Subaxial Cervical Spine Trauma

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Updated by Robert Morgan, MD November 2010

Learning Objectives

- Articulate cervical spine instability patterns
- Articulate procedure for spine “clearance”
- Identify management considerations
- Identify operative indications
- Articulate nonoperative management methods

Subaxial Cervical Spine

- From C3-C7
- ROM
  - Majority of cervical flexion
  - Lateral bending
  - Approximately 50% rotation

Osseous Anatomy

- Uncovertebral Joint
  - Lateral projections of body
  - Medial to vertebral artery
- Facet joints
  - Sagittal orientation 30-45 degrees
- Spinous processes
  - Bifid C3-5, ? C6, prominent C7

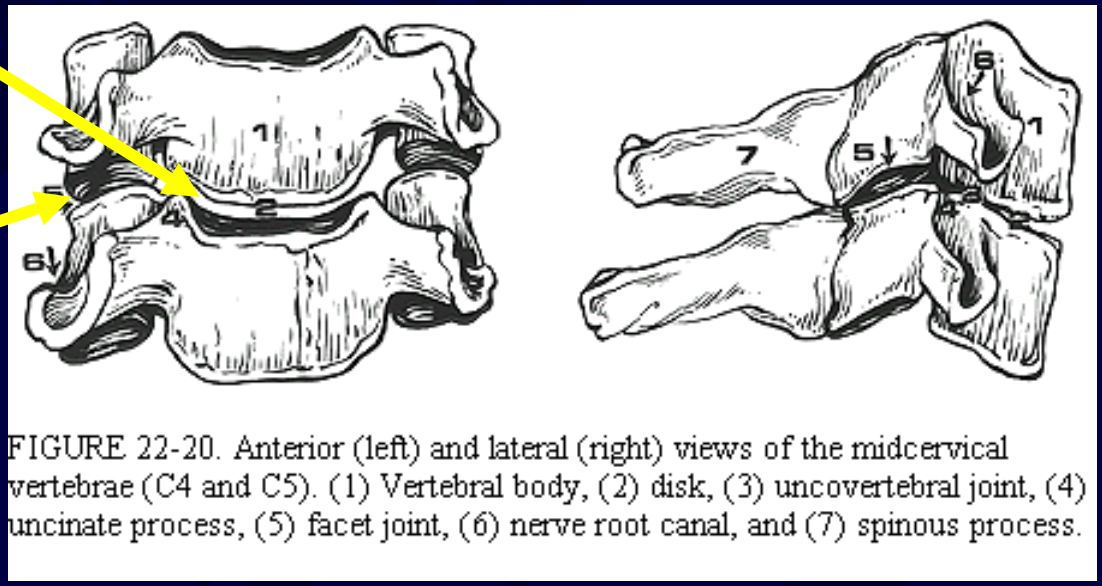


FIGURE 22-20. Anterior (left) and lateral (right) views of the midcervical vertebrae (C4 and C5). (1) Vertebral body, (2) disk, (3) uncovertebral joint, (4) uncinate process, (5) facet joint, (6) nerve root canal, and (7) spinous process.

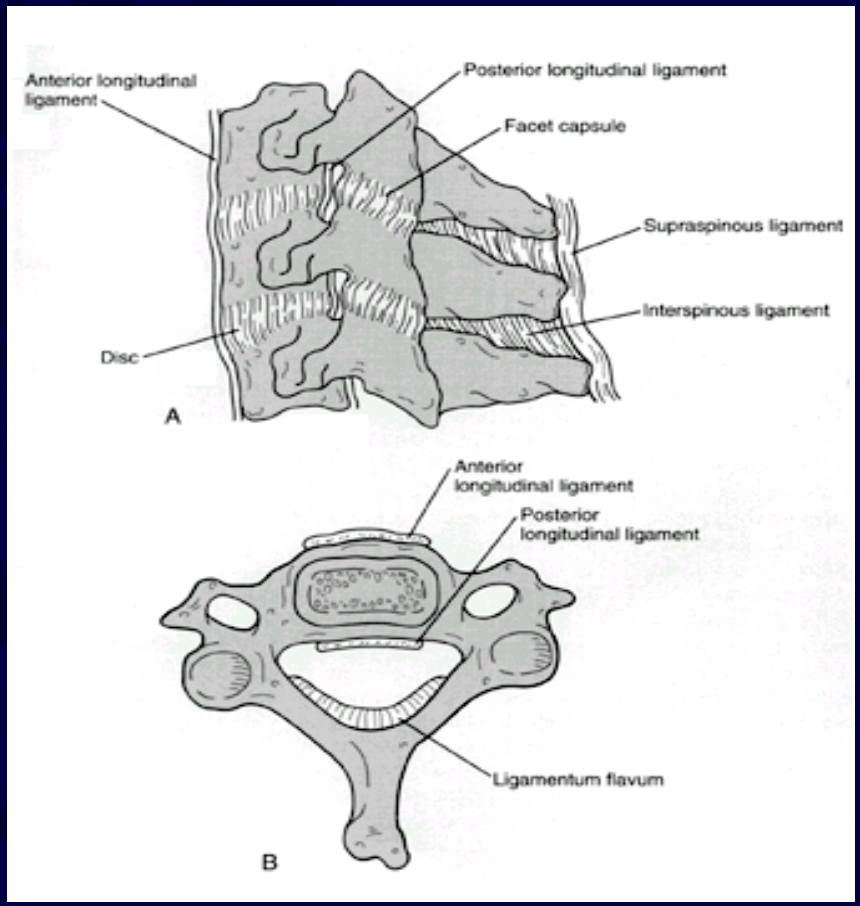
Lateral Mass Anatomy

- **Medial border - Lateral edge of the lamina**
- **Lateral border - watch for bleeders**
- **Superior/Inferior borders - facets**
- **C7 frequently has abnormal anatomy**

- **Vertebral artery is just anterior to the medial border of the lateral mass, enters at C6**
- **Nerve runs dorsal to the artery and anterior to the inferior half of the lateral mass**
- **4 quadrants of the lateral mass with the superolateral quadrant being “safe”**

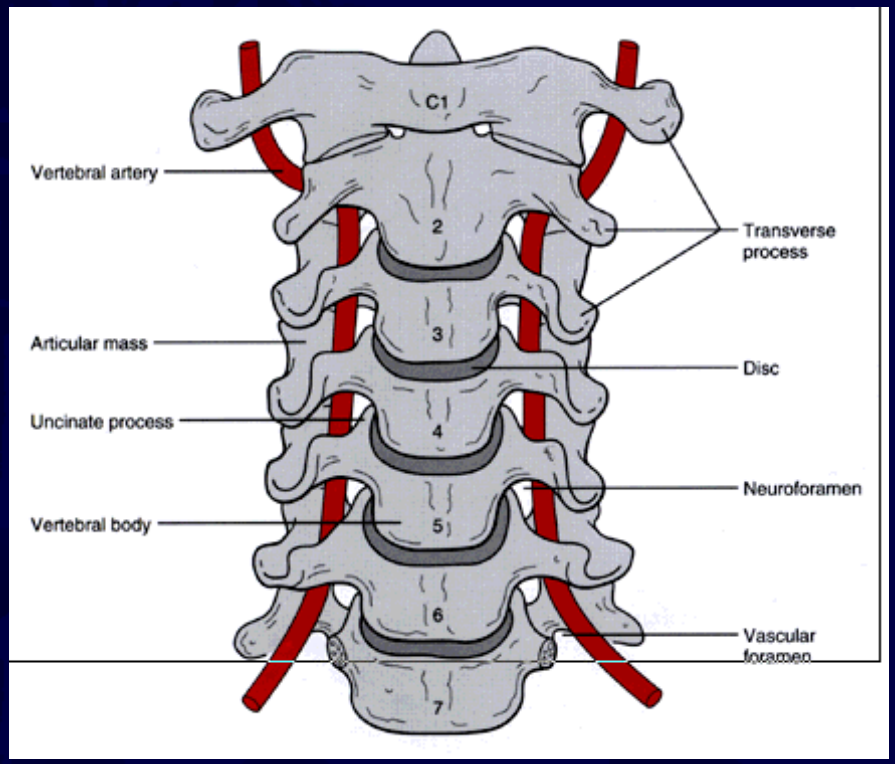
Ligamentous Anatomy

- Anterior
  - ALL, PLL, intervertebral disc
- Posterior
  - Nuchal Ligaments - ligamentum nuchae, supraspinous ligament, interspinous ligament
  - Ligamentum flavum and the facet joint capsules



Vascular Anatomy

- Vertebral Artery
  - Originates from subclavian
  - Enters spine at C6 foramen
  - At C2 it turns posterior and lateral
  - Forms Basilar Artery
- Foramen Transversarium
  - Gradually moves anteriorly and medially from C6 to C2



Neuroanatomy

- Spinal cord diameter subaxial: 8-9mm
- Occupies ~ 50% of canal
- Neural Foramen
  - Pedicles above and below
  - Facets posteriorly
  - Disc, body and uncinate process anteriorly

Columns

- Holdsworth 2 column theory
  - Anterior Column
    - **Body, disc, ALL, PLL**
  - Posterior Column
    - **Spinal canal, neural arch and posterior ligaments**

Instability

"Clinical instability is defined as the loss of the spine's ability under physiologic loads to maintain its patterns of displacement, so as to avoid initial or additional neurologic deficits, incapacitating deformity and intractable pain."

White and Panjabi 1987

Stability

- **Evaluation of stability should include**
  - **anatomic components (bony and ligamentous)**
  - **static radiographic evaluation of displacement**
  - **dynamic evaluation of displacement (controversial)**
  - **neurologic status (unstable if neurologic injury)**
  - **future anticipated loads**

Radiographic Exam
Spine Stability

TABLE 32-1. *Guidelines for biomechanical interpretation of radiographs*

Element	Point value
Anterior elements destroyed or unable to function	2
Posterior elements destroyed or unable to function	2
Relative sagittal plane translation $>$ 3.5 mm	2
Relative sagittal plane rotation $>$ 11°	2
Positive stretch test	2
Spinal cord damage	2
Nerve root damage	1
Abnormal disc narrowing	1
Dangerous loading anticipated	1
Total of $\geq$5 = unstable	

Spine Stability

Table 1. SLIC Scale

	Points
Morphology	
No abnormality	0
Compression	1
Burst	+1 = 2
Distraction (*e.g.*, facet perch, hyperextension)	3
Rotation/translation (*e.g.*, facet dislocation, unstable teardrop or advanced staged flexion compression injury)	4
Disco-ligamentous complex (DLC)	
Intact	0
Indeterminate (*e.g.*, isolated interspinous widening, MRI signal change only)	1
Disrupted (*e.g.*, widening of disc space, facet perch or dislocation)	2
Neurological status	
Intact	0
Root injury	1
Complete cord injury	2
Incomplete cord injury	3
Continuous cord compression in setting of neuro deficit (Neuro Modifier)	+1

Physical exam

- **Palpation**
  - Neck pain
    - 84% patients with a clinical exam and fracture have midline neck pain
      Stiell, I. et al. N Engl J Med 2003;349:2510-2518
    - 20% of patients with a clinically significant cervical spine fracture with negative plain films have a fracture on CT scan
      Mace,S.E. Ann.Emerg.Med; 1985, 14, 10, 973-975
  - Step off between spinous processes
  - Crepitus
- **Range of motion**
- **Detailed neurologic exam (RECTAL!)**

Radiographic Evaluation

- Lateral C-spine to include C7-T1
- BEWARE with changing standards (many just get CT now)
- Bony anatomy
- Soft tissue detail
- Don’t forget T-L spine

Which films?

- **Cross table lateral**
  - **Must include C7-T1 (5% of C-spine injuries)**
- **Three view trauma series**
- **Flexion/Extension**
  - **Controversial as to timing**
  - **Only in cooperative alert patient with pain and negative 3 view**
  - **Negative study does not rule out injury**
  - **If painful, keep immobilized, reevaluate**

Missed Injuries

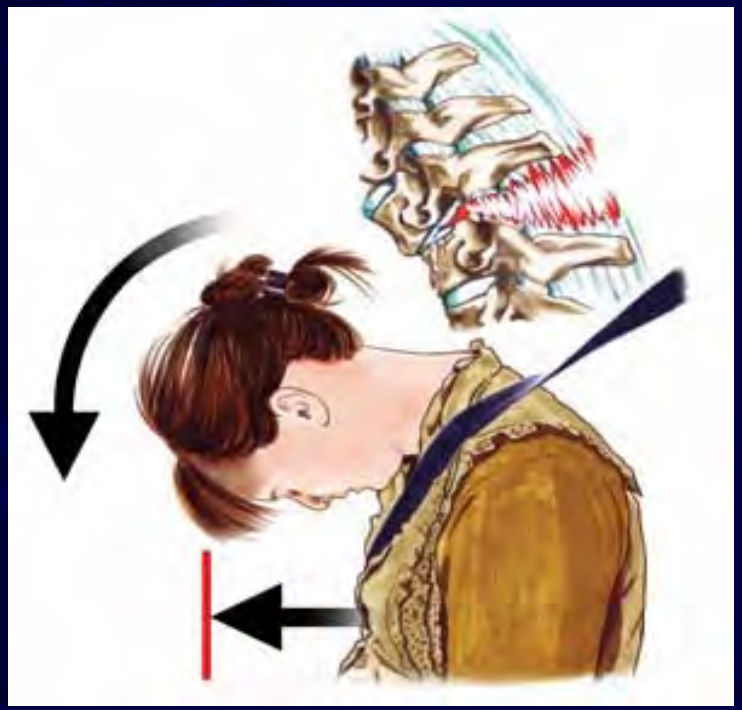
The presence of a single spine fracture does not preclude the inspection of the rest of the spine!

Mechanism of Injury

- Hyperflexion
- Axial Compression
- Hyperextension

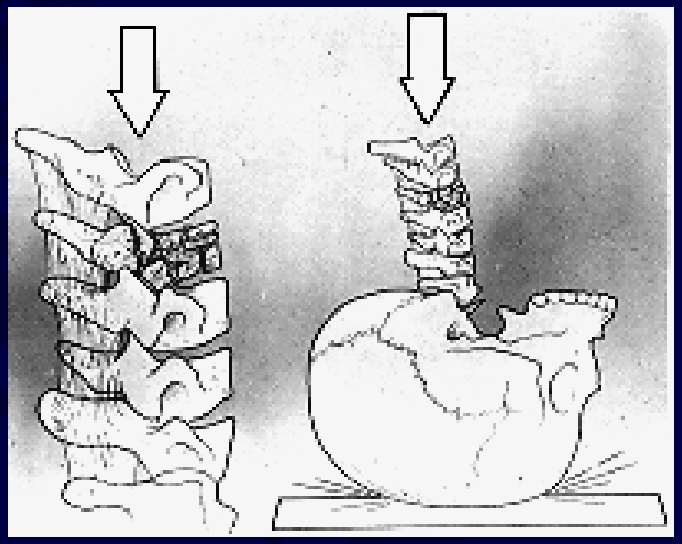
Hyperflexion

- Distraction creates tensile forces in posterior column
- Can result in compression of body (anterior column)
- Most commonly results from MVC and falls



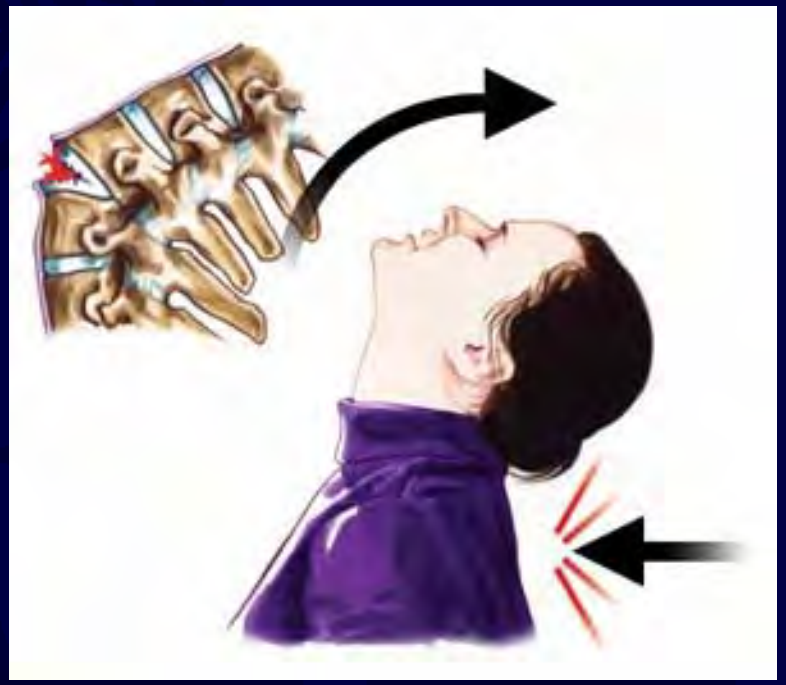
Compression

- Result from axial loading
- Commonly from diving, football, MVA
- Injury pattern depends on initial head position
- May create burst, wedge or compression fx's



Hyperextension

- **Impaction of posterior arches and facet compression causing many types of fx's**
  - lamina
  - spinous processes
  - pedicles
- **With distraction get disruption of ALL**
- **Evaluate carefully for stability**
- **LOOK FOR CENTRAL CORD SYNDROME**



Classification

- Allen and Ferguson Spine 1982
- Harris et al OCNA 1986
- Anderson Skeletal Trauma 1998
- Stauffer and MacMillan Fractures 1996
- AO/OTA Classification
- Most are based on mechanism of injury
- SLIC is not mechanism based

AO/OTA Classification

- Not specific for cervical spine
- Provides some treatment guidelines

- Type A
  - Axial loading; compression; stable
- Type B
  - Bending type injuries
- Type C
  - Circumferential injuries; multi-axial

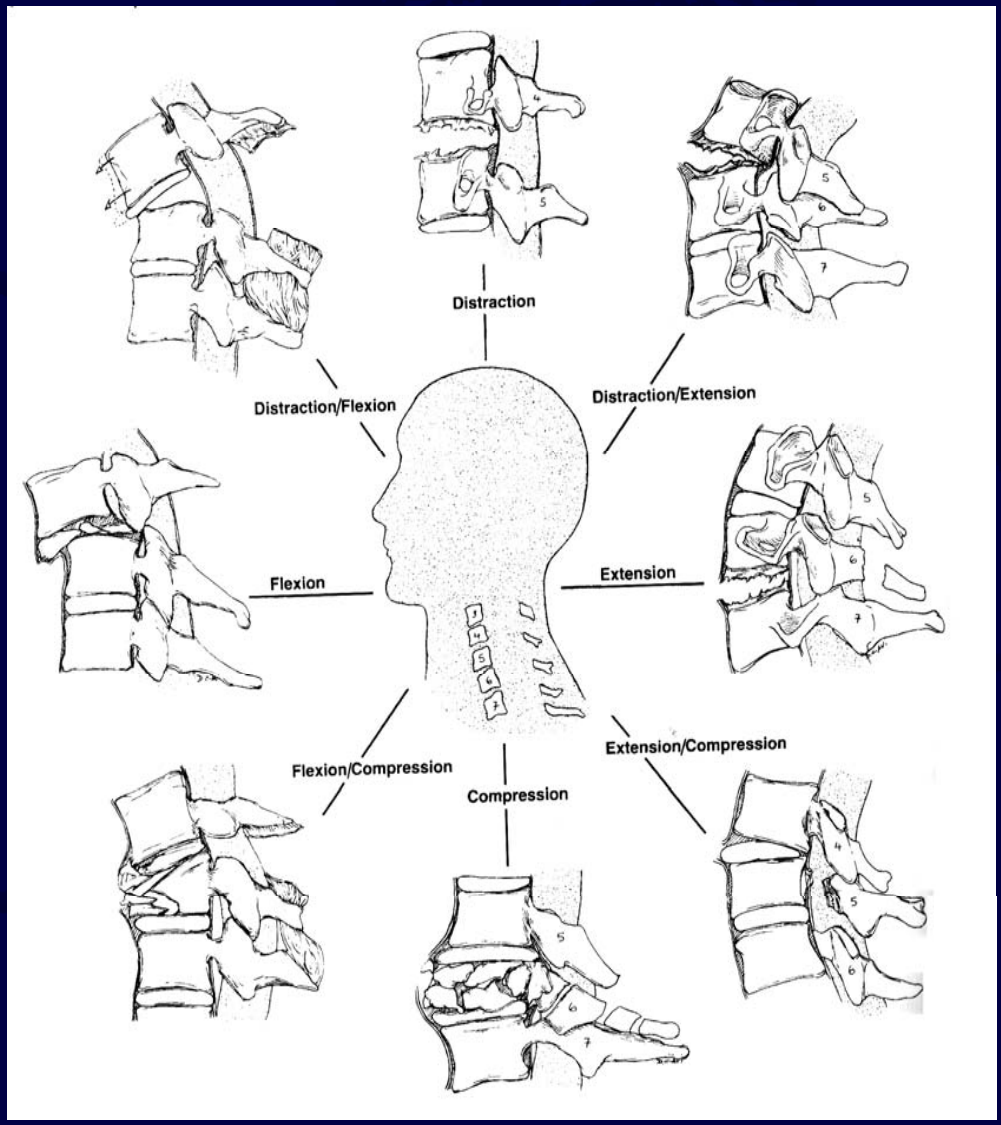
Allen and Ferguson

- **165 patients**
- **Stability of each pattern is based on the two column theory**
- **Each category is broken down into stages**
- **Uses both mechanism and stability to determine treatment and outcome**

- **6 categories**
  - Compressive flexion
  - Vertical compression
  - Distractive flexion
  - Compression extension
  - Distractive extension
  - Lateral flexion

Allen and Ferguson *Spine* 1982

Allen and Ferguson



Distraction-Flexion

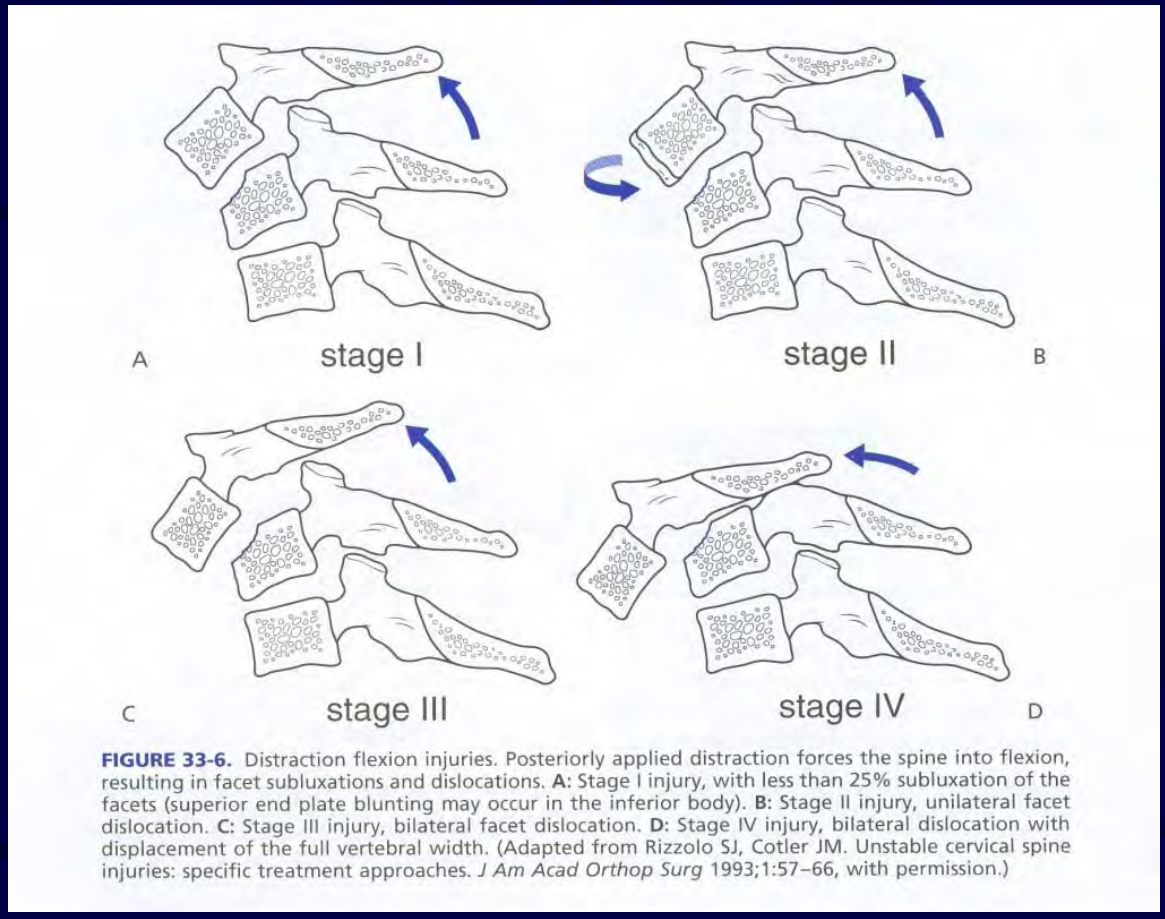


FIGURE 33-6. Distraction flexion injuries. Posteriorly applied distraction forces the spine into flexion, resulting in facet subluxations and dislocations. **A:** Stage I injury, with less than 25% subluxation of the facets (superior end plate blunting may occur in the inferior body). **B:** Stage II injury, unilateral facet dislocation. **C:** Stage III injury, bilateral facet dislocation. **D:** Stage IV injury, bilateral dislocation with displacement of the full vertebral width. (Adapted from Rizzolo SJ, Cotler JM. Unstable cervical spine injuries: specific treatment approaches. *J Am Acad Orthop Surg* 1993;1:57–66, with permission.)

Rizzolo SJ, Cotler JM. Unstable cervical spine injuries: specific treatment approaches. *J Am Acad Orthop Surg* 1993; 1:57-66

Wiring?

- Shapiro 1993
  - Retrospective case series of 24 patients with unilateral locked facets
  - 5 patients underwent successful closed reduction with 2/5 having resubluxation in halo.
  - 1 of 24 patients posteriorly reduced and wired resubluxed and subsequently underwent an anterior fusion with plating.
  - Conclusion: Posterior reduction and wiring was more effective than halo management for unilateral locked facet injuries.

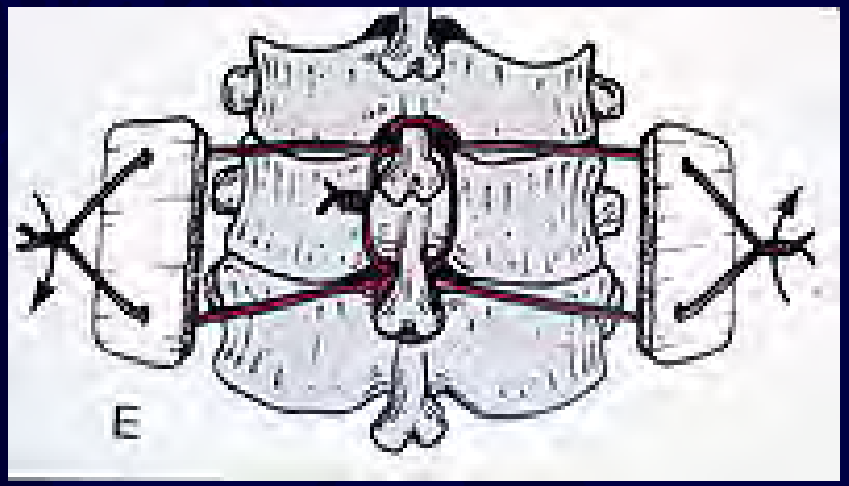
- Hadley 1992
  - Retrospective case series of 68 patients with facet fracture dislocations
  - l25/30 patients with unilateral facet injuries were followed for a mean of 18 months. 34/37 patients with bilateral facet injuries were followed for a mean of 24 months.
  - 28 patients failed closed reduction. 7/31 closed reduced patients treated in halo developed late instability. 1/24 patients treated with open reduction went on to late instability
  - Conclusion: Posterior reduction and wiring was more effective than halo management for unilateral and bilateral facet fracture dislocations. Late instability was common in injuries able to be reduced and subsequently treated closed.

Wiring?

- Lukhele 1994
  - Retrospective case series of 43 patients with facet fractures treated with posterior wiring
  - 12 patients had associated laminar fractures, 5 of which went on to develop deformity and increased neurologic deficit. These were subsequently treated with anterior diskectomy and plating.
  - Conclusion: Intact posterior elements are necessary for successful posterior wiring.

Wiring?

- Koivikko 2004
  - Retrospective study of 106 distraction flexion injuries with operative arm and nonoperative control group
  - Operative management consisted of posterior Rogers wiring in 51 patients. 6 of these patients subsequently required revision for loss of reduction.
  - 16 nonoperatively treated patients subsequently underwent operative management for late instability or neurologic decline.
  - Operatively treated patients had improved radiographic parameters and less neck pain. There was no difference in neurologic outcomes.
  - Conclusion: Operative management with posterior wiring was safe and effective and operatively managed patients had improved radiographic parameters and less neck pain.



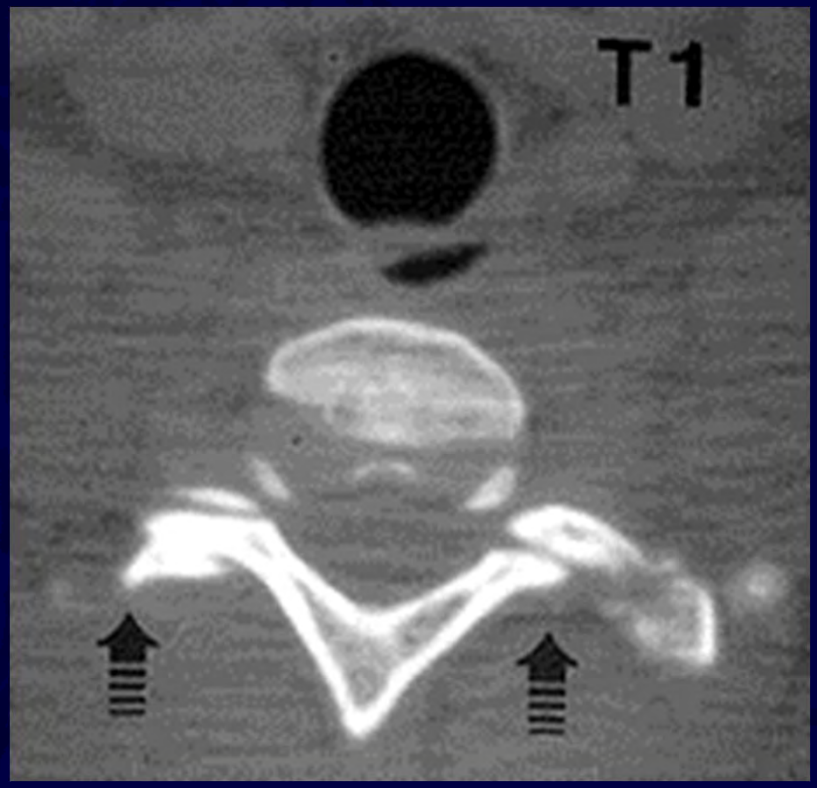
Bohlman Triple Wiring

Unilateral Facet Dislocation (Distraction Flexion stage 2)

- Flexion/rotation injury
- Painful neck
- 70% radiculopathy, 10% SCI
- Easy to miss-supine position can reduce injury!
- “Bow tie” sign: both facets visualized, not overlapping

Unilateral Facet Dislocation

- Reduce to minimize late pain, instability
- Flex, rotate to unlock; extend
- 50% successful reduction
- OR vs. halo



Unilateral Facet Dislocation

Note C7 fracture also!

Unilateral Facet Dislocation Treatment

- *Nonoperative*
  - Cervicothoracic brace or halo x 12 weeks
  - Need anatomic reduction
- *OR approach and treatment depends on pathology*
  - Anterior diskectomy and fusion w/plate
  - Posterior foraminotomy and fusion with segmental stabilization

Halo treatment

- Pasciak 1993
  - Retrospective case series of 32 patients with unilateral facet dislocations
  - 9 patients presented with spinal cord injury and were operated upon without further comment.
  - 15/23 dislocations were able to be reduced and held in traction up to 3 weeks.
  - Instability was demonstrated in 7 patients with subsequent unspecified fusion. 8 patients failed closed reduction and underwent posterior reduction and fusion.
  - Conclusion: Failure of closed reduction and late instability is common in unilateral facet injuries.

Bilateral Facet Dislocation (Distraction Flexion-Stage 3)

- Injury to cord is common
- 10-40% herniated disk into canal
- Treatment somewhat controversial
- Vertebral body displaced at least 50%

Bilateral Facet Dislocation

- Timing for reduction
  - Spinal cord injury may be reversible at 1-3 hours
- Need for MRI
  - If significant cord deficits, reduce prior to MRI
  - If during awake reduction, paresthesias or declining status
  - Difficult closed reduction
  - If neurologically stable, perform MRI prior to operative treatment (loss of reduction?)

Surgical Decompression and Stabilization

Dimar et al *Spine* 1999

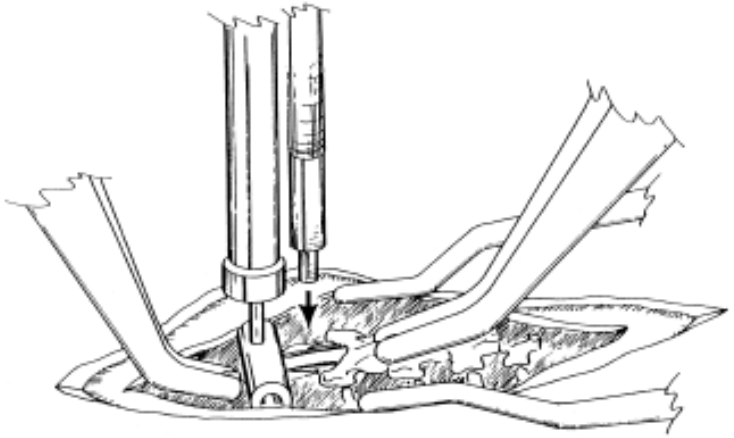


Figure 2. Spinal cord test apparatus used to create a 12.5-g/cm spinal cord injury.

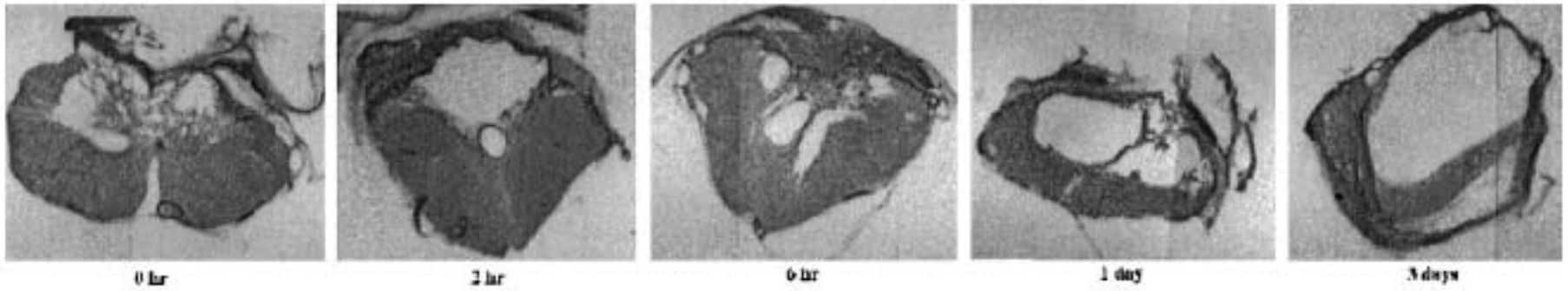


Figure 14. Histology: neurologic recovery *versus* duration of canal. Narrowing axial gross sections of time until decompression injury groups (0, 2, 6, 24, and 72 hours) demonstrating progressively more severe dorsal cord cavitation. Note the almost total myelomalacia of the cord at 72 hours.

Timing of Reduction vs. MRI

- 82 pts uni/bilateral facet fx/dx
- CR successful 98%
- Emergent OR in 2
- Post-reduction MRI
  - 22% herniation
  - 24% disruption
- Prereduction MRI
- 2/11 HNP
- 5/11 HNP post reduction
- One patient with secondary neuro deterioration
  - Root impingement
  - Onset several hours after reduction

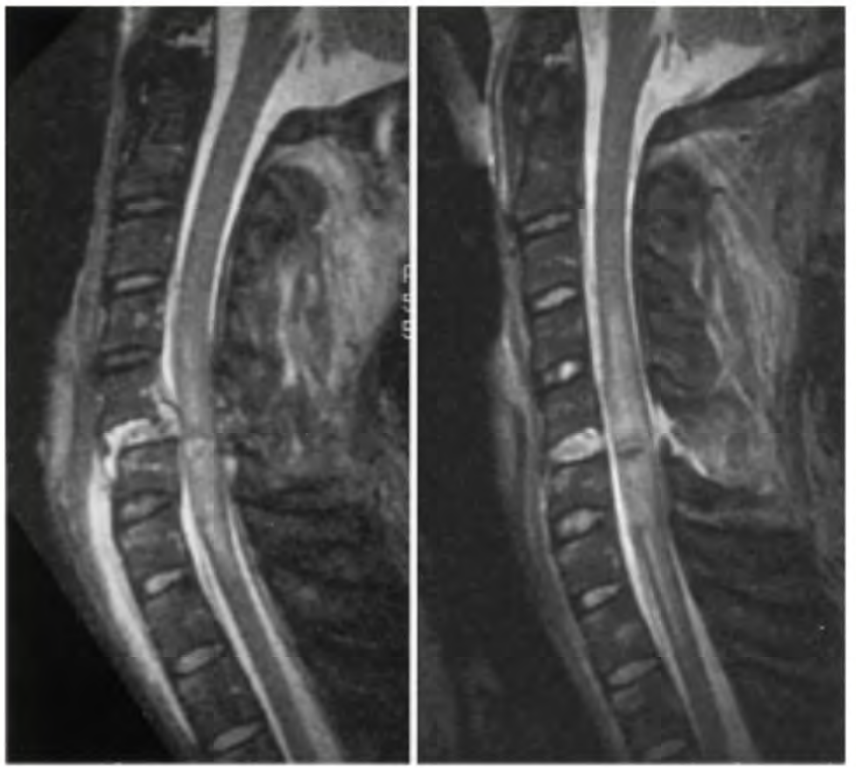
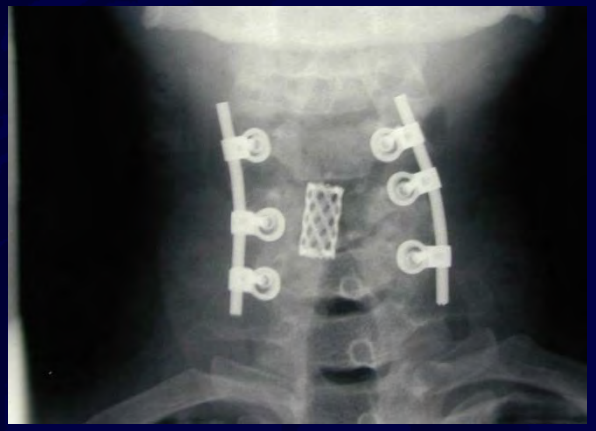


FIG. 5. Midline sagittal MR images of the cervical spine showing *(left)* disc extrusion into the spinal canal and posterior to the C-5 body with associated spinal cord edema (TR 4705, TE 34) and *(right)* reduction of the disc herniation following closed reduction and persistent spinal cord edema extending from C4–7 (TR 6101, TE 34).

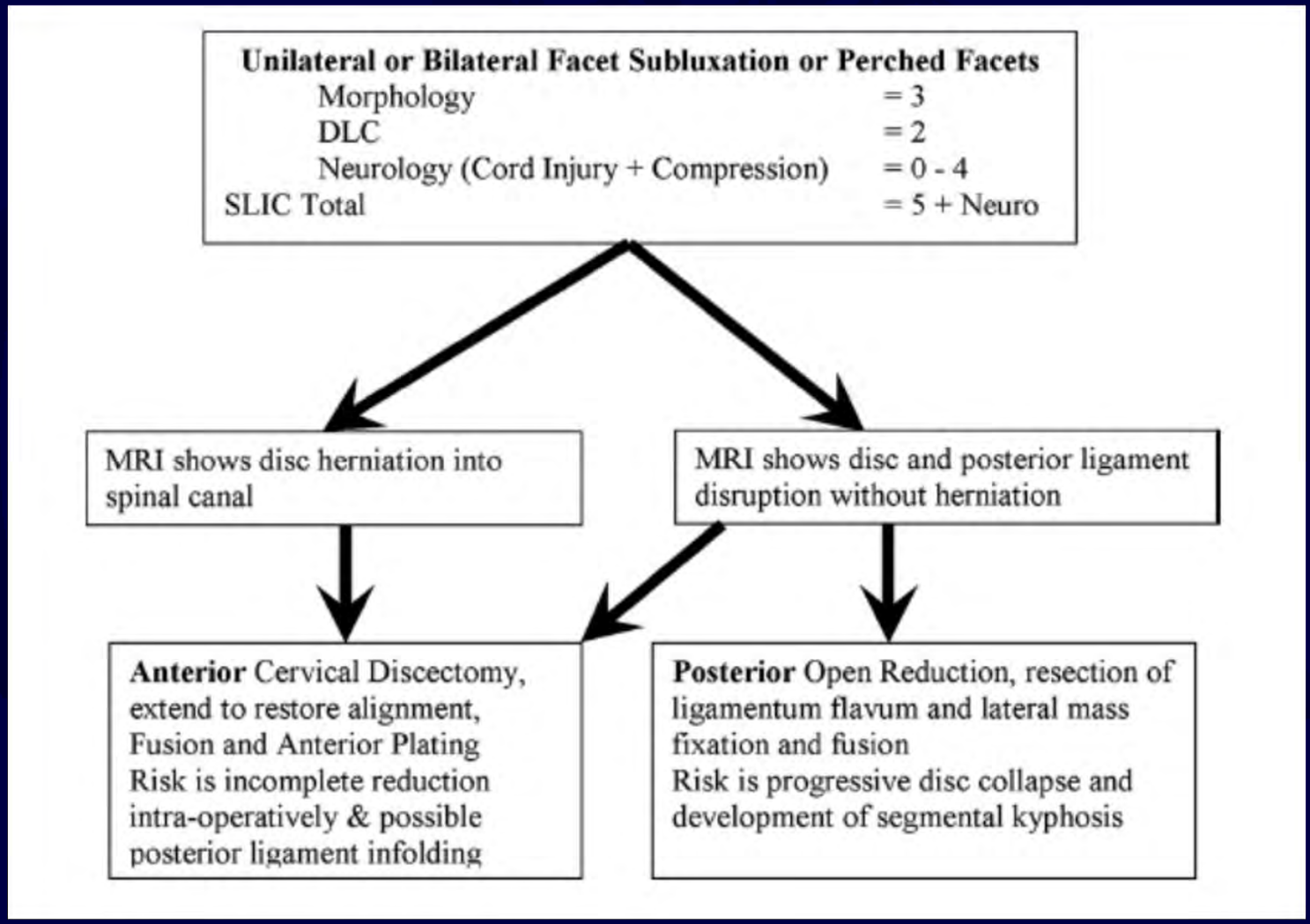
Grant et al, *J Neurosurg*,1999

Bilateral Facet Dislocation Treatment

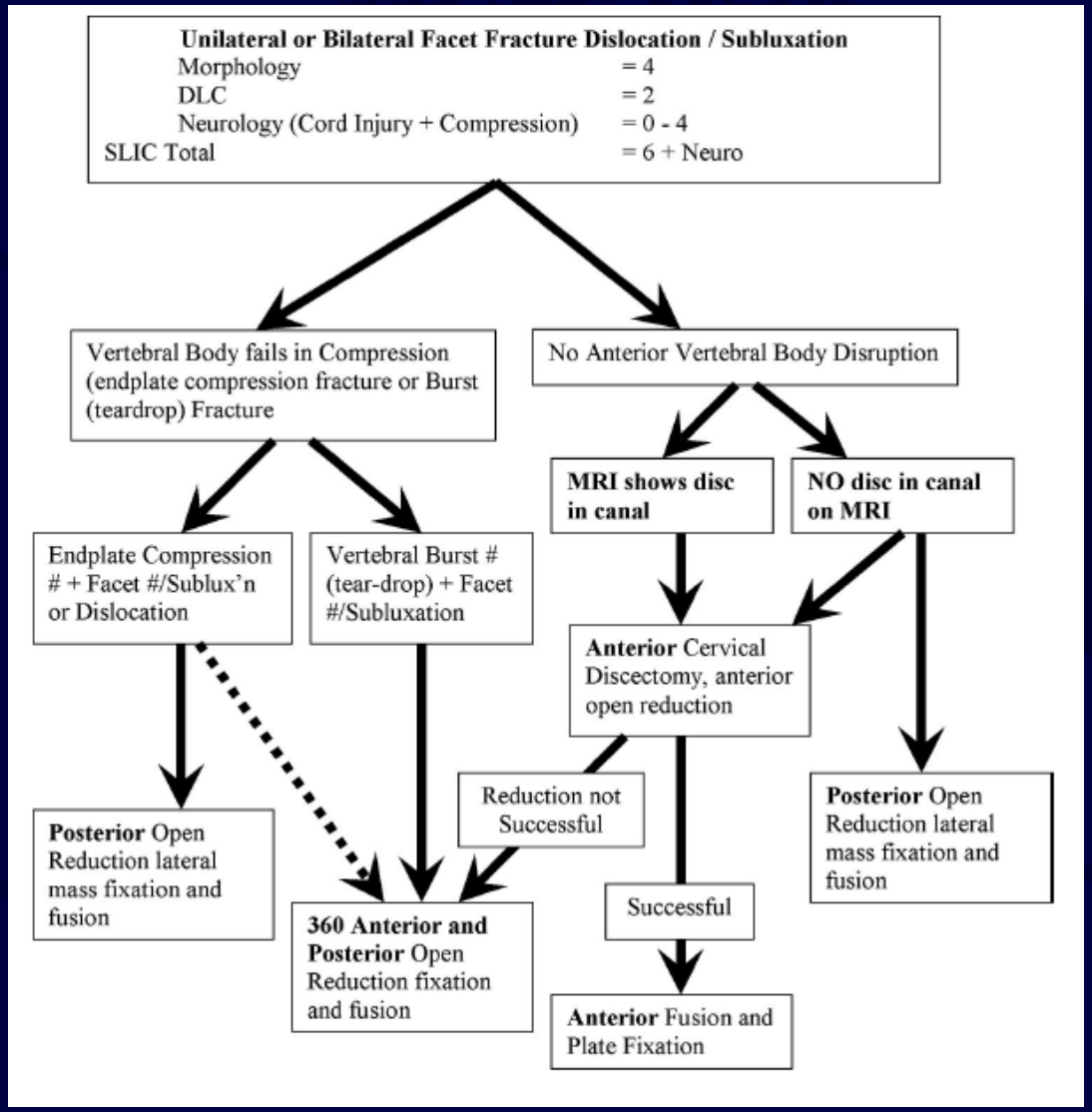
- Closed reduction/imaging as discussed
- Definitive treatment requires surgical stabilization
  - Review MRI for pathology
  - Anterior decompression and fusion
  - If poor bone quality, consider posterior segmental stabilization
  - Occasional anterior & posterior stabilization



SLIC Algorithm



SLIC Algorithm



What about isolated facet fractures?

- Stability depends on ligamentous complex
  - SLIC 0
  - Can be rotationally unstable
- Most commonly involves superior articular process (80%)
- Can have late pain and disability
- Late arthrodesis is an option
- Be aware of “fracture separation” of lateral mass

Anterior Only

- Brodke 2003
  - Randomized prospective study of 52 patients with spinal cord injuries and subaxial instability
  - 24 distraction flexion injuries total were treated with 6 anterior diskectomy and plating procedures and 18 posterior instrumented fusions.
  - There was no statistically significant difference in complications,neurologic or radiographic outcomes between the two groups
  - Conclusion: Both anterior diskectomy and plating as well as posterior instrumented fusion are safe and effective in treating distraction-flexion injuries.

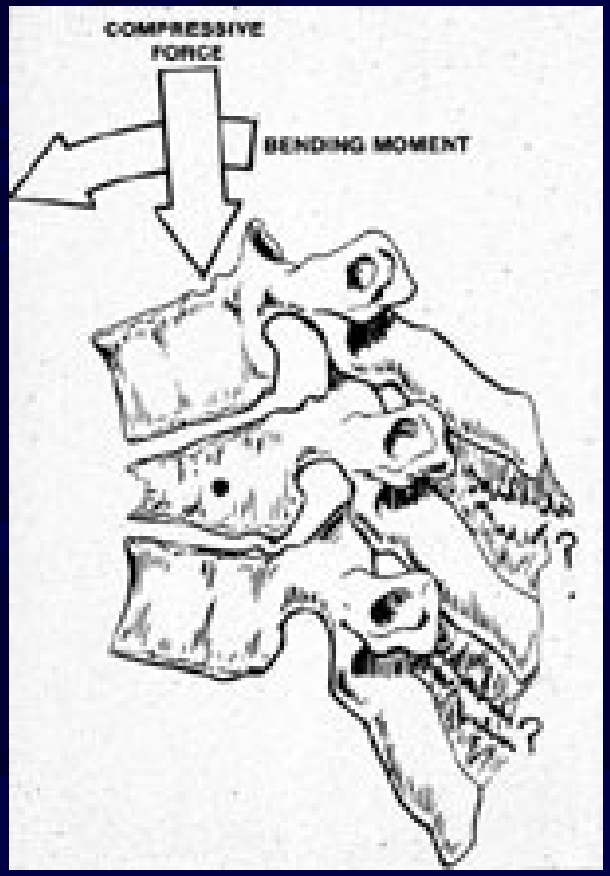
More on Anterior Only

- **Elgafy 2007**
  - **Retrospective case-control study of 65 patients with cervical fracture dislocations treated with posterior instrumentation**
    - Instrumentation was 47.6% lateral mass plating, 46.2% interspinous process wiring, combined 6.2%.
    - Iliac crest autograft was used in 57/65 patients. Solid fusion was achieved in 96.7%.
    - Bilateral facet injuries with initial segmental kyphosis was strongly associated with late kyphosis.
    - Conclusion: Consider anteriot/posterior procedure in bilateral facet subluxations/dislocations to prevent late kyphosis.

- **Ordonez 2000**
  - **Retrospective case series of ten patients with distraction-flexion injuries treated with anterior reduction and plating.**
    - Satisfactory reduction was obtained in 9 patients with one patient requiring an additional posterior procedure to achieve reduction.
    - Two patients had asymptomatic partial resubluxations that did not result in further operations.
    - Risk factors for failed reduction include significant posterior element disruption and facet fracture comminution.
    - Conclusion: Anterior diskectomy and plating is safe and effective in distraction-flexion injuries that are not highly unstable or involve facet fractures.

Compression Fractures

- Flexion force
- The question is one of ligamentous damage/posterior instability
- Stability determines treatment



Compression

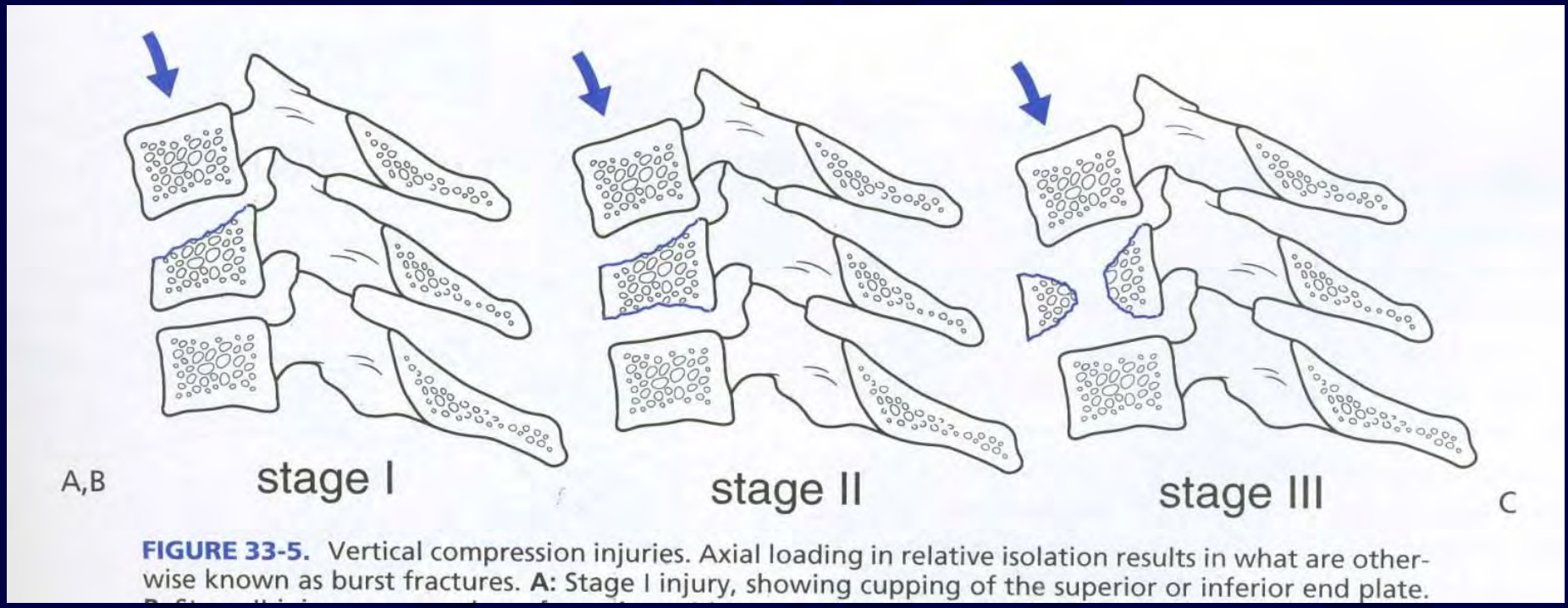


FIGURE 33-5. Vertical compression injuries. Axial loading in relative isolation results in what are otherwise known as burst fractures. **A:** Stage I injury, showing cupping of the superior or inferior end plate.

Rizzolo SJ, Cotler JM. Unstable cervical spine injuries: specific treatment approaches. *J Am Acad Orthop Surg* 1993; 1:57-66

Compression-Flexion

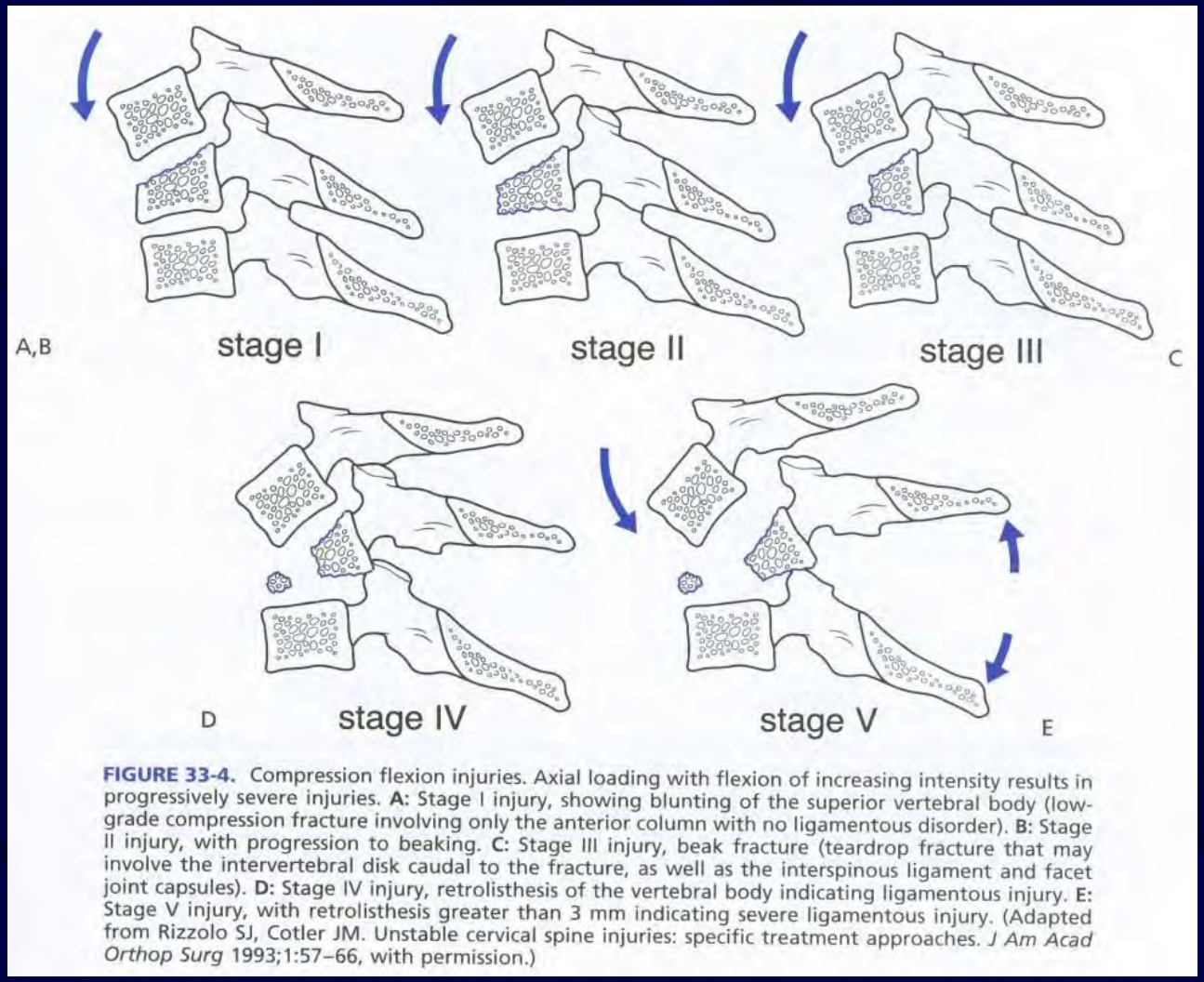


FIGURE 33-4. Compression flexion injuries. Axial loading with flexion of increasing intensity results in progressively severe injuries. **A:** Stage I injury, showing blunting of the superior vertebral body (low-grade compression fracture involving only the anterior column with no ligamentous disorder). **B:** Stage II injury, with progression to beaking. **C:** Stage III injury, beak fracture (teardrop fracture that may involve the intervertebral disk caudal to the fracture, as well as the interspinous ligament and facet joint capsules). **D:** Stage IV injury, retrolisthesis of the vertebral body indicating ligamentous injury. **E:** Stage V injury, with retrolisthesis greater than 3 mm indicating severe ligamentous injury. (Adapted from Rizzolo SJ, Cotler JM. Unstable cervical spine injuries: specific treatment approaches. *J Am Acad Orthop Surg* 1993;1:57–66, with permission.)

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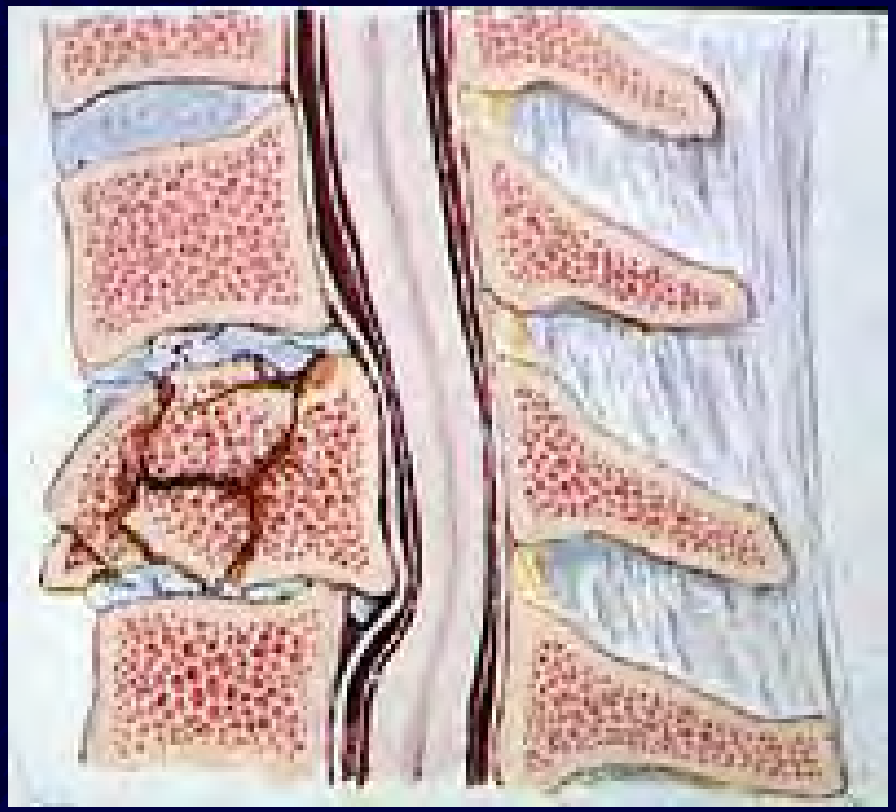
Burst Fractures

- Comminuted body fracture with retropulsion
- Traction reduction
- Treatment based on neuro status and instability

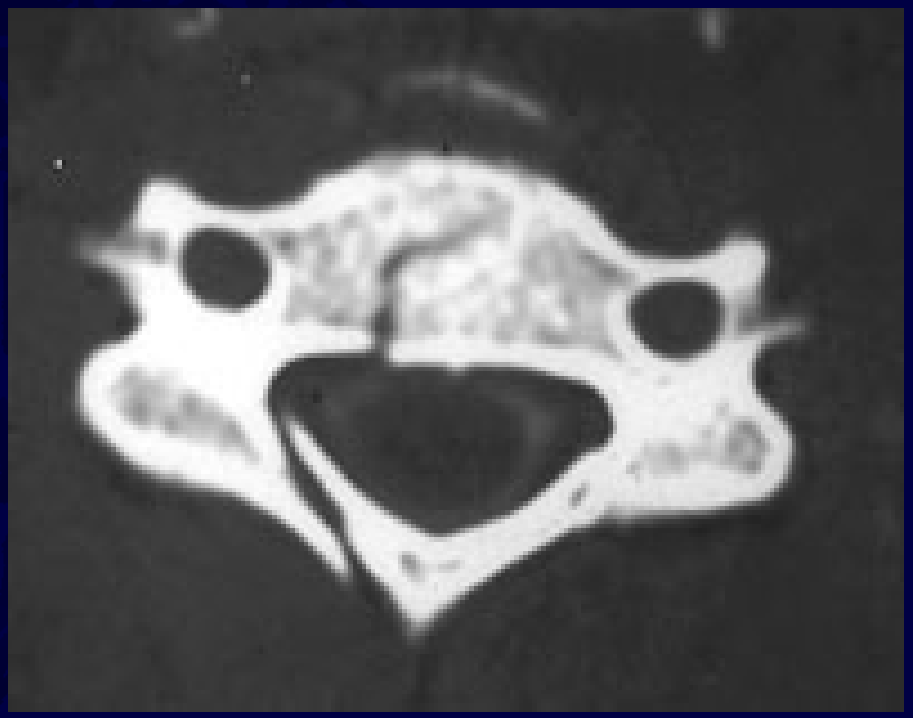


Teardrop Fracture

- **Extension (upper cervical spine)**
  - Usually benign
  - Avulsion type
- **Flexion (lower cervical spine)**
  - Anterior wedge or quadrangular fragment
  - Unstable

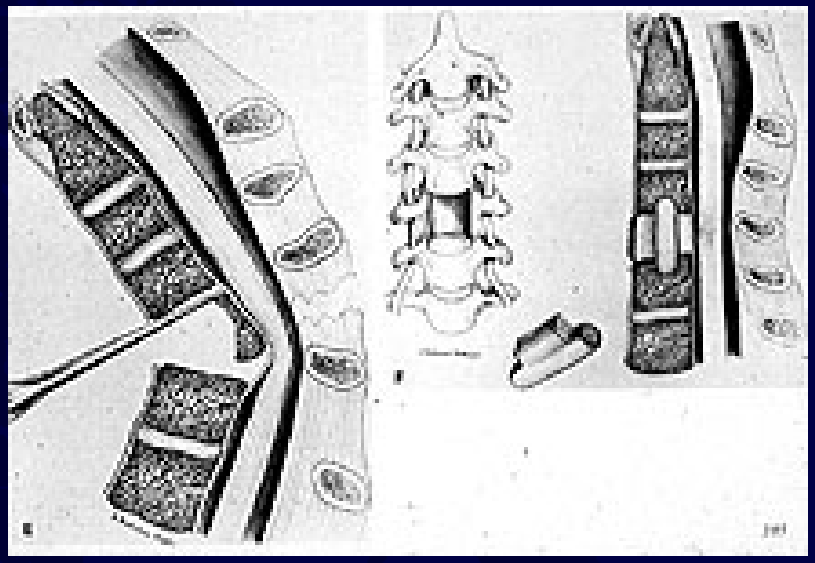
Teardrop Fracture

- High energy flexion,compressive force
- Often posterior element disruption
  - Unstable injury
- Routinely requires surgery



Burst Fractures Treatment

- Surgical treatment routine for high grade burst fractures
- Most commonly treated with corpectomy, anterior grafting of some type and rigid plate fixation
- Supplemental posterior fixation if patient osteopenic or injury to posterior structures warrants stabilization



Compression-Extension

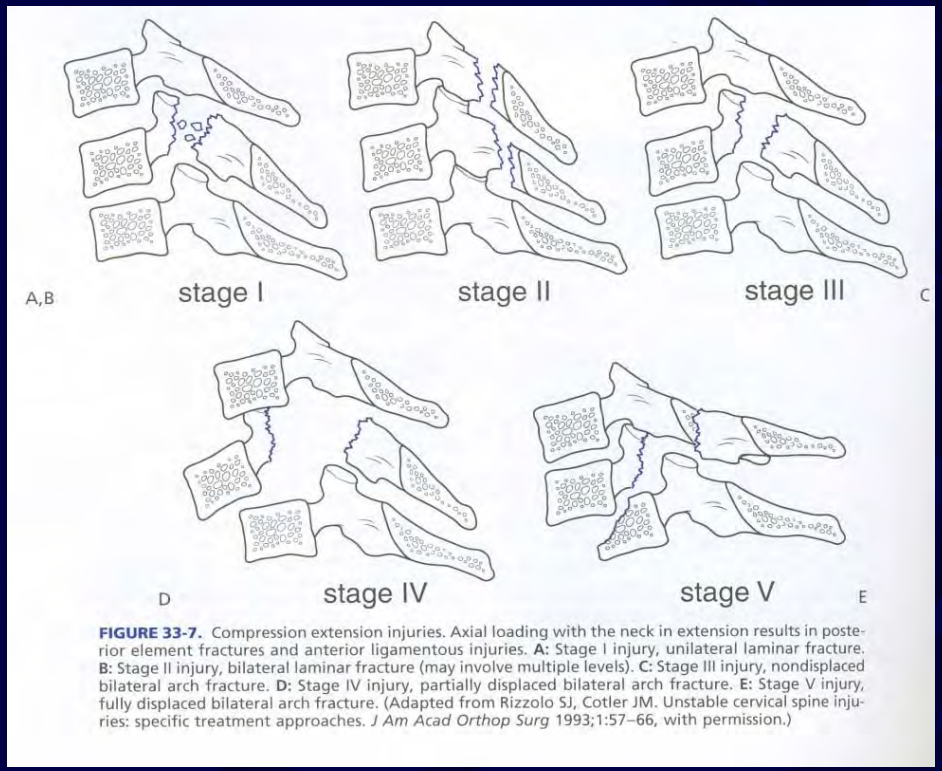


FIGURE 33-7. Compression extension injuries. Axial loading with the neck in extension results in posterior element fractures and anterior ligamentous injuries. **A:** Stage I injury, unilateral laminar fracture. **B:** Stage II injury, bilateral laminar fracture (may involve multiple levels). **C:** Stage III injury, nondisplaced bilateral arch fracture. **D:** Stage IV injury, partially displaced bilateral arch fracture. **E:** Stage V injury, fully displaced bilateral arch fracture. (Adapted from Rizzolo SJ, Cotler JM. Unstable cervical spine injuries: specific treatment approaches. *J Am Acad Orthop Surg* 1993;1:57–66, with permission.)

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Lateral Mass Fractures

- Lateral mass fracture involves ipsilateral lamina and pedicle
- Extension type injury?
- Understand the anatomy
- 2 level surgical stabilization

CAUTION!

Beware:

- Ankylosing spondylitis
  - If neck pain, treat as fracture
- Obese patients
- Poorly imaged patients
- Distracting injuries
- Rotational injuries

SLIC Algorithm

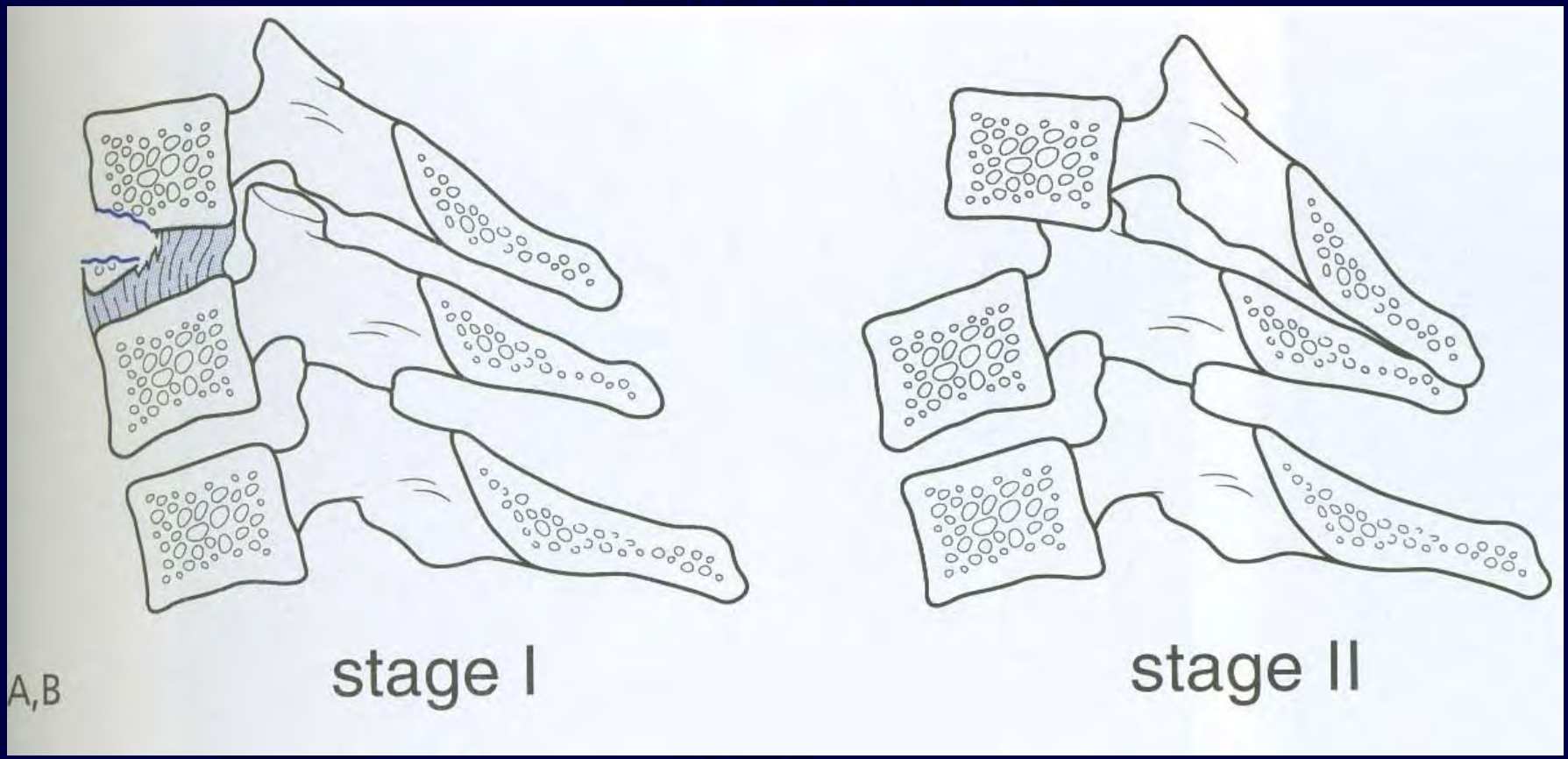
Hyper-extension Injury +/- Avulsion Fractures	
Morphology	= 3
DLC (likely disrupted)	= 2
Neurology (Cord Injury + Compression)	= 0 - 4
SLIC Total	= 5 + Neuro

↓

Anterior Discectomy Fusion and Plate
In a very stiff spine (DISH) may choose to add posterior fixation

Be cautious of anterior only constructs in osteoporosis!

Distraction Extension



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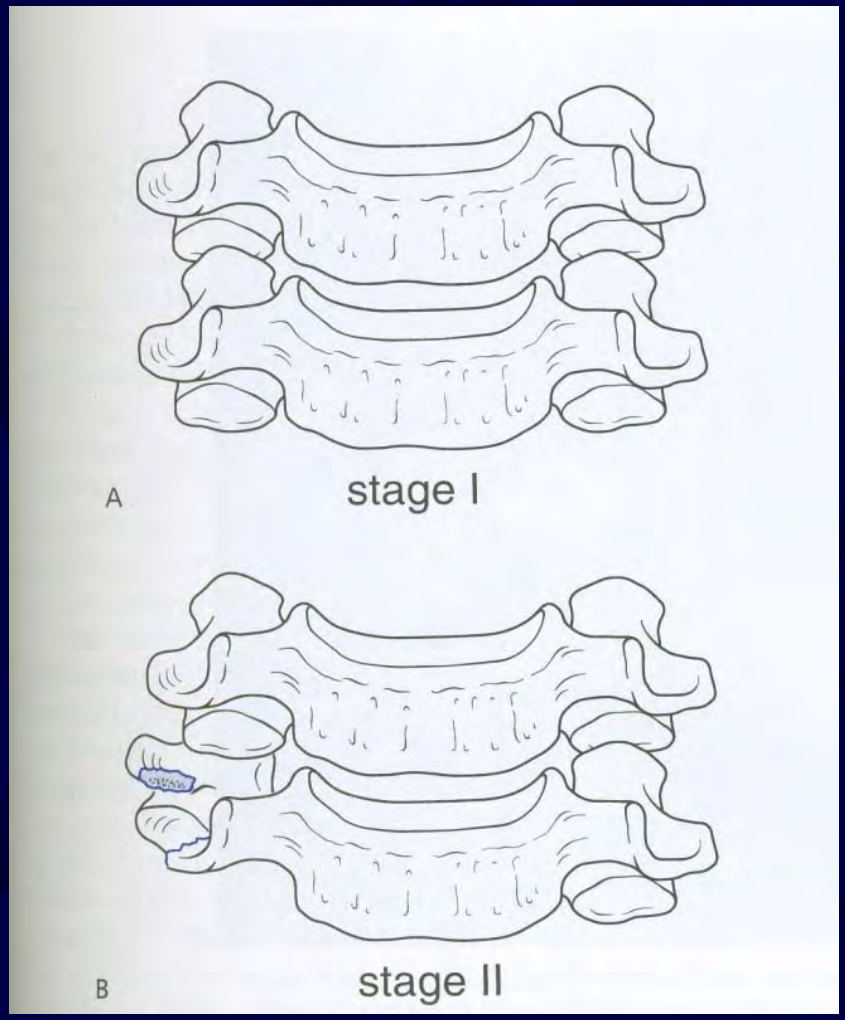
Distraction-Extension

Series (reference number)	Description of Study	Quality of evidence	Topic and conclusion
Vaccaro 2001	Retrospective consecutive case series of 24 patients with distraction-extension injuries	Very low	16 injuries were treated operatively, 8 nonoperatively. 9 patients were treated anteriorly only, 6 patients were treated with combined anterior and posterior procedures, one patient was treated posteriorly only. 2 patients treated operatively deteriorated due to over distraction at time of graft placement. Almost 50% of patients had ankyosing spondylitis or diffuse idiopathis skeletal hyperostosis. Conclusion: Anterior fusion with plating was safe and effective if overdistraction was avoided. Combined procedures were often necessary. Closed reduction and treatment with halo was successful. Overall mortality in this patient population is high
Lieberman 1994	Retrospective case series of 41 patients age greater than 65 with cervical spine fractures	Very low	3 patients with distraction-extension injuries. 1 died, one was treated with a collar, one quadriparetic patient was treated with operative reduction, anterior fusion Conclusion: This was an uncommon injury pattern in this series
Anderson 1991	Retrospective case series of 30 patients treated with posterior cervical plating	Very low	One patient with an extension type injury at C56 was quadriparetic and treated with posterior plating to solid fusion despite a screw loosening in a C4-C7 construct. Conclusion: posterior plating is safe and effective in this uncommon injury.
Rockswold 1990	Retrospective case series of 140 patients with cervical spine injuries	Very low	7 patients sustained unstable extension injuries, 3 were successfully treated in a halo vest, 3 were successfully treated operatively. One patient not included in the data analysis died due to flexion position in the halo resulting in airway compromise. Conclusion: Nonoperative management may be successful if flexion positioning can be avoided.
Bucholz 1989	Retrospective case series of 124 cervical spine injuries	Very low	12 extension injuries, all treated initially in halo. 1/12 failed halo treatment and subsequently underwent posterior wiring with successful result. Conclusion: halo treatment of these injuries may be safe and effective in the

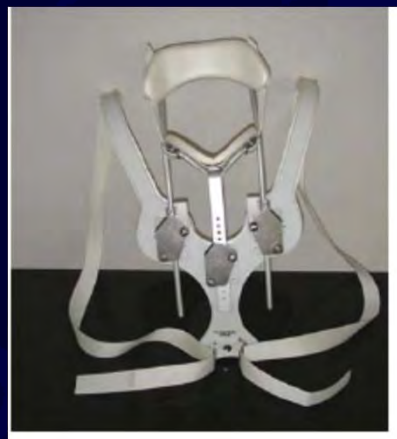
Lateral Flexion



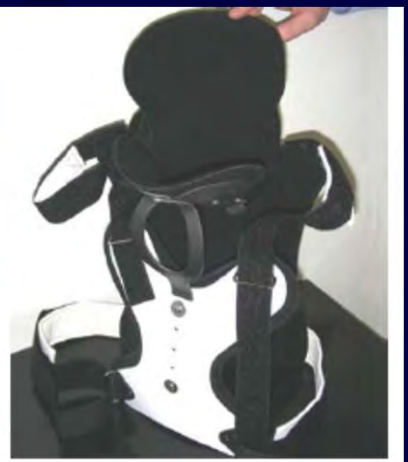
Rizzolo SJ, Cotler JM. Unstable cervical spine injuries: specific treatment approaches. *J Am Acad Orthop Surg* 1993; 1:57-66

Non-operative Care

- Rigid collars
  - Conventional collars offer little stability to subaxial spine and transition zones
  - May provide additional stability with attachments (JTO!)
  - Good for post-op immobilization
- Halo
  - Many complications
  - Better for upper cervical spine injuries
  - Subaxial “snaking”



Sternal-occipital-mandibular immobilizer (SOMI) brace.



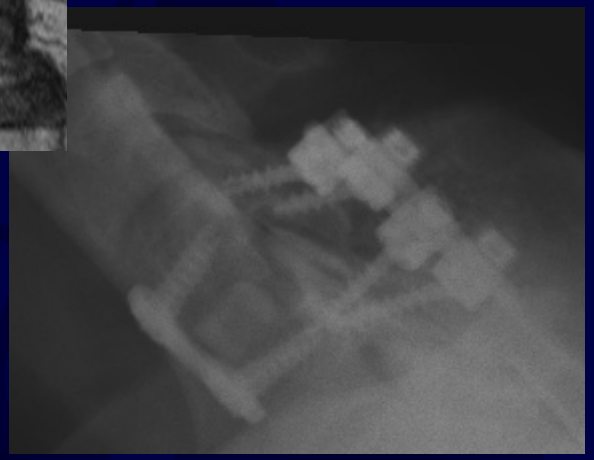
Minerva brace.

Spinal Orthoses. Steven S. Agabegi, MD, Ferhan A. Asghar, MD and Harry N. Herkowitz, MD *J Am Acad Orthop Surg*,18,11, 657-667.

Treatment Guidelines

- Anterior Approach
  - Burst fx w/SCI
  - Disc involvement
  - Significant compression of anterior column

- Posterior Approach
  - Ligamentous injuries
  - Lateral mass Fx
  - Dislocations



Occasionally you need circumferential approach!

Anterior Surgery

- **Advantages**
  - **Anterior decompression**
    - Trend towards improved neuro outcome
  - **Atraumatic approach**
  - **Supine position**
    - Acute polytrauma
- **Disadvantages**
  - **Limited as to number of motion segments included**
  - **Potential for increased morbidity**
  - **Poor access to CT transition zone**

Posterior Surgery

- Advantages
  - Rigid fixation
  - Foraminal decompression
  - Deformity correction
  - May extend to occiput and CT transition zones
  - Implant choices

- Disadvantages
  - Minimal anterior cord decompression
  - Prone positioning
  - Trend towards increased blood loss

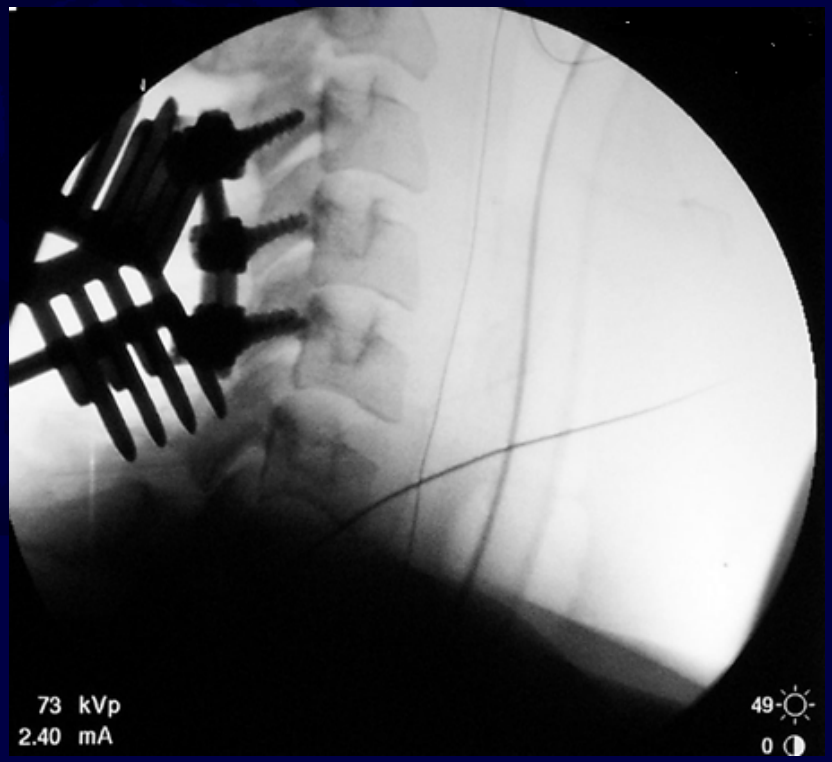
Lateral Mass Screws

(workhorse of posterior instrumentation)

- ***Magerl***
- **Start slightly medial to center of lateral mass**
- **Upward and outward trajectory**
- **Improved biomechanical stability (longer screw)**
- **Decreased risk of morbidity to root or artery**

- ***Roy-Camille***
- **Straight, slightly lateral trajectory from center of lateral mass**

- ***An***
- **Split the difference**



Controversies

- Myth of Myelopathy
- Blunt Vertebral Artery Injury
- Clearing the Cervical Spine

Myth of Myelopathy

- No clear case of spinal cord injury after direct laryngoscopy in English literature
  - McLeod and Calder Criteria
- All airway maneuvers cause some motion at fracture site
  - Lessened with manual in line immobilization
  - Increased with increasing instability
- Fiberoptic intubation minimizes displacements
  - May still require direct laryngoscopy
  - May require surgical airway

Crosby, E. Airway Management in Adults After Cervical Spine Trauma. *Anaesthesiology*. 2006

Blunt Vertebral Artery Injury

Table 1. SCREENING TRIGGERS FOR SUSPECTED BLUNT CEREBROVASCULAR INJURY

Cervical spine fracture
Neurologic exam not explained by brain imaging
Horner's syndrome
LeFort II or III facial fractures
Skull base fractures involving the foramen lacerum
Neck soft tissue injury (e.g., seatbelt injury or hanging)

Table 4. ARTERIAL INJURY RATES ASSOCIATED WITH EACH SCREENING CRITERION

Condition	CAI Rate	VAI Rate
Cervical spine fracture (n = 109)	6 (5%)	36 (33%)
Neck hematoma (n = 28)	5 (18%)	2 (7%)
Facial fracture (n = 28)	3 (11%)	2 (7%)
Horner's syndrome (n = 20)	2 (10%)	1 (5%)
Neuro. exam incompatible with brain imaging (n = 19)	6 (31%)	3 (16%)
Basilar skull fracture (n = 10)	3 (30%)	0 (0%)

CAI, carotid artery injury; VAI, vertebral artery injury.

Miller *et al*. Prospective screening for blunt cerebrovascular injuries. *Annals of Surgery*. 2002

Treatment?

	Current Study (2 year period)	Prior Study (5 year period)	*P* Value
CAI			
Number of injuries	27	75	—
Incidence	0.39%	0.50%	.25
Stroke rate	33%	31%	.78
VAI			
Number of injuries	49	64	—
Incidence	0.71%	0.40%	.04
Stroke rate	0%	14%	.0007

CAI, carotid artery injury; VAI, vertebral artery injury.

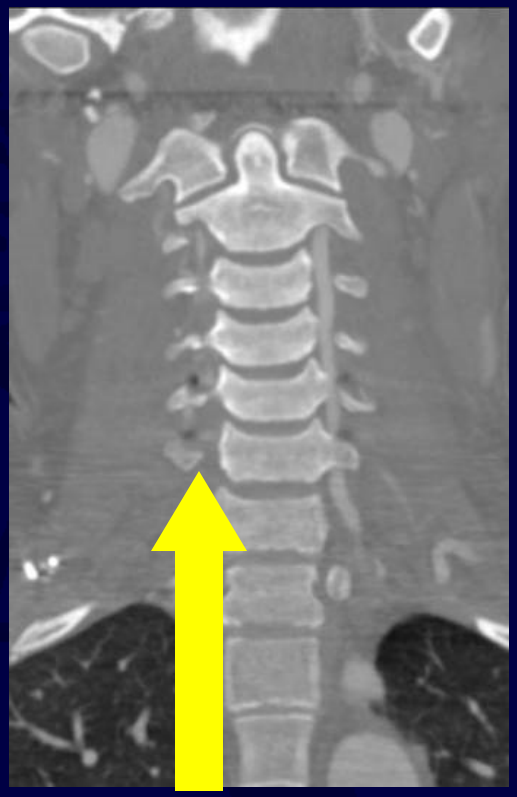
Miller *et al*. Prospective screening for blunt cerebrovascular injuries. *Annals of Surgery*. 2002

Diagnosis?

Table 6. SENSITIVITY AND SPECIFICITY OF COMPUTED TOMOGRAPHIC ANGIOGRAPHY (CTA) AND MAGNETIC RESONANCE ANGIOGRAPHY (MRA) FOR DIAGNOSIS OF CAI AND VAI

	CAI	VAI
CTA		
Sensitivity	47%	53%
Specificity	99%	99%
MRA		
Sensitivity	50%	47%
Specificity	100%	97%

CAI, carotid artery injury; VAI, vertebral artery injury.



Miller *et al*. Prospective screening for blunt cerebrovascular injuries. *Annals of Surgery*. 2002

Stiell, I. et al. N Engl J Med 2003;349:2510-2518

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Clearing the Cervical Spine

Table 1. The NEXUS Low-Risk Criteria.*

Cervical-spine radiography is indicated for patients with trauma unless they meet all of the following criteria:

- No posterior midline cervical-spine tenderness,†
- No evidence of intoxication,‡
- A normal level of alertness,§
- No focal neurologic deficit,¶ and
- No painful distracting injuries.‖

* Criteria are from Hoffman and colleagues.[26]

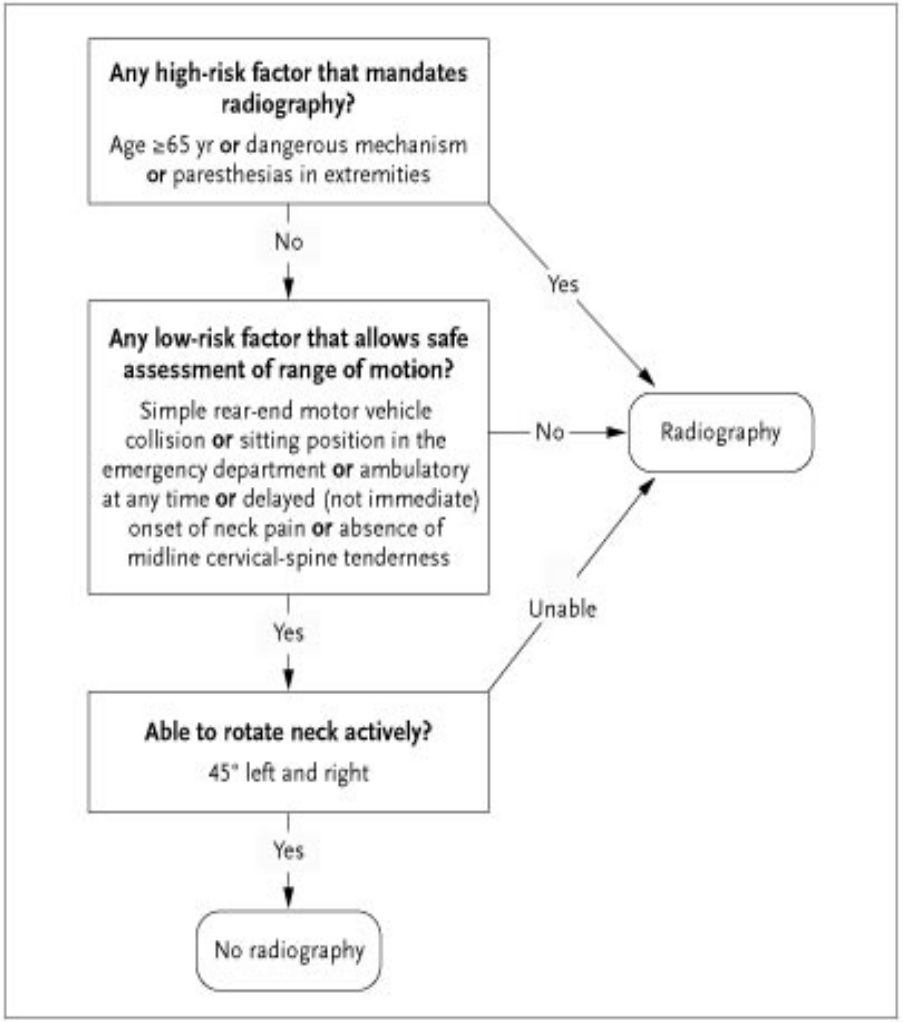
† Midline posterior bony cervical-spine tenderness is present if the patient reports pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient evinces pain with direct palpation of any cervical spinous process.

‡ Patients should be considered intoxicated if they have either of the following: a recent history provided by the patient or an observer of intoxication or intoxicating ingestion, or evidence of intoxication on physical examination such as an odor of alcohol, slurred speech, ataxia, dysmetria, or other cerebellar findings, or any behavior consistent with intoxication. Patients may also be considered to be intoxicated if tests of bodily secretions are positive for alcohol or drugs that affect the level of alertness.

§ An altered level of alertness can include any of the following: a Glasgow Coma Scale score of 14 or less; disorientation to person, place, time, or events; an inability to remember three objects at five minutes; a delayed or inappropriate response to external stimuli; or other findings.

¶ A focal neurologic deficit is any focal neurologic finding on motor or sensory examination.

‖ No precise definition of a painful distracting injury is possible. This category includes any condition thought by the clinician to be producing pain sufficient to distract the patient from a second (neck) injury. Such injuries may include, but are not limited to, any long-bone fracture; a visceral injury requiring surgical consultation; a large laceration, degloving injury, or crush injury; large burns; or any other injury causing acute functional impairment. Physicians may also classify any injury as distracting if it is thought to have the potential to impair the patient's ability to appreciate other injuries.



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Characteristics of the 8283 Study Patients

No kids and few elderly

Table 2. Characteristics of the 8283 Study Patients.*

Characteristic	Value	Characteristic	Value
Age — yr		Characteristics of motor vehicle collision — no. (%)	
Mean	37.6±16	Simple rear-end collision	1812 (21.9)
Range	16–100	Ejection from vehicle	68 (0.8)
Male sex — no. (%)	4328 (52.3)	Rollover	444 (5.4)
Mechanism of injury — no. (%)		Death of other(s) in same collision	42 (0.5)
Motor vehicle collision	5564 (67.2)	Head-on collision	263 (3.2)
Motorcycle collision	78 (0.9)	Time from injury to assessment (hr)	4.1±16.2
Collision involving other motorized vehicles	53 (0.6)	Arrived at hospital by ambulance — no. (%)	5210 (62.9)
Pedestrian struck and thrown	107 (1.3)	Transferred from another institution — no. (%)	476 (5.7)
Pedestrian struck	158 (1.9)	Cervical-spine radiography performed — no. (%)	5936 (71.7)
Bicycle struck	96 (1.2)	Telephone follow-up required — no. (%)	2338 (28.2)
Bicycle collision	61 (0.7)	Acute cervical-spine injury — no. (%)	217 (2.6)
Other bicycle accident	105 (1.3)	Fracture	209 (2.5)
Fall from elevation >10 ft (3 m) or down >15 stairs	183 (2.2)	Dislocation	71 (0.9)
Fall from elevation of 3 to 10 ft (1 to 3 m) or down 5 to 15 stairs	350 (4.2)	Ligamentous instability	8 (0.1)
Fall from elevation <3 ft (1 m) or down <5 stairs	641 (7.7)	"Clinically important" cervical-spine injury — no. (%)†	169 (2.0)
Assault with a blunt object	73 (0.9)	Development of neurologic deficit — no. (%)	45 (0.5)
Assault with fist or feet	199 (2.4)	Stabilizing treatments — no. (%)	180 (2.2)
Diving	25 (0.3)	Internal fixation	44 (0.5)
Fall onto head (axial load)	32 (0.4)	Halo	45 (0.5)
Contact sports (axial load)	88 (1.1)	Brace	13 (0.2)
Heavy object onto head (axial load)	74 (0.9)	Rigid collar	81 (1.0)
Other sports	166 (2.0)	Admitted to hospital — no. (%)	430 (5.2)
Head struck by other object	106 (1.3)		
Hit head on an object	101 (1.2)		
Other	23 (0.3)		

* Plus–minus values are means ±SD.

† "Clinically important" cervical-spine injury was defined as any injury except an isolated avulsion fracture of an osteophyte; an isolated fracture of a transverse process not involving a facet joint; an isolated fracture of a spinous process not involving lamina; and a simple compression fracture with less than 25 percent loss of vertebral body height. All clinically important injuries were detected at the initial visit to the emergency department.

Sensitivity, Specificity, and Negative Predictive Value of the Two Rules for 162 Cases of "Clinically Important" Injury among 7438 Patients

Table 4. Sensitivity, Specificity, and Negative Predictive Value of the Two Rules for 162 Cases of "Clinically Important" Injury among 7438 Patients.*

Result of Assessment	Canadian C-Spine Rule		NEXUS Criteria	
	Injury	No Injury	Injury	No Injury
Positive (no.)	161	3995	147	4599
Negative (no.)	1	3281	15	2677
Sensitivity (%)	99.4 (95% CI, 96–100)†		90.7 (95% CI, 85–94)†	
Specificity (%)	45.1 (95% CI, 44–46)†		36.8 (95% CI, 36–38)†	
Negative predictive value (%)	100		99.4	

* A total of 845 cases were classified as indeterminate and are therefore omitted from this analysis.
† P<0.001. CI denotes confidence interval.

Table 5. Characteristics of Patients with Cervical-Spine Injury Not Identified by Decision Rules.

Patient	Age	Sex	Mechanism of Injury	CCR-Positive Criterion	Injury	Hospitalized	Treatment
	yr						
Clinically important injuries							
1	21	M	Heavy object fell on head	Dangerous mechanism	C1 arch fracture	No	Hard collar
2	67	M	Motor vehicle collision, head-on	Age ≥65 yr, dangerous mechanism	C2 odontoid fracture	Yes	Halo
3	42	M	Fall >10 ft (3 m)	Dangerous mechanism	C7 body fracture	Yes	Hard collar
4	18	M	Motor vehicle collision	None	C2 odontoid fracture	No	Hard collar
5	71	F	Pedestrian struck and thrown	Age ≥65 yr, dangerous mechanism	C4 pedicle fracture	Yes	Hard collar
6	36	M	Motor vehicle collision, rollover, ejected	Dangerous mechanism, paresthesias	C7 body or pedicle fracture	Yes	Internal fixation
7	50	M	Fall >5 stairs	Dangerous mechanism, paresthesias	C5–C6 perched facet	Yes	Hard collar
8	20	M	Contact sports, axial load	Dangerous mechanism, paresthesias	C7 pedicle fracture	Yes	Hard collar
9	24	M	Fall >10 ft (3 m)	Dangerous mechanism	C7 compression fracture	Yes	Internal fixation
10	18	M	Motor vehicle collision, rollover, ejected	Dangerous mechanism	C2 hangman's fracture	Yes	Halo
11	71	M	Fall >10 ft (3 m)	Age ≥65 yr, dangerous mechanism	C6–C7 facet fracture	Yes	Hard collar
12	29	M	Contact sports, axial load	Dangerous mechanism	C5–C6 perched facet	Yes	Halo
13	31	M	All-terrain vehicle, ejected	Dangerous mechanism	C1 arch fracture	Yes	Hard collar
14	56	M	Motor vehicle collision, rollover	Dangerous mechanism	C7 bilateral laminar fracture	Yes	Hard collar
15	49	F	Fall >5 stairs	Dangerous mechanism	C1 arch facet fracture	Yes	Hard collar
16	35	M	Motor vehicle collision, head-on	None — CCR indeterminate	C1–C2 ligamentous instability	No	Hard collar
Clinically unimportant injuries							
1	20	M	Pedestrian struck	Dangerous mechanism	C7 spinous-process fracture	No	None
2	35	M	Fall >5 stairs	Paresthesias	C7 spinous-process fracture	No	Hard collar
3	22	M	Fall >10 ft (3 m)	Dangerous mechanism	C1 body avulsion fracture	Yes	Hard collar
4	75	M	Motor vehicle collision, high speed	Age ≥65 yr, dangerous mechanism	C2 body avulsion fracture	Yes	Hard collar
5	58	M	Fall, 3 to 10 ft (1 to 3 m)	Dangerous mechanism	C6 osteophyte fracture	No	None
6	17	M	Motor vehicle collision	None	C3 body avulsion fracture	No	Hard collar
7	21	M	Motor vehicle collision, head-on	Dangerous mechanism	C5 body avulsion fracture	No	None
8	94	F	Fall <3 ft (1 m)	Age ≥65 yr	C3 spinous-process fracture	No	None
9	73	M	Fall >5 stairs	Age ≥65 yr, dangerous mechanism	C2 spinous-process fracture	No	None

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Clearing the Cervical Spine

- **Neck pain, negative CT**
  - **MRI negative, no late decompensation**
  - **(93 patients Shuster *et al Arch Surg* 2005)**
- **Obtunded or unreliable**
  - **MRI negative 354/366, picked up cord contusion**
  - **MRI negative for ligamentous injury 362/366**
    - 4 incidental sprains
  - **CT negative predictive value 98.9% ligamentous injury**
  - **CT negative predictive value 100% for instability**
  - **(Hogan *et al Radiology* 2005)**

OK to clear the spine based on good quality CT images with reconstructions except in the spondylotic spine!

Summary

- Successful treatment based on knowledge of anatomy, mechanism of injury and compromise of bone and/or soft tissue
- Stabilization of the spine
- Decompression of neurological deficit
- Restore alignment
- Restore function

Thank You!

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