured corporal drop are used to hang someone, a classic hangman's C2 fracture is the result.
- Pathophysiology and Classification

  Hangman's fracture involves a bilateral arch fracture of C2 (pars interarticularis i.e, the pedicle) with variable C2 on C3 displacement.

Type	Description	Mechanism of Injury
Type I	Stable. Fractures through the pars with less than 2 mm displacement of C2 on C3.	Axial loading and then extension.
Type II	Unstable. Significant displacement of C2 on C3 (>2 mm or >118 angulation). Disruption of PLL.	Axial loading, extension, and then rebound flexion.
Type IIA	Less displaced but more angulated than II.	Same as II.
Type III	Pure flexion injuries. C2-C3 facet capsules are disrupted with angulation and anterolisthesis.	Compression and flexion.

Clinical Features

- not highly specific symptoms,
  diffuse neck pain with stiffness
- relative sparing of the spinal cord because of the capacious bony canal.

Treatment

- type I may be treated in a rigid collar for 12 weeks.
- remainder are all treated initially with Halo immobilization.
- up to 5% will eventually require surgery.

Surgical Indications

- inability to reduce fracture
- failure to maintain reduction in Halo vest.
- C2-3 disk herniation with spinal cord compromise.
- established non-union (late)

Surgical Procedures

1. C1-C3 arthrodesis
2. C2 pedicle screws.
3. C2-C3 anterior discectomy with fusion and plate.

Injuries of the Lower Cervical Spine

Classification

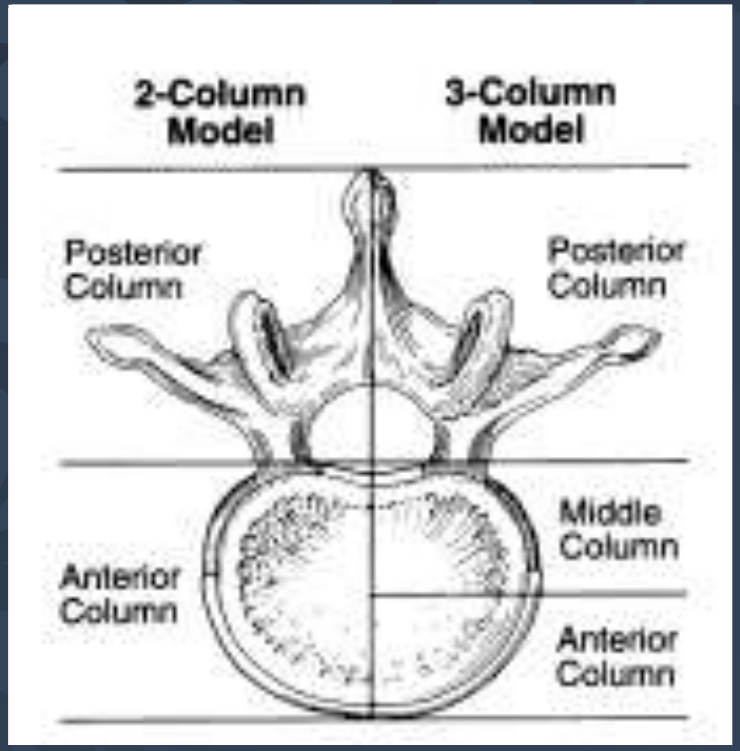
I. flexion-dislocation
II. flexion-compression
III. compression burst
IV. extension

Criteria for Instability

- White and Panjabi also concluded that horizontal motion between vertebrae should not exceed 2.7 mm (3.5 mm with standard X-ray magnification), and angular motion should not exceed 11 mm.

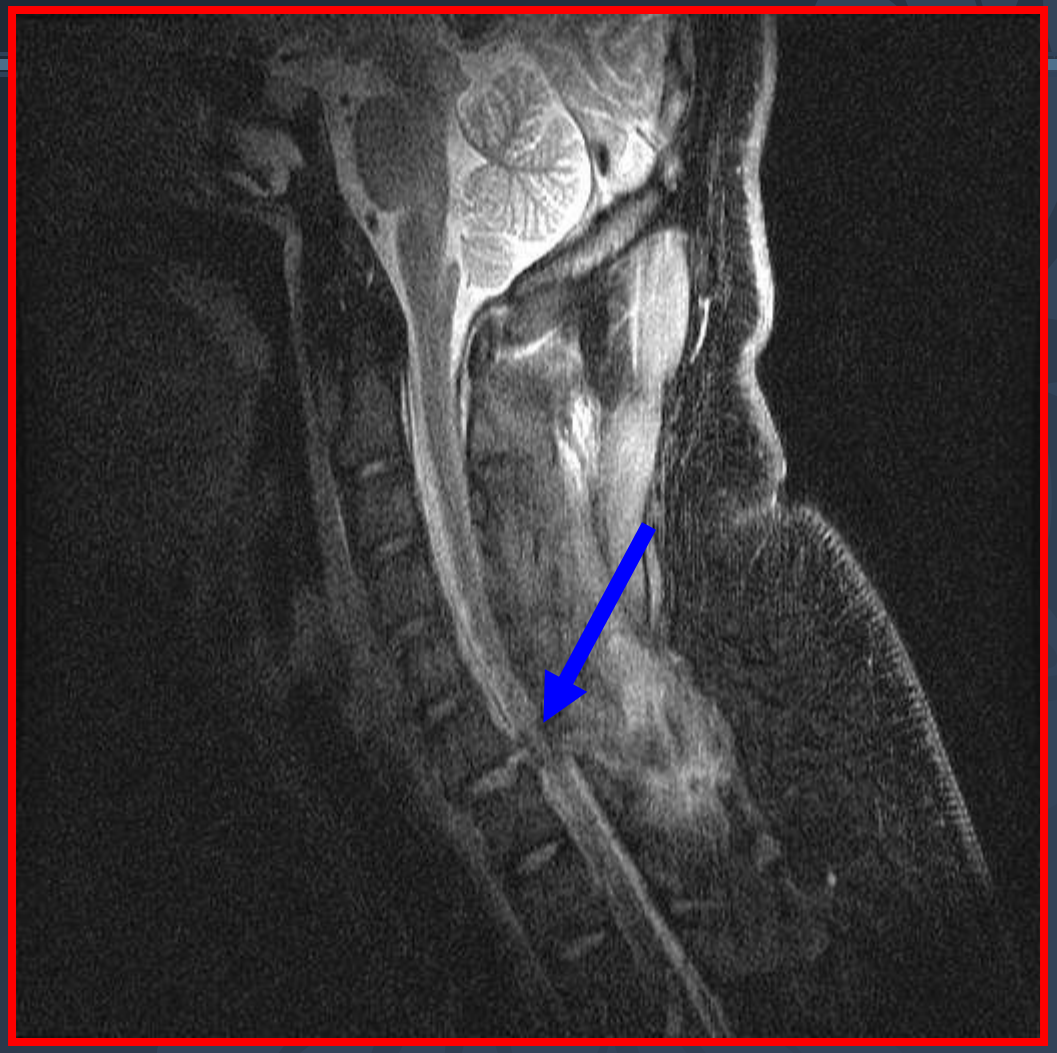
Three column model

- failure of 2 of the 3 columns implies that there will be instability.
- 1. anterior column
  2. middle column
  3. posterior column



Flexion Dislocation Injuries

A) unilateral facet subluxation
B) bilateral facet dislocation



Indications for surgery

1. failure to obtain reduction
2. failure to maintain reduction
3. pseudoarthrosis
4. purely ligamentous injury
5. re-subluxation
6. any patient with jumped facets

Flexion Compression Injuries

A) wedge compression
B) teardrop flexion fracture

Compression Burst Fractures

- characterized by axial loading injuries to a spine which is held in a neutral or very slightly flexed position.
- immobilized by traction with a Halo vest.

Extension Injuries

- may occur either in distraction or compression.

Surgical Considerations

- absolute Indications
  1. inability to obtain reduction
  2. inability to maintain reduction
- indications for emergent surgery
  1. progression of neurological deficit
  2. complete myelographic or MRI CSF block
  3. fragments in spinal canal in incomplete SCI
  4. necessity for decompressing a cervical nerve root
  5. open or penetrating trauma
  6. non-reducible fractures

Contraindications for emergent surgery

1. complete SCI
2. central cord syndrome.
3. medically unstable patient.

Surgical techniques

- posterior approaches
- anterior approaches
- cervical orthoses

Thoracolumbar Spine Fractures

Epidemiology

- represent 40% of all spine fractures
- majority due to motor vehicle accidents.
- grouped into
  - thoracic (T1–T10)
  - thoracolumbar (T11–L1)
  - lumbar fractures (L2–L5)
- 60% occur between T12 and L2

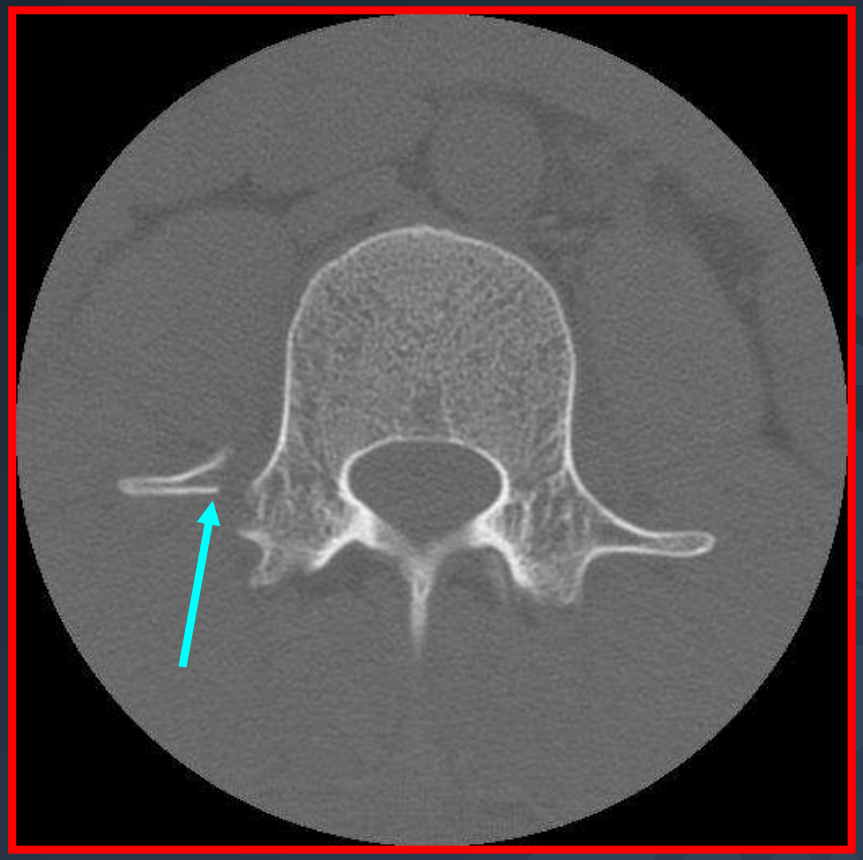
Biomechanics

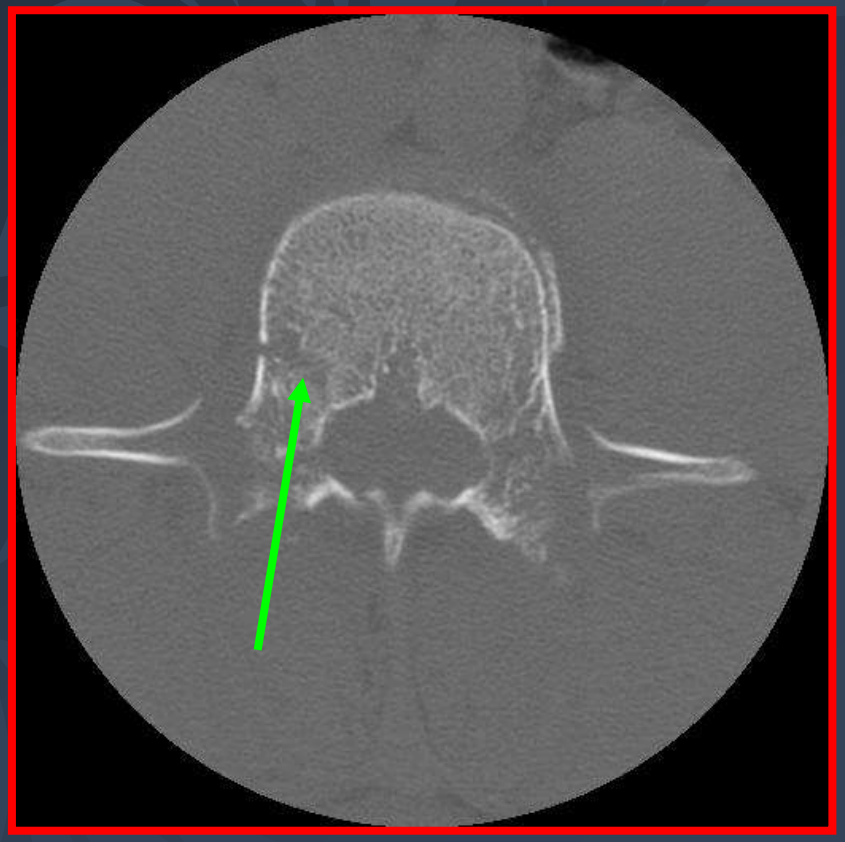
- In general, **compression** causes **burst** fractures, **flexion** causes **wedge** fractures, **rotation** causes **fracture dislocations**, and **shear** causes **seatbelt type** fractures.

- thoracic region is inherently more stable because of the rib cage and ligaments linking the ribs and spine.
- the three column model states that failure of two or more columns results in instability.
- the middle column is crucial, its mode of failure distinguishes the four types of spine fractures.

Imaging

- most important initial study is a complete plain film series of the spine.
- 5-20% of fractures are multiple.
- CT is used to define the bony anatomy in the injured area.
- MRI essential to define spinal cord anatomy and also for assessing ligamentous injury.





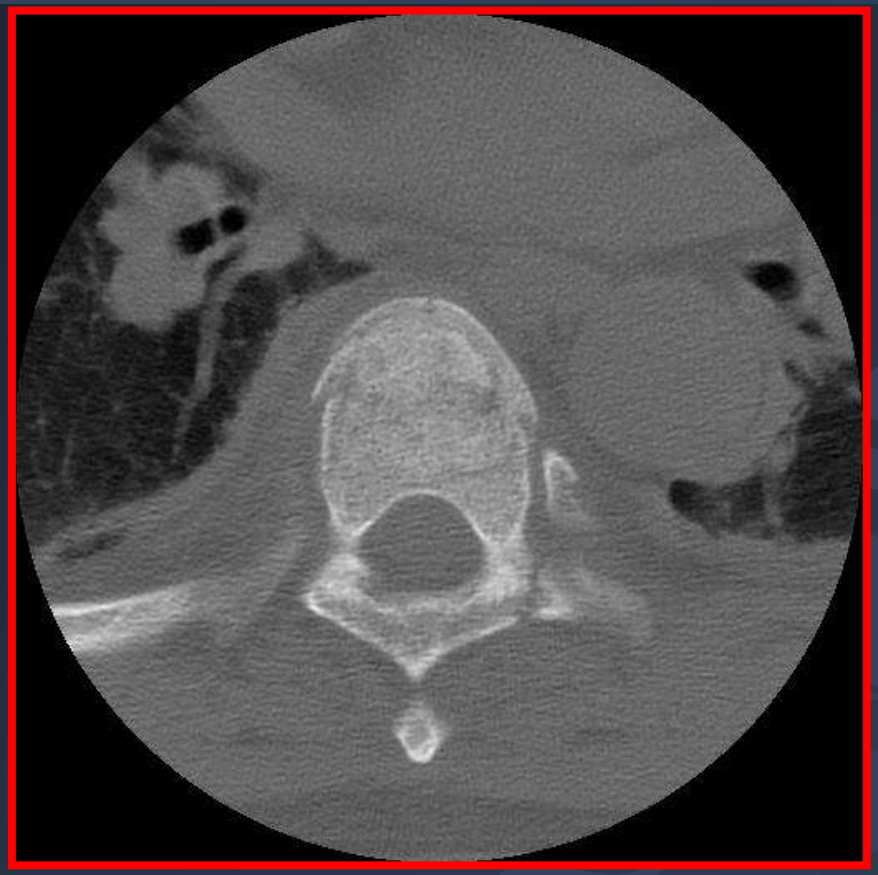
Flexion Compression Fractures

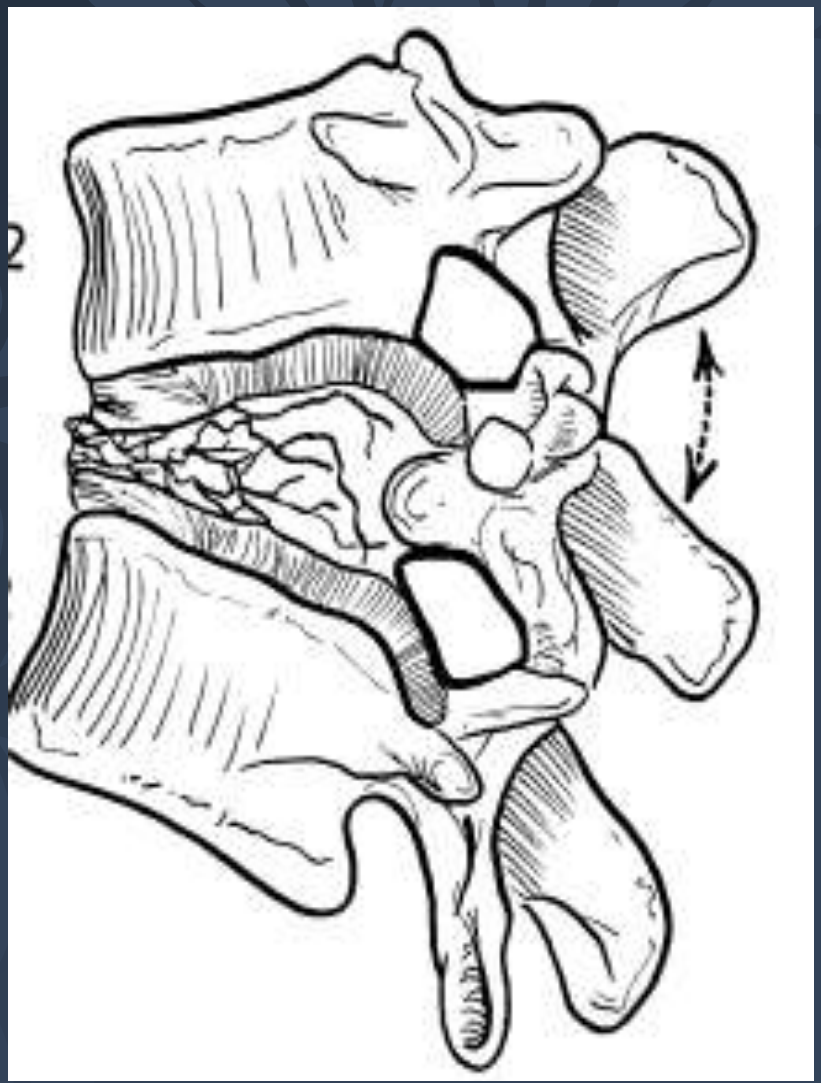
- most common type of fracture.
- failure of the anterior column due to flexion and compression.
- a minimum of 30% loss of ventral height is necessary to appreciate a kyphotic deformity on x-rays.

- generally considered stable.
- usually managed with
  - bedrest
  - analgesics
  - early mobilization

Burst Fractures

- 17% of major spinal fractures
- between T1–T10, most burst fractures are associated with complete neurological deficit.
- bony fragments may be retropulsed into the canal (25% of cases) and associated fractures of the posterior elements are common.
- failure of anterior and middle column defines these as unstable.

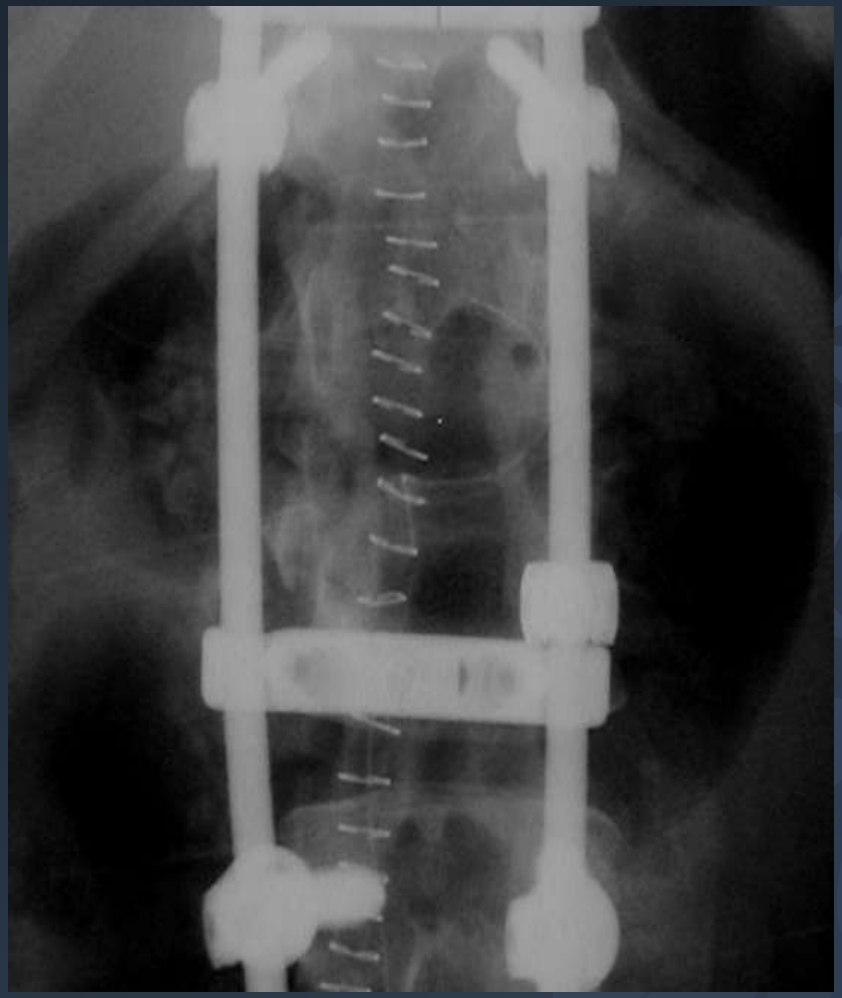


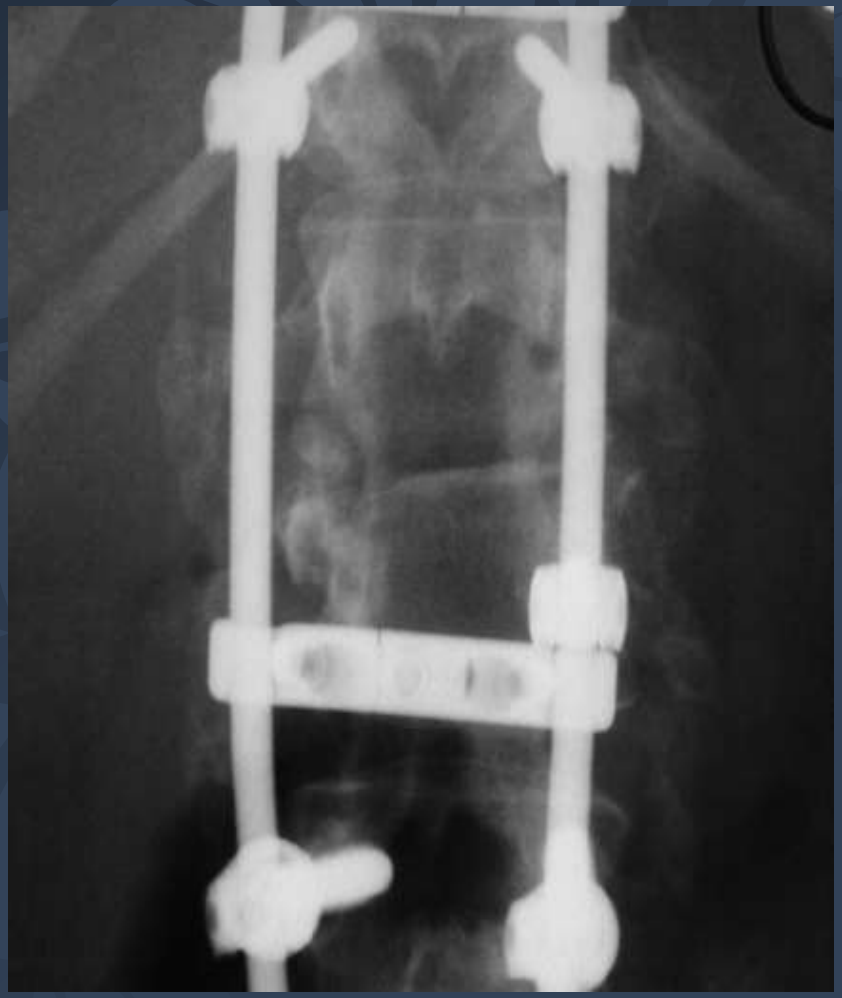


Management

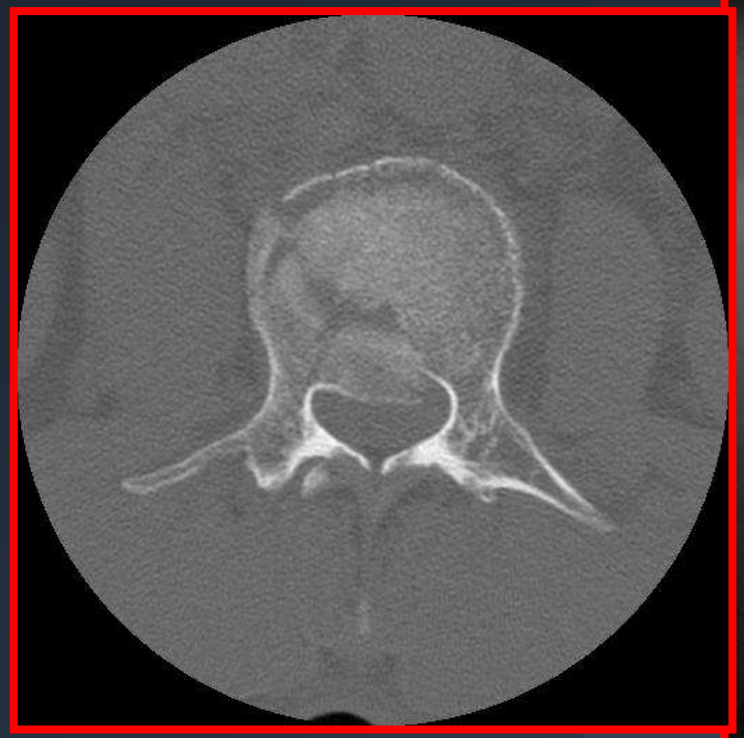
- those fractures with canal compromise in the presence of neurological deficit should be treated with surgical decompression and fusion.

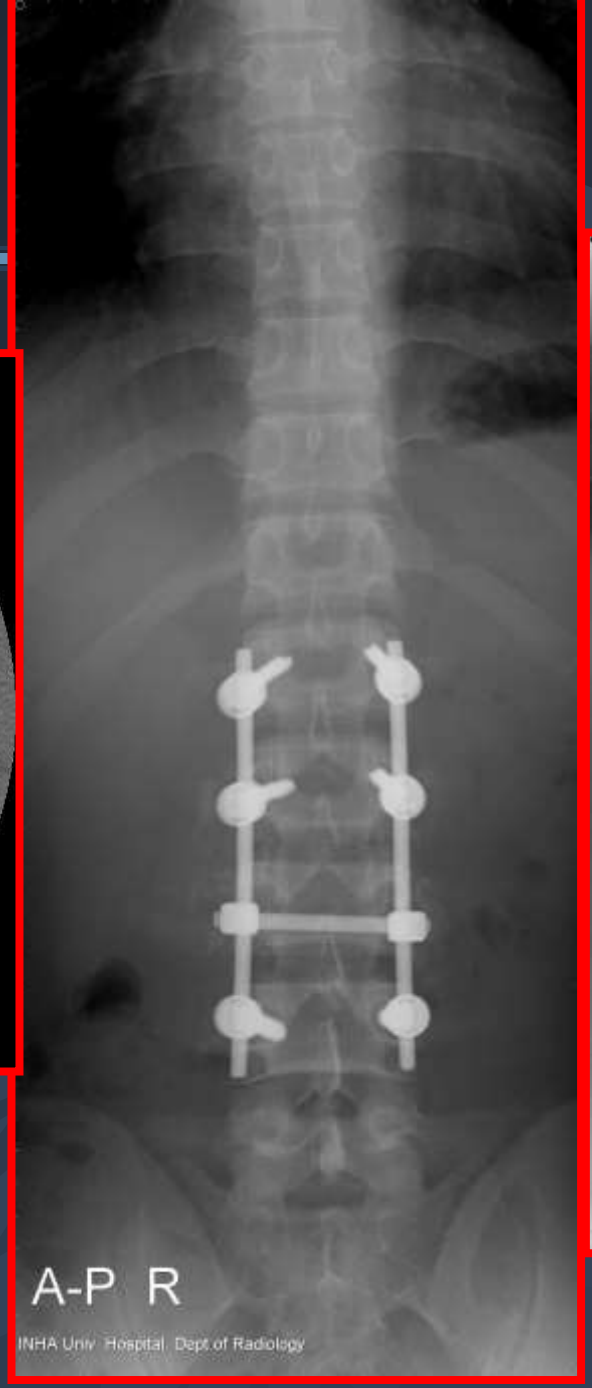
- the treatment of burst fractures with canal compromise and no neurological deficit is controversial.
- generally, management is based upon determination of stability.
- those fractures with >50% loss of vertebral body height, or if the posterior column injury includes a facet fracture or dislocation are considered unstable.





- commonly sited indications for surgery are either,
  - i) angular deformity >15-40 degrees
  - ii) canal compromise >40-70%

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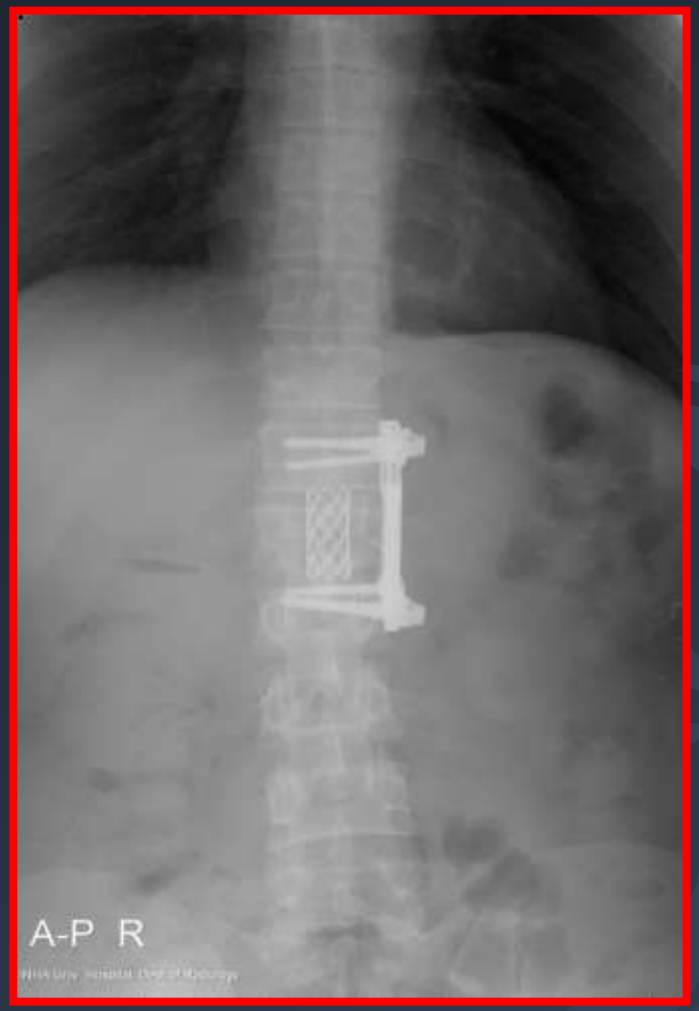
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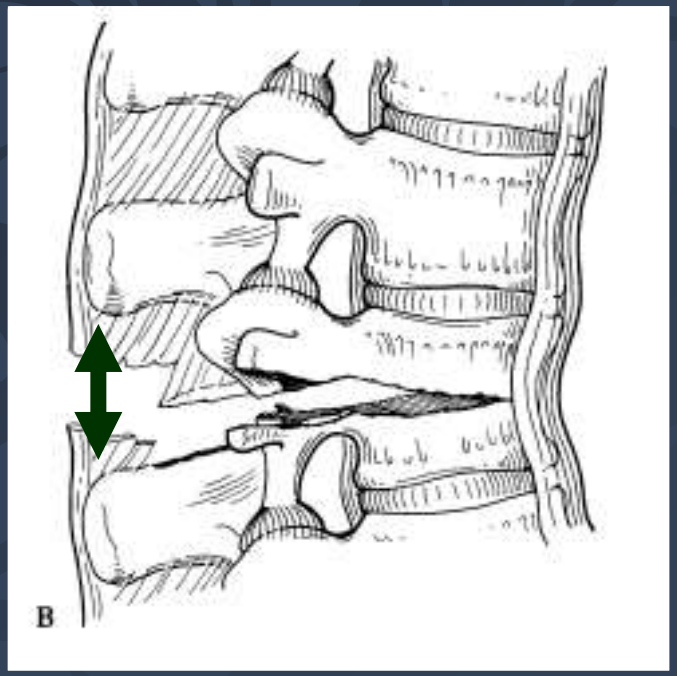
Seat Belt Injuries

- 6% of major spinal injuries.
- caused by hyperflexion and distraction of the posterior elements.



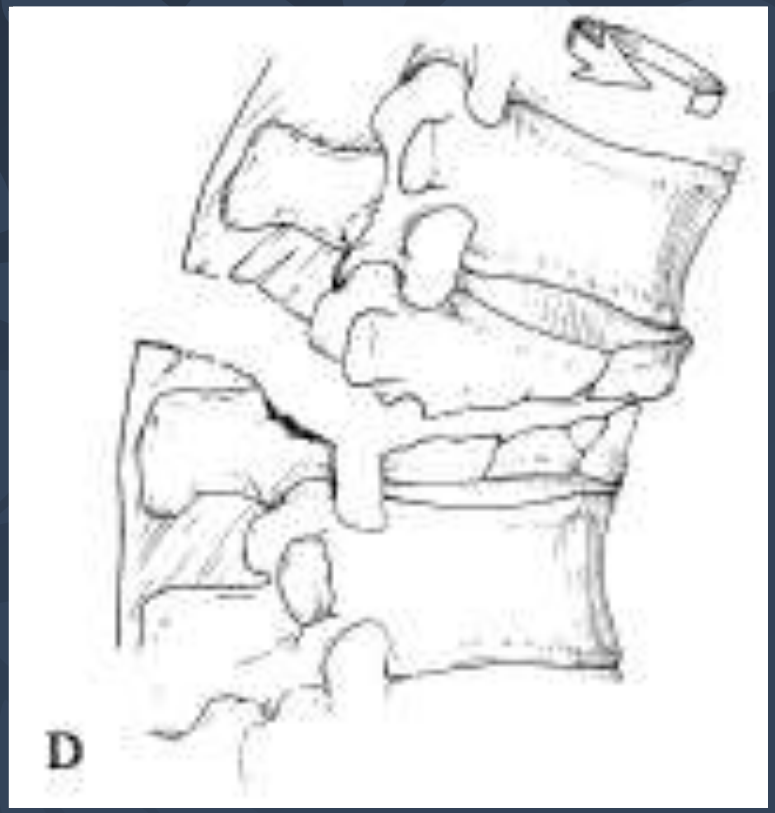
- the middle and posterior columns fail in distraction with an intact anterior hinge.
- unstable in flexion but will not present with an anterior subluxation, which would indicate that the ALL is disrupted (i.e. a fracture–dislocation).
- PLL is also intact and sometimes fracture fragments are moved back from the canal simply by distraction.

Management

- treatment of mainly osseous injuries is bracing while mainly ligamentous injuries are treated with posterior fusion.

Fracture Dislocations

- 19% of major spinal fractures.
- anterior and cranial displacement of the superior vertebral body with failure of all three columns.



Extension Distraction Fractures

- rare injuries.
- hyperextension force tears the ALL and leads to separation of the disc.
- all are unstable and require fixation.

Treatment

- By Degree

  according to Denis, first degree is mechanical instability, second degree is neurolgical, and third is both.

- first degree: manage with external orthosis
  - i) >30 degree wedge compression fracture
  - ii) Seat belt injuries.
- second degree: mixed category
- third degree: all require surgery
  - i) fracture dislocations
  - ii) burst fractures who fail non-operative management
  - iii) burst fractures who develop new neurological deficit

Non-operative Therapy

- external orthosis for 8-12 weeks

  serial radiographs every 2-3 weeks for the first 3 months, then 4-6 week intervals until 6 months and at 3 month intervals for 1 year.

Indications for operative therapy

1. progressive neurological deficit
2. spinal cord compression
3. dural laceration
4. unstable spine

Spinal Shock

Definition

- loss of all cord function distal to the site of injury (motor, sensory, sympathetic).

Etiology

1. trauma
2. vascular
3. infection

Pathophysiology

- sudden loss of descending, tonic input from the rubrospinal, vestibulospinal and the corticospinal tracts.

Natural history

- can last days, weeks, or occasionally months.
- there is loss of facilitatory inputs which gradually return via sprouting, membrane hyperexcitability, and residual connections.
- the stretch reflexes begin to return (flexors in the upper extremities and extensors in the lower extremities).

4. return of bulbocavernosus reflex heralds time course out of spinal shock.
5. mass reflexes return with cutaneous stimuli, or bladder distension and include spasms, colon and bladder evacuation, hypertension, profuse sweating.
6. return of sacral reflex for bladder and bowel.

Treatment

1. maintain adequate intravascular volume
2. maintain blood pressure (spinal cord arterial pressure).
3. keep bladder well decompressed; attend to bowel routine.
4. surgical stabilization if indicated or surgical decompression.

– The End –