

Subaxial Cervical Spine Trauma

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Learning Objectives

- Evaluation of subaxial cervical spine trauma
- Classification of subaxial cervical spine trauma
- Nonoperative management of subaxial cervical spine injuries
- Operative treatment strategies of subaxial cervical spine injuries



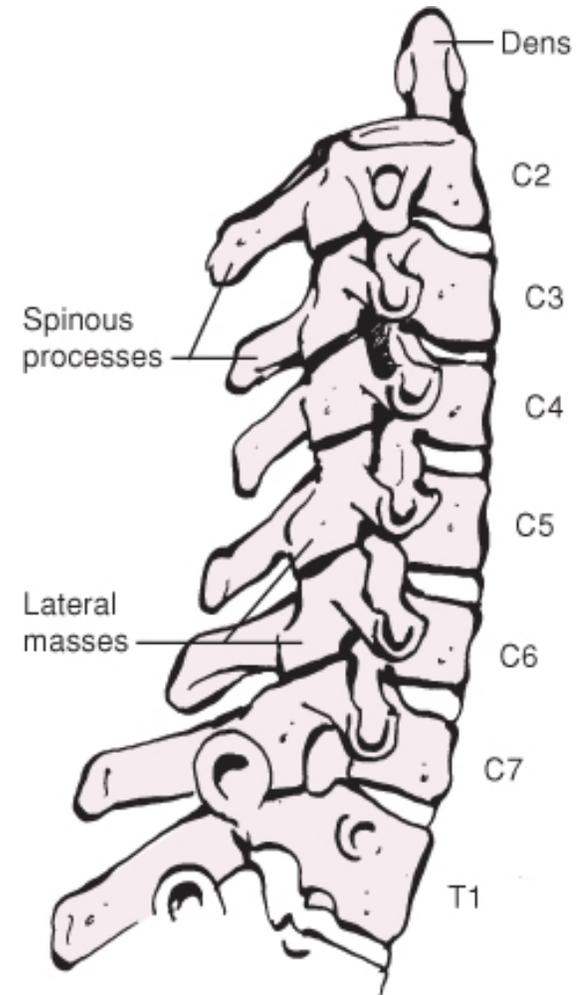
Epidemiology

- 2% - 5% of all trauma admissions in the US will be diagnosed with a cervical fracture
- ***Subaxial spine injuries represent 65% of fractures and 75% of all dislocations of cervical spine***
- C7 Fracture or C7-T1 dislocation accounted for ~17% of all Cervical injuries
- SCI occurring in ~12,000 people per year in the US. treatment strategies of subaxial injuries



Anatomy

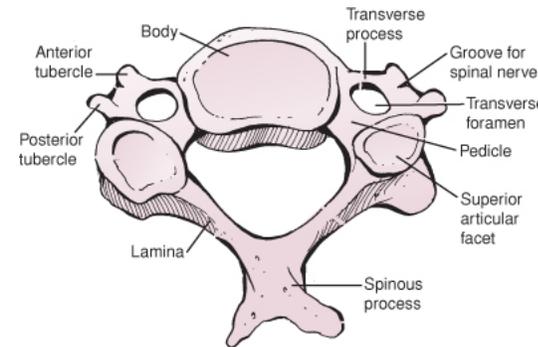
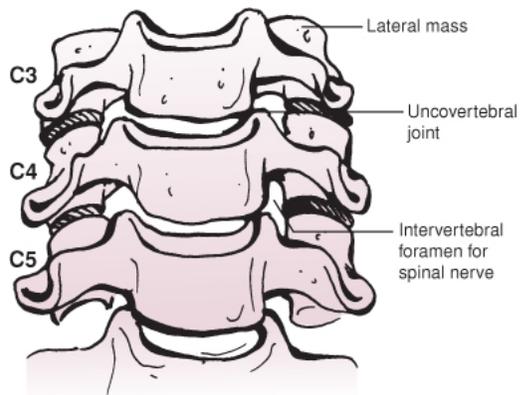
- C3-7 vertebrae represent the subaxial cervical spine
- C7 lateral mass is thin and small
- The facet joint capsules are the strongest anatomic structure posteriorly
- The Anterior Longitudinal Ligament is strongest structure anteriorly
- The spinous process of C3-C5 is always bifid, C6 may be bifid and C7 is never bifid





Anatomy

- The superior facet is located behind the neuroforamen.
- Superior cortical surface is concave in the coronal plane and convex in the sagittal plane.
- The lateral aspect of the vertebral body has a superior projection (uncinate process)
- Spinal cord A-P diameter is about 8 mm



uncinate processes



Vertebral Artery Anatomy

- V1: Preforaminal (Origin to Foramen)
- V2: Foraminal (Enters at C6 in 95% of population)
- V3: C2 to skull base (extradural)
- V4: Skull base (intradural with formation of basilar artery to brainstem)

Initial Evaluation

- Airway
- Breathing
- Circulation

- Cervical spine precautions:
 - Stabilize and immobilize neck
 - Nasal or fiber optic intubation if required



Physical Exam

- Palpation
 - Neck pain
 - 84% of patients with cervical fractures have midline pain
 - Crepitus
 - Interspinous step off
- Range of motion
 - Locked rotation
- Detailed neurologic examination including rectal

Radiographic Evaluation

- 3 views (AP-Lat & open mouth) +/- Swimmers view
- Sensitivity 35-53% specificity 97%
- With flex-ex views increases to 99% and 97% - however not typically utilized in the acute trauma situation and does not rule out injury



Radiographic Evaluation

- Lateral C-spine XR to include Occiput to C7-T1
- Bony anatomy and evaluation of soft tissues for prevertebral swelling



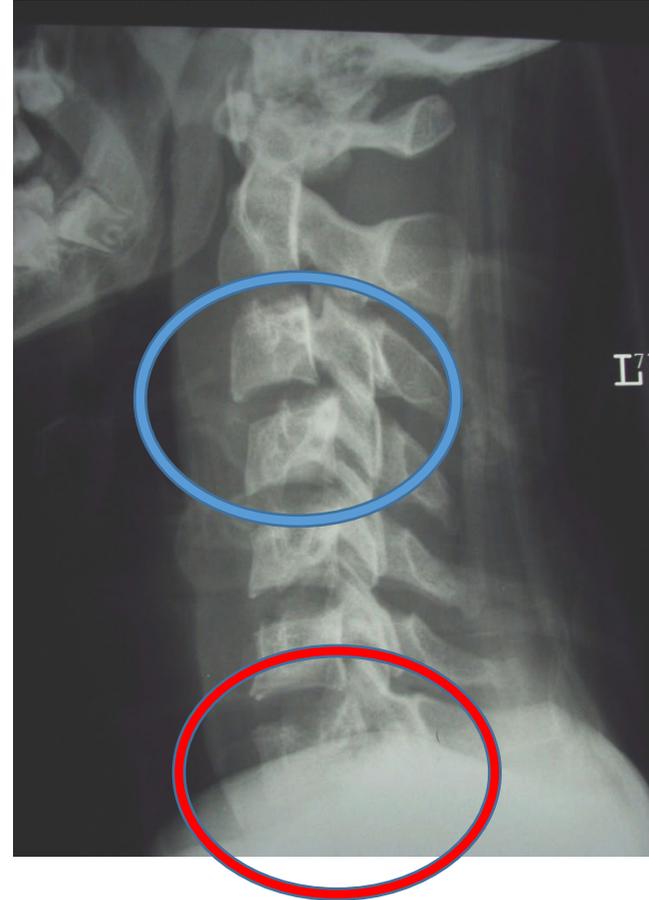
Radiographic Evaluation

- Cross table lateral
 - Must include C7-T1 (5% of C-spine injuries)
- Three view trauma series
- Flexion/Extension
 - Not performed in acute setting, replaced by CT
 - Rarely used- in cooperative alert patient with pain and negative 3 view
 - Negative study does not rule out injury
 - If painful, keep immobilized, reevaluate

Missed Injuries

The presence of a single spine fracture does not preclude the inspection of the rest of the spine

Must evaluate noncontiguous spine injuries which are present up to 30%



Radiographic Evaluation

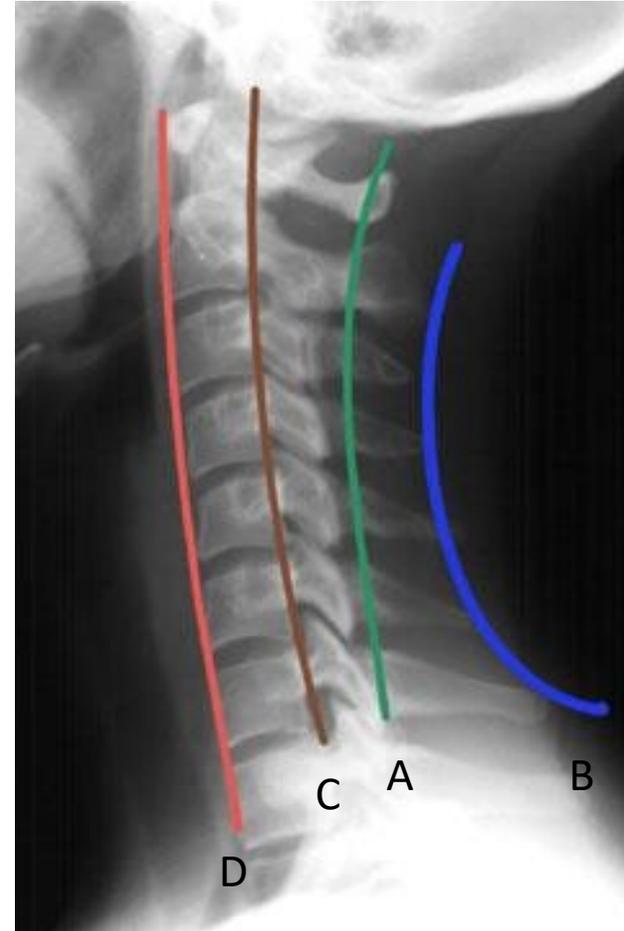
Congruency of lines:

A: Spinolaminar line

B: Posterior spinous line

C: Posterior vertebral bodyline

D: Anterior vertebral body line



Radiographic Evaluation

Congruency of lines:

Facet joints (yellow circle)

Lateral mass (red triangle)

Lamina (orange Square)

Spinous process
(white Diamond)

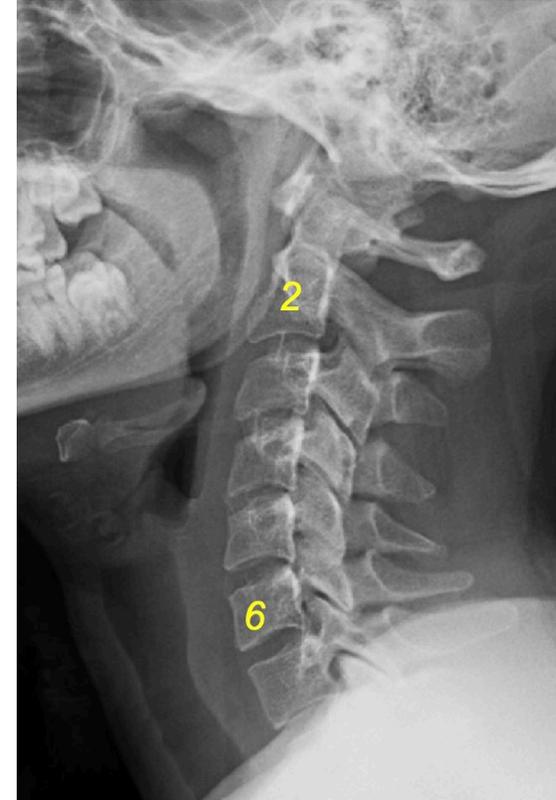


Radiographic Evaluation

Soft tissue evaluation:

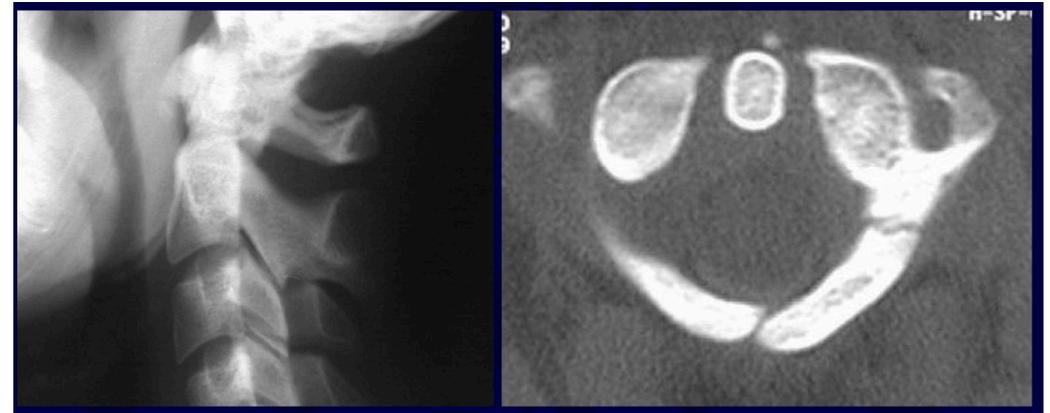
Maximum shadow accepted:

- 6mm at C2
- 2cm at C6
- “6 at 2 and 2 at 6”



CT C Spine Evaluation

- Screening CT C spine has replaced cervical radiographs series at most Level 1 trauma centers
- Increased accuracy identifying :
 - Subtle cervical fractures
 - Facet subluxations and dislocations
 - Occiput – C2 injuries
 - C7-T1
 - Can be difficult to visualize the cervicothoracic junction on plain films





CTA C Spine Evaluation

- CTA neck evaluate carotid or vertebral injuries
 - Vertebral artery (VA) injury and Blunt Carotid Injury (BCI) together make up blunt cerebrovascular injury (BCVI)
 - Partial or complete occlusion, pseudoaneurysm, dissection, intimal flaps, and traumatic arteriovenous (AV) fistulas
- Less than 5% of CTA diagnose vertebral artery (VA) injury
 - VA injury: patients more likely to have subjective neck pain, (67% vs 21%), and positive finding on physical examination of the cervical spine: laceration, step-off, subluxation, crepitus, tenderness to palpation (100% vs 29%)

MR C Spine

- Mandatory if neuro deficit
- Highly consider if operative treatment of C spine injury is anticipated
- Increased accuracy identifying cervical fractures and subluxations



MR C Spine

- MRI C spine evaluation for:
 - Spinal cord integrity
 - Space available for cord
 - Disc herniation
 - May influence decision to perform anterior vs posterior vs combined approach
 - Posterior ligamentous injuries



Classifications

Multiple classification systems:

- Harris et al OCNA 1987
- Anderson Skeletal Trauma 1998
- Stauffer and MacMillan Fractures 1996
- Allen and Ferguson 1982
- AO /OTA
- Sub-axial Cervical Spine Injury Classification (SLIC) 2007
- AOSpine subaxial cervical spine injury classification system 2015



Allen and Ferguson

- Mechanistic, based on radiographic evaluation
- Categories:
 - Compressive flexion
 - Vertical compression
 - Distractive flexion
 - Compression extension
 - Distractive extension
 - Lateral flexion
- No guidance on clinical treatment of patient

Sub-axial Cervical Spine Injury Classification (SLIC)

Three major components:

- Injury morphology
 - Compression
 - Distraction
 - Translation/rotation
- Discoligamentous status
- Neurologic status

Sub-axial Cervical Spine Injury Classification (SLIC)

Injury Morphology	Points	DLC status	Points	Neuro status	Points
Compression Burst	1 1	Intact	0	Intact	0
Distraction	3	Intermediate	1	Nerve root Deficit	1
Translation/ Rotation	4	Disrupted	2	Complete Cord injury	2
Total	Max 4	Total	Max 2	Incomplete Cord Injury	3
				Add-on: Persistent compression or stenosis with deficit	1
				Total	Max 4

Sub-axial Cervical Spine Injury Classification (SLIC)

Recommended treatment based on points

- Score > 4 \rightarrow Operative
- Score < 4 \rightarrow Nonoperative
- Score $= 4$ \rightarrow Surgeons discretion

Determined by concomitant injury, comorbidities,
presence of neurologic deficit

AOSpine subaxial cervical spine injury classification system

Type	Description
A0	Minor, nonstructural fractures No bony injury or minor injury such as an isolated lamina fracture or spinous process fracture.
A1	Wedge-compression Compression fracture involving a single endplate without involvement of the posterior wall of the vertebral body.
A2	Split Coronal split or pincer fracture involving both endplates without involvement of the posterior wall of the vertebral body.
A3	Incomplete burst Burst fracture involving a single endplate with involvement of the posterior vertebral wall.
A4	Complete burst Burst fracture or sagittal split involving both endplates.

Type	Description
B1	Posterior tension band injury (bony) Physical separation through fractured bony structures only.
B2	Posterior tension band injury (bony capsuloligamentous, ligamentous) Complete disruption of the posterior capsuloligamentous or bony capsuloligamentous structures together with a vertebral body, disk, and/or facet injury.
B3	Anterior tension band injury Physical disruption or separation of the anterior structures (bone/disk) with tethering of the posterior elements.

Type	Description
C	Translational injury in any axis-displacement or translation of one vertebral body relative to another in any direction

Type	Description
BL	Bilateral injury

Type	Description
F1	Nondisplaced facet fracture With fragment <1 cm in height, <40% of lateral mass.
F2	Facet fracture with potential for instability With fragment >1 cm, > than 40% lateral mass, or displaced.
F3	Floating lateral mass
F4	Pathologic subluxation or perched/ dislocated facet



AOSpine subaxial cervical spine injury classification system

- Neurologic status at the moment of admission should be scored according to the following scheme:

Type	Description
N0	Neurologically intact
N1	Transient neurologic deficit, resolved
N2	Radiculopathy
N3	Incomplete spinal cord injury
N4	Complete spinal cord injury
NX	Cannot be examined

AOSpine subaxial cervical spine injury classification system

Case-specific modifiers

- There are four modifiers, which can be used in addition to ad 1 and 2:

Type	Description
M1	Posterior capsuloligamentous complex injury without complete disruption
M2	Critical disk herniation
M3	Stiffening/metabolic bone disease (ie.: DISH, AS, OPLL, OLF)
M4	Vertebral artery abnormality

AOSpine subaxial cervical spine injury classification system

Classification nomenclature

- Injuries are first classified by their level and primary injury type, either C, B, or A. If there are multiple levels, the most severe level is classified first. The secondary injuries are parenthesized.

For example, a C6-C7 translational injury (C) with a C7 compression fracture (A1) would be classified as:

C6-C7:C
(C7:A1)

And a C5-C6 flexion distraction injury (B2) with a C6 compression fracture (A1) would be classified as:

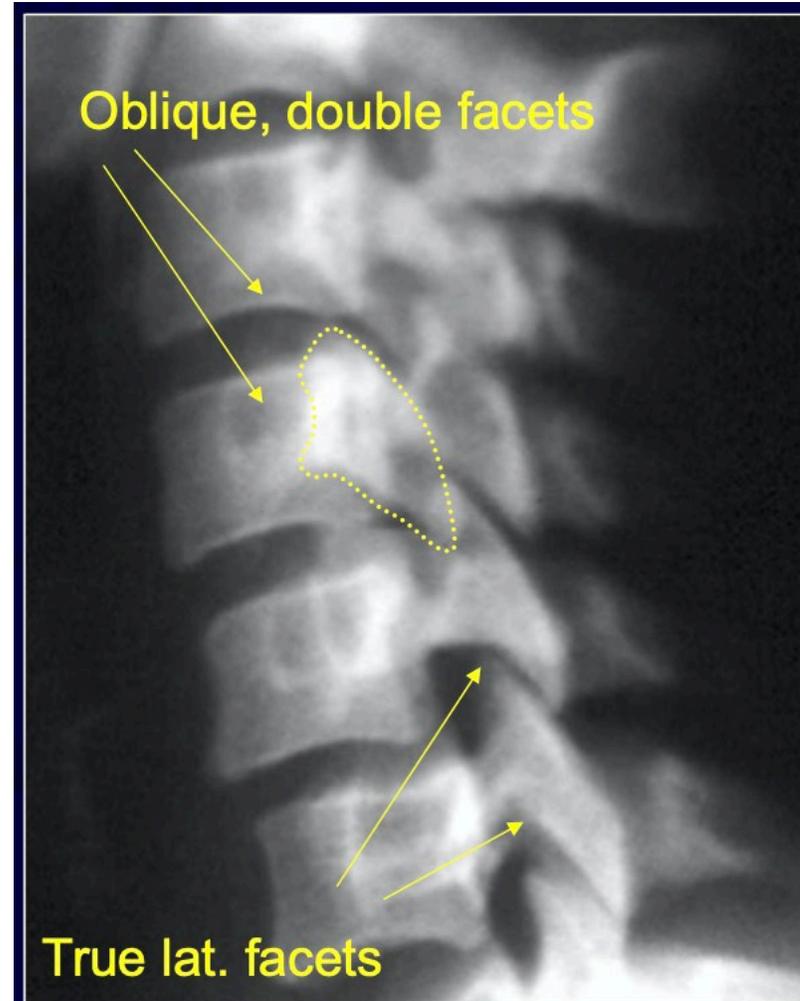
C5-C6:B2
(C6:A1)

Facet Fractures

- Stability depends on:
 - Unilateral versus bilateral
 - Disco-ligamentous and PLC integrity
 - Size and character of the fracture fragments
- Rotationally unstable injuries
- Most commonly involve superior articular process
- Floating lateral mass may occur
 - more unstable injury compared to facet fracture
 - injury of ipsilateral pedicle and lamina
- May cause neurological deficit (exiting nerve root)

Unilateral Facet Dislocations Fractures

- Flexion/distraction, rotational injuries
- 70% associated with radiculopathy
- 30% associated with SCI
- Supine imaging may show reduced facets
- 'Bow tie' sign- both facets visualized, not visualized
- May see a spondylolisthesis of up to 25%



Unilateral Facet Dislocations Fractures

- “Empty Facet Sign” on CT scan
- Rotated vertebra, with 2 segments seen on one axial CT image



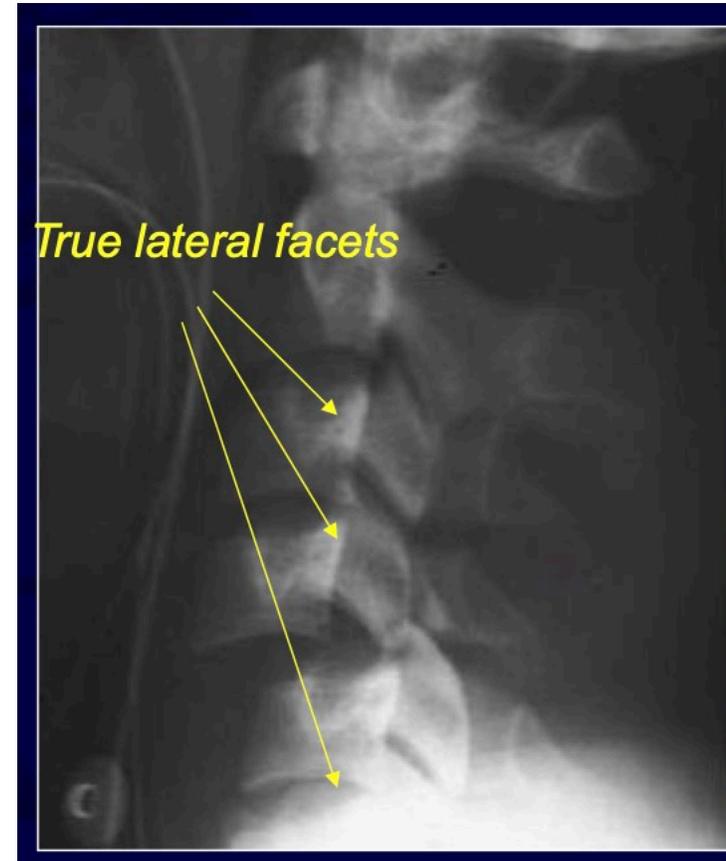
Traumatic Disc Herniation

- Reduction may push herniated disc into spinal canal
- Total discectomy via anterior surgical approach is safest prior to reduction attempt



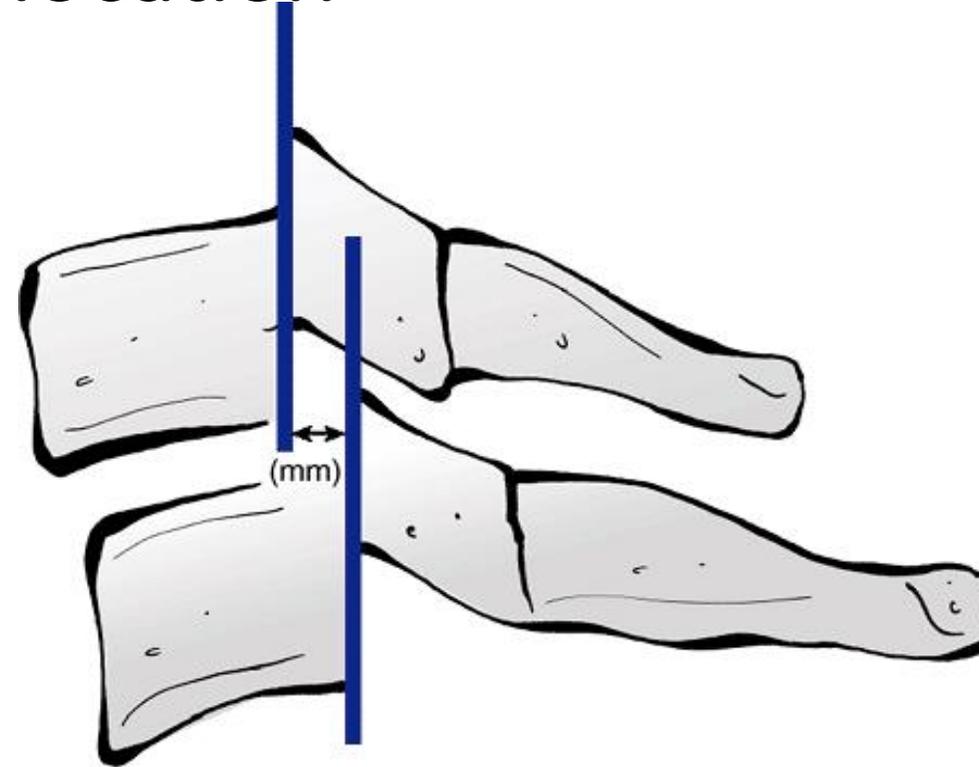
Bilateral Facet Dislocation

- Vertebral body displaced **at least 50%**
- SCI common
- 10-40% incidence of herniated disk into canal
- Unstable injuries, requiring surgical stabilization for definitive management





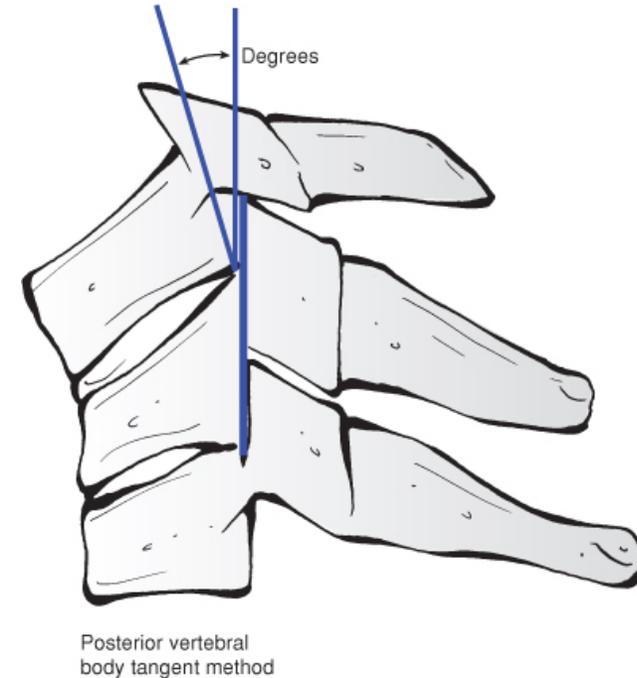
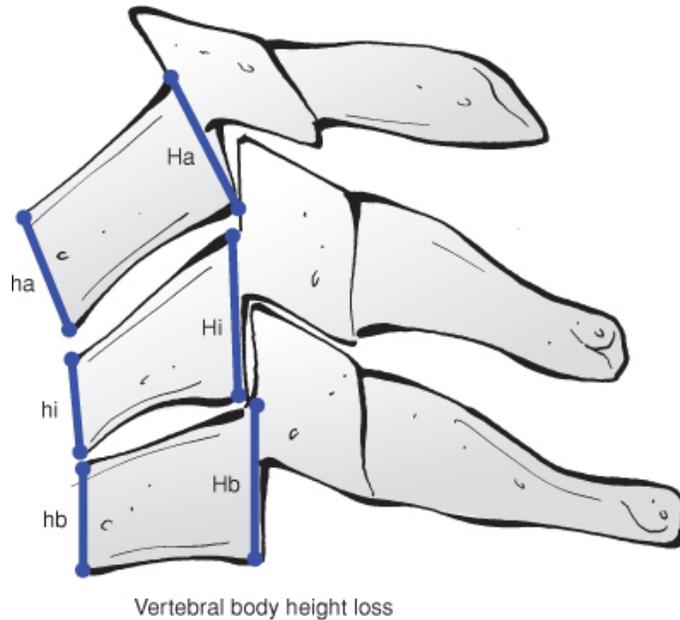
Bilateral Facet Dislocation



Vertebral body translation

Translation more than **3.5 mm** indicates instability

Sagittal Plane Alignment



Kyphosis more than **11 degrees** suggest posterior ligamentous injury and instability (25 deg. in flexion/extension views)

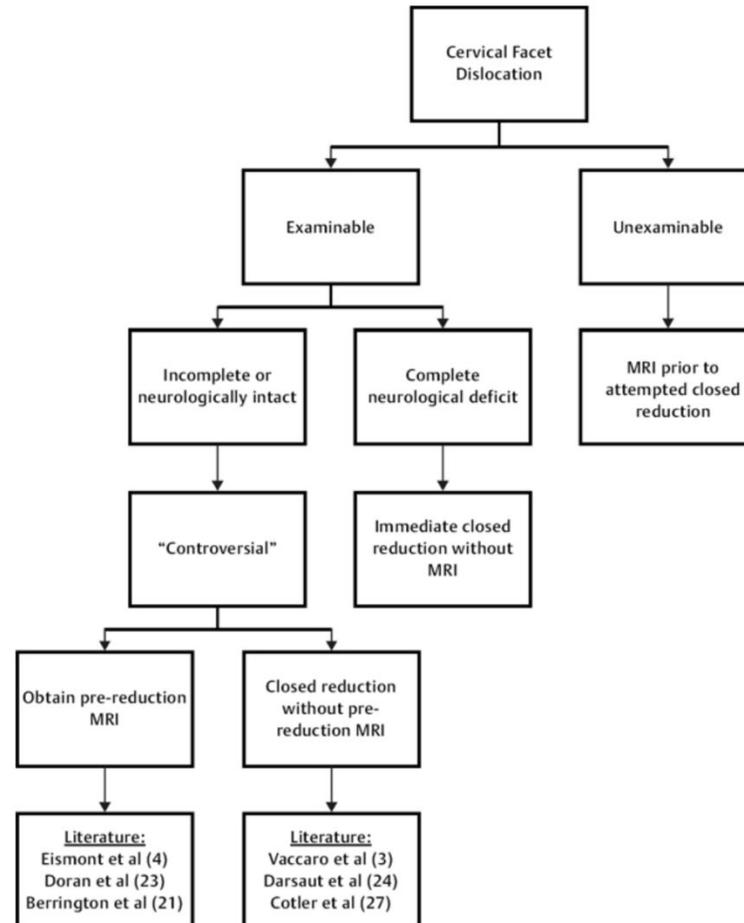
Dynamic imaging evaluated in subacute setting more often than at time of acute injury

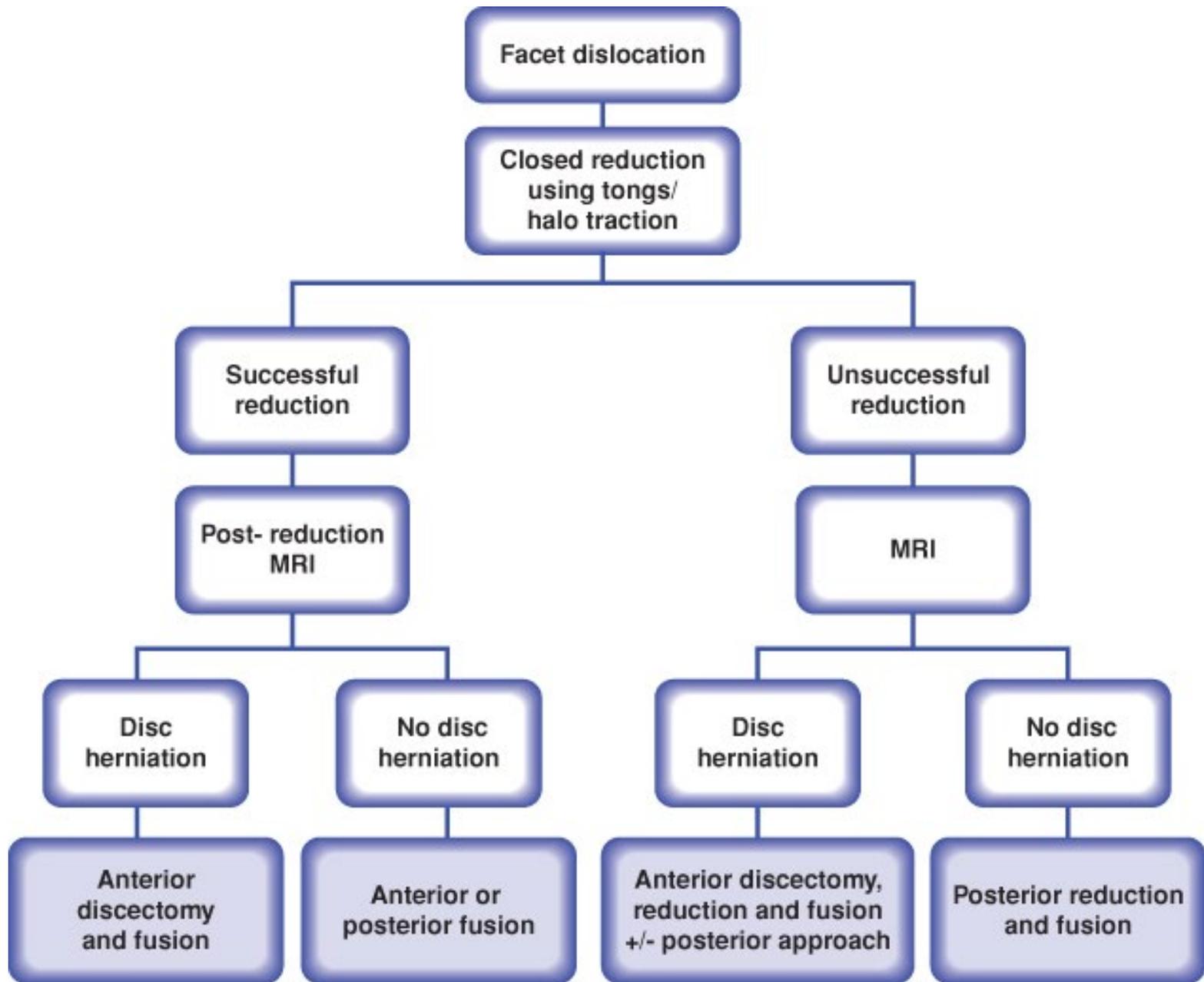
Facet Dislocation Reduction

- Timing for reduction is critical, SCI may be reversible at 1-3 hours
- Awake reduction then MRI
 - In setting of significant neurologic deficits
- MRI before reduction
 - In setting of difficult reduction
 - If during reduction attempt worsening of serial neurologic examination
 - Obtunded or uncooperative patient
 - Obtain or repeat MRI prior to operative intervention post reduction

Closed Reduction of Facet Dislocation

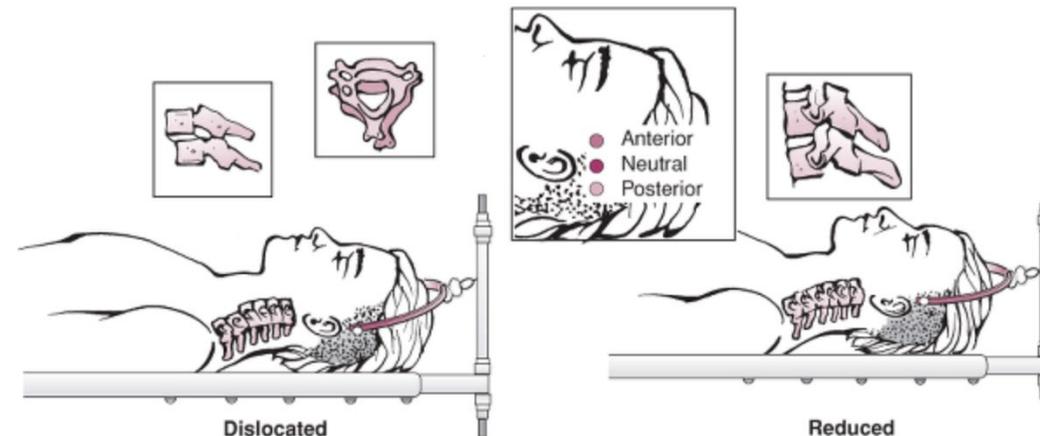
- Reduction of facet dislocations algorithm :





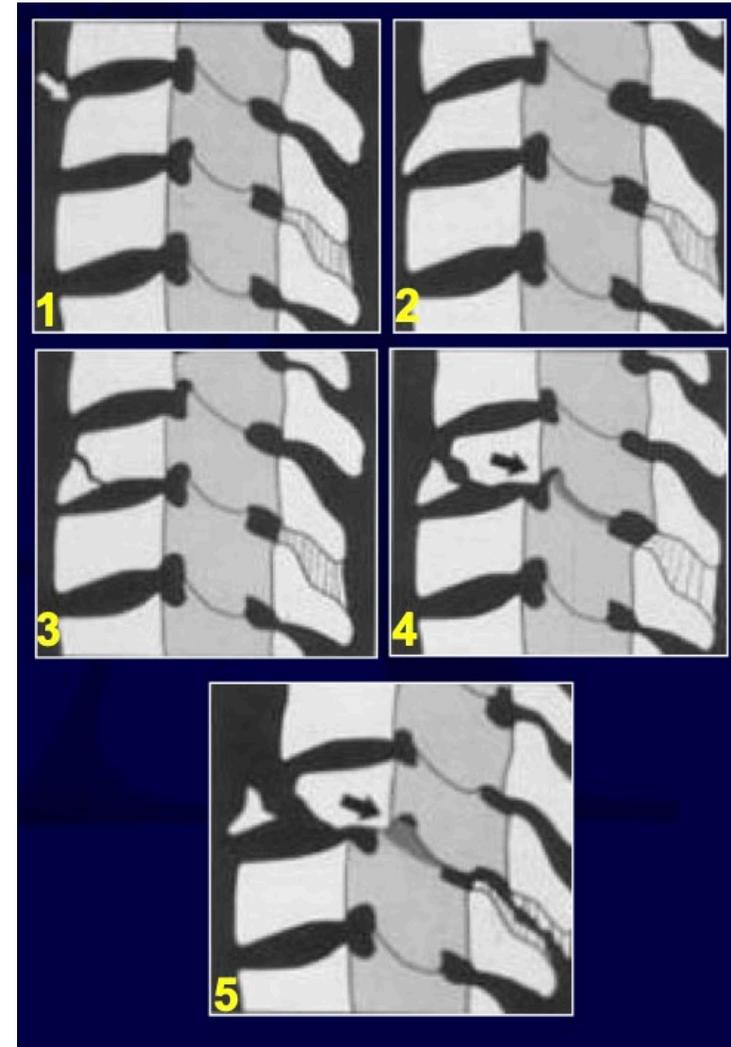
Reduction Technique

- Reduction technique
 - Application of tongs, with gradual addition of weight starting with approximately weight of head (approx. 10 pounds)
 - Cervical flexion can facilitate reduction
 - Serial neurologic examination and plain films crucial
 - More weight required in lower subaxial segments
 - “10 lbs per level”



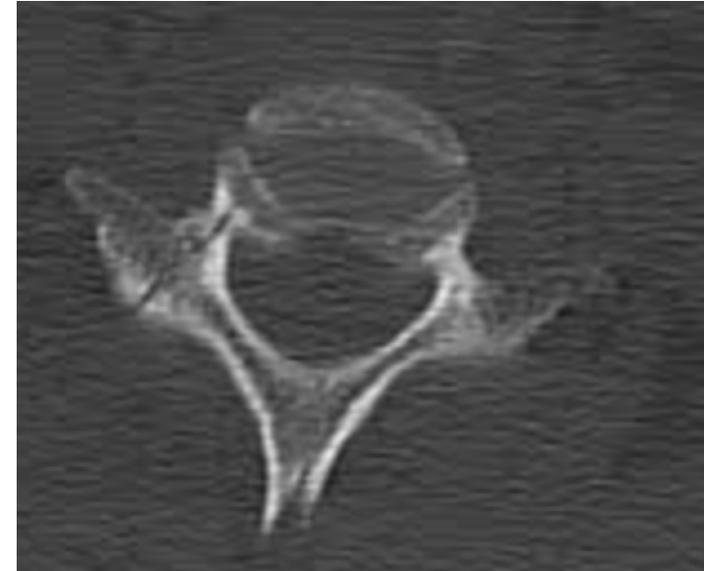
Teardrop Fractures

- High energy flexion, axial load compression injury
- Spectrum on injury, may be highly unstable
- Posterior element disruption results in most unstable patterns of teardrop fractures
- Surgical stabilization:
 - Corpectomy
 - Anterior and posterior combined stabilization



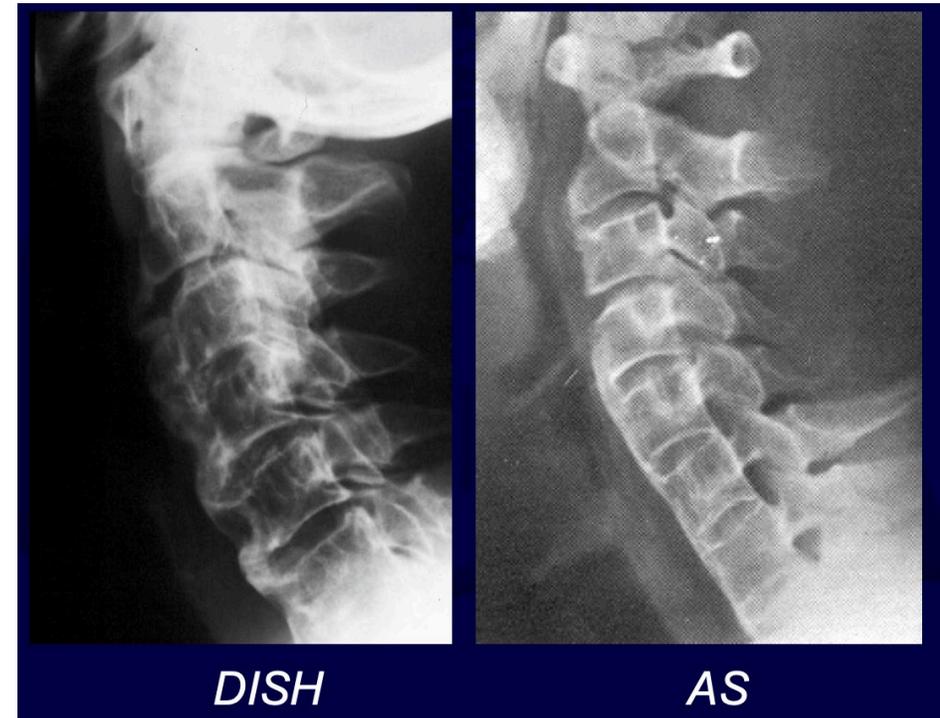
Lateral Mass Fractures

- Lateral mass fractures may involve ipsilateral lamina and pedicle
 - Referred to as a floating lateral mass
 - affects stability of the inferior articular process of the cranial vertebra and the superior articular process of the caudal vertebra
 - Entire lateral mass is free, or floating
- Surgical stabilization:
 - Usually 2 level stabilization if ipsilateral lamina and pedicle fractures to stabilize both levels



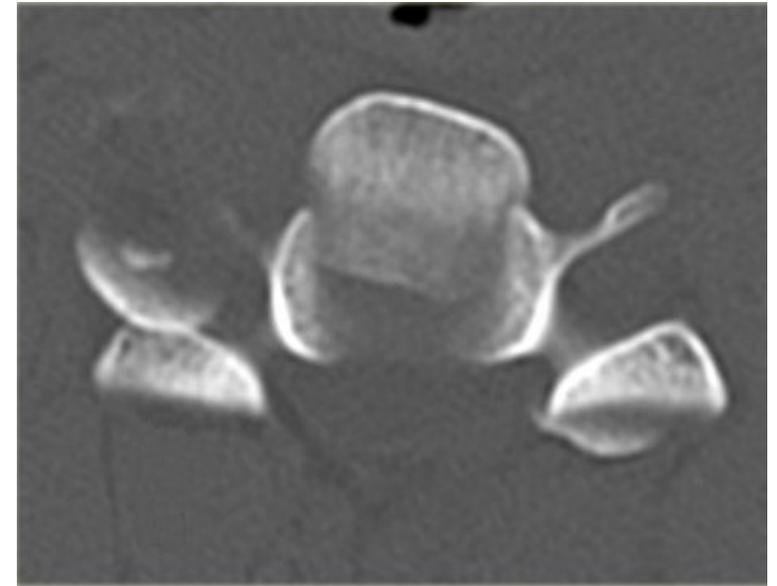
Cervical Fractures in DISH/AS

- Stiff fused spine behaves as long bone
- Longer segment stabilization with low tolerance to accept change from auto-fused alignment
- Straightening the spine may result in neurologic injury – neuromonitoring essential with positioning patient
- Relatively high rates of epidural hematoma



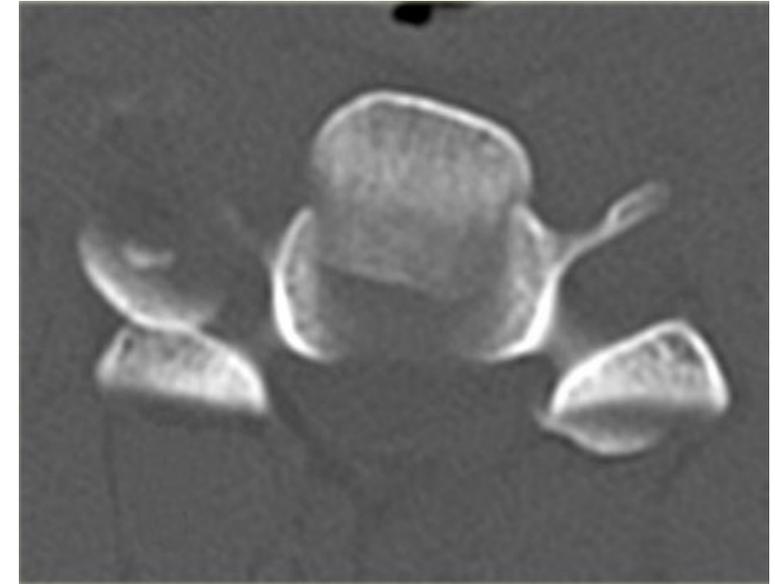
Case Example

31-year-old man with a C4/C5 unilateral facet dislocation and a C5 nerve root deficit.



Case Example

31-year-old man with a C4/C5 unilateral facet dislocation and a C5 nerve root deficit.



SLIC classification:

Rotational injury morphology, 4 points

Disrupted DLC, 2 points

Nerve root injury, 1 point

SLIC score = 4 + 2 + 1 = 7 (operative)

Empty Facet Sign

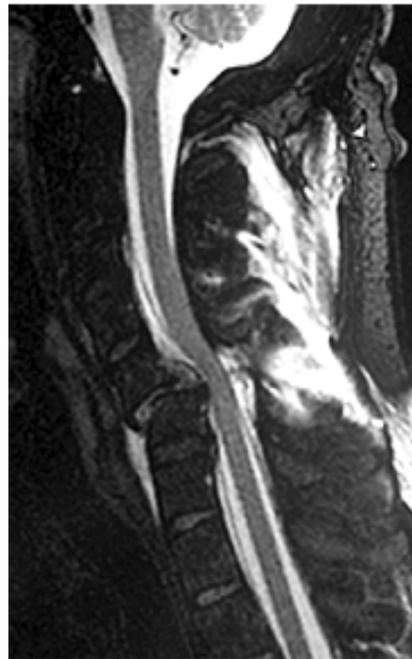
Case Example

27-year-old woman with a C5-6 bilateral facet dislocation and incomplete spinal cord injury.



Case Example

27-year-old woman with a C5-6 bilateral facet dislocation and incomplete spinal cord injury.



SLIC Classification:

Translational injury morphology, 4 points

Disrupted DLC, 2 points

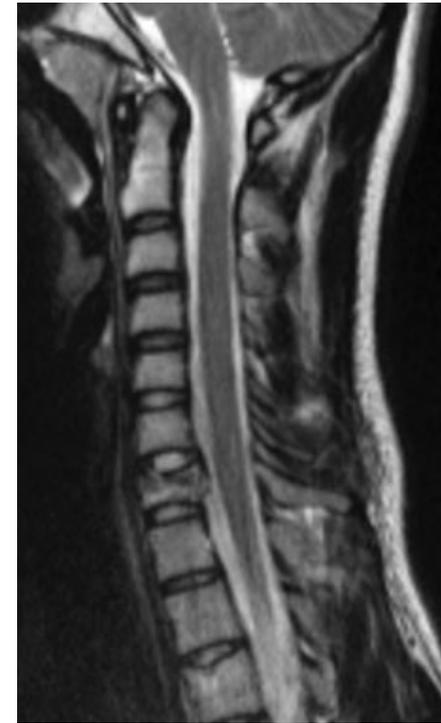
Incomplete spinal cord injury, 3 points

SLIC Score = 4 + 2 + 3 = 9 (operative)

Anterior total discectomy prior to anterior open reduction then C5-6 fusion +/- posterior cervical fixation for augmentation of stability

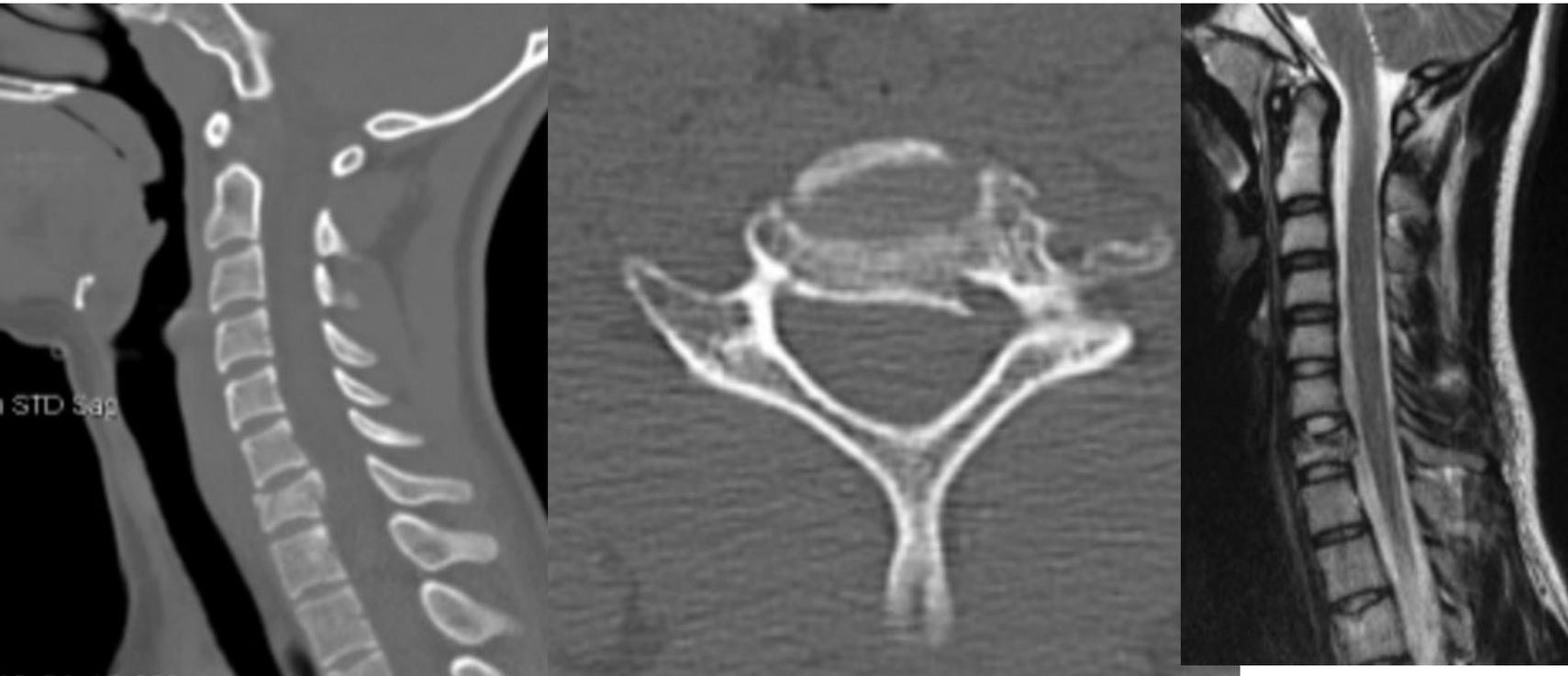
Case Example

18-year-old woman, neurologically intact, C7 burst fracture



Case Example

18-year-old, neurologically intact, C7 burst fracture (no focal kyphosis, posterior interspinous splaying or facet subluxations are evident). T2 weighted MRI showing normal intensity in disc and anterior and posterior ligamentous structures)



SLIC Classification:

Morphology - burst fracture, 2 points;

DLC – intact, 0 points;

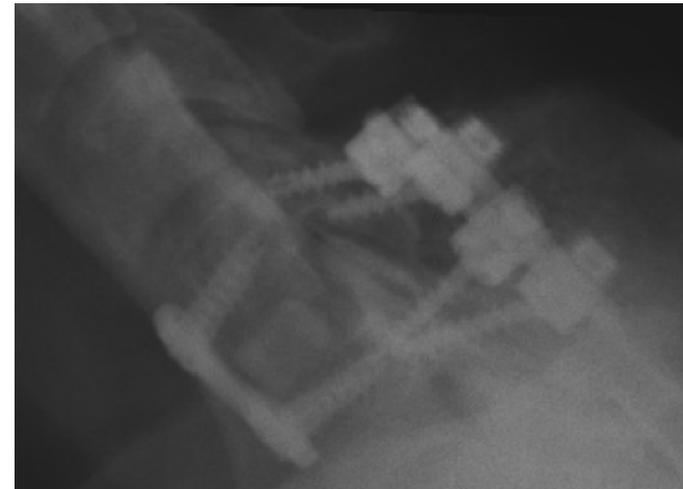
Neurological status – intact, 0 points.

SLIC score $2 + 0 + 0 = 2$ (non-operative)

Treatment Guidelines

- Anterior approach
 - Burst fx w SCI
 - Disc involvement requiring discectomy
 - Significant compression of anterior column
- Posterior approach
 - Ligamentous injuries
 - Lateral mass fractures
 - Dislocations of facet
 - Inability to obtain closed reduction

Combined anterior and posterior often performed dependent on injury characteristics, stability, and need for circumferential decompression



Anterior Surgery

- Advantages
 - Anterior decompression
 - Trend towards improvement of neurologic outcome
 - Atraumatic approach
 - Less postoperative pain and blood loss
 - Supine position in multiply injured patient
- Disadvantages
 - Limited number of motion segments that may be included
 - Potential for increased morbidity
 - Dysphagia
 - Can be very debilitating in a patient with a spinal cord injury
 - May be limiting for cervicothoracic junction

Posterior Surgery

- Advantages
 - Rigid fixation
 - Foraminal decompression
 - Deformity correction
 - May extend to occiput or cervicothoracic junction
 - Facilitates an open reduction of locked or irreducible facets
- Disadvantages
 - Limited anterior cord decompression
 - Increased blood loss and postoperative pain
 - Higher wound healing complications
 - Prolonged prone positioning can be dangerous in a critically ill patient

Summary

- Evaluation of sub-axial cervical spine injuries relies on examination and physical examination
- Multiple classification systems- SLIC system most often for guidance of treatment at this time
- Nonoperative treatment requires stable injuries, appropriate alignment in brace with neurologically intact patients
- Operative treatment dictated by the need to obtain stability and/or neurological decompression