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Author(s): Stephen Hartsell (University of Utah), MD, FACEP 2012

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“The role of radiography in the initial evaluation of C-Spine Trauma”

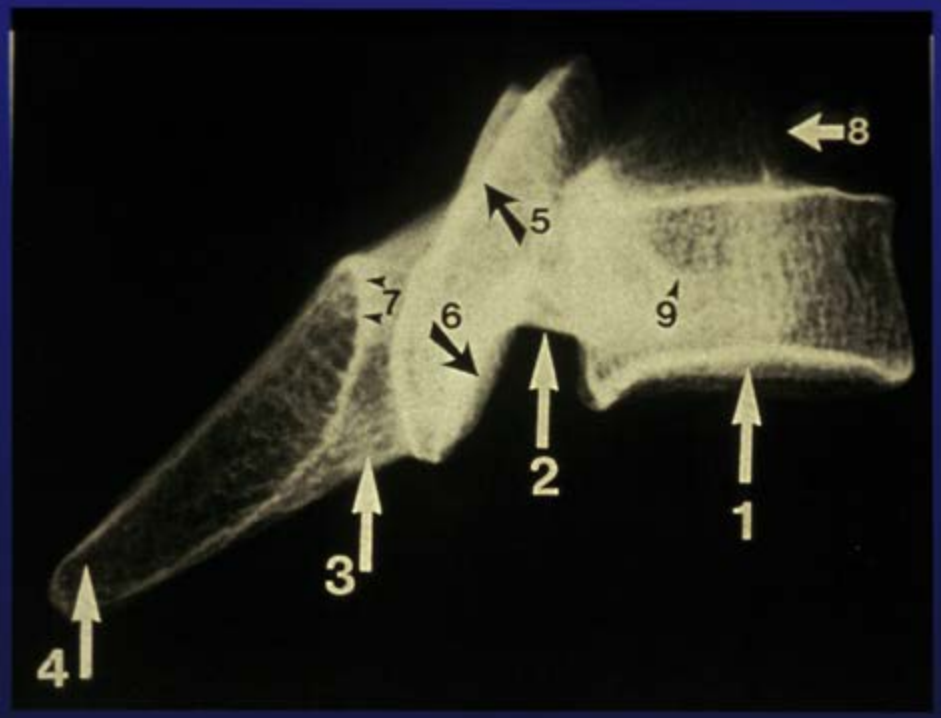
Stephen Hartsell MD, FACEP
Director of Education
Division of Emergency Medicine
University of Utah

OBJECTIVES

- Better understand normal radiographic anatomy
- Standardized approach to reading c-spine radiographs
- Review of common cervical spine injuries seen in the blunt trauma patient and their significance
- Discuss using NEXUS as a framework; who to x-ray, which studies needed to adequately screen for CSI and appropriate use of advanced imaging

Normal Radiographic Anatomy

Normal Lower Cervical Vertebra



1) Vertebral end-plate
2) Pedicle
3) Laminae
4) Spinous process
5) Superior facet
6) Inferior facet
7) Spinolaminar line
8) Uncinate process

ABCs of the C-Spine

- Alignment, Adequacy
- Bony Element
- Cartilage Space, Connective Tissue
- Soft Tissue

Cross Table Lateral View Alignment/Adequacy

- C7 –T1 thru post. F. Magnum
- ALL & PLL
- Spinolaminar Line
- Tips of Spinous Processes
- Predental Space <=3mm
- Basion Dental interval (BDI)
- Basion Axial Interval (BAI)

CTLV – Alignment
BDI, BAI <= 12mm

Pseudosubluxation C2

CTLV – Bony elements
Density & Symmetry

- Ant. & post. Cortices body
- Sup. & Inf. Endplates
- Ring of C2
- Transverse processes
- Pedicles
- Articular Masses
- Sup. & Inf. Facets
- Laminae
- Spinous processes
- C1-2 and C5-7

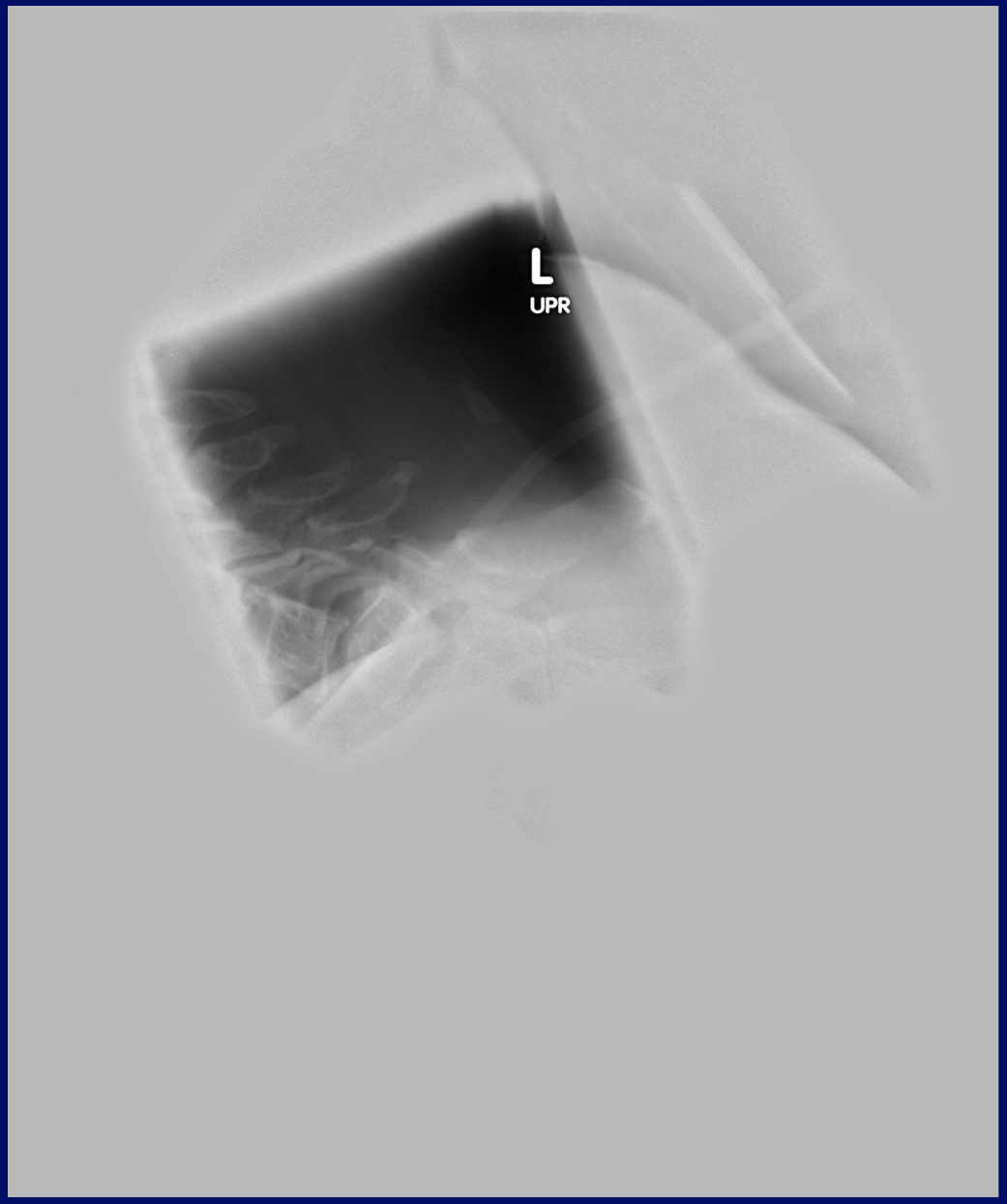
Cartilage space and connective tissue

- Intervertebral disc
- Interfacetal joints
- Interlaminal space
- Interspinous space

Soft Tissue

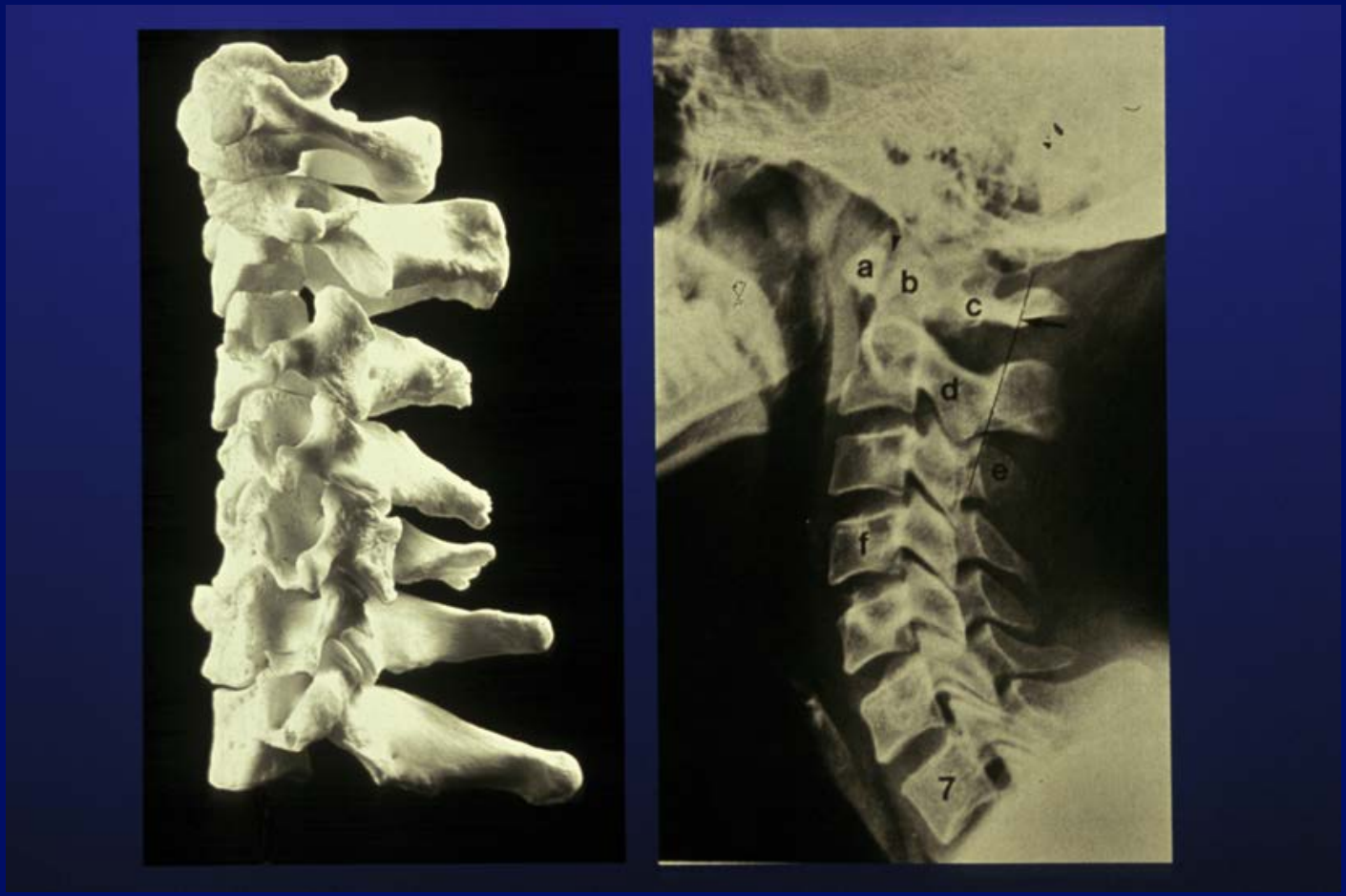
- Retropharyngeal space
  <= 6mm
- Retrotracheal space
  <= 22mm
- Cervical esophagus at
  C4-5
- Absolute measurement not
  reliable, sensitivity~5%
  lower C-spine

Is This An Adequate CTLV ?



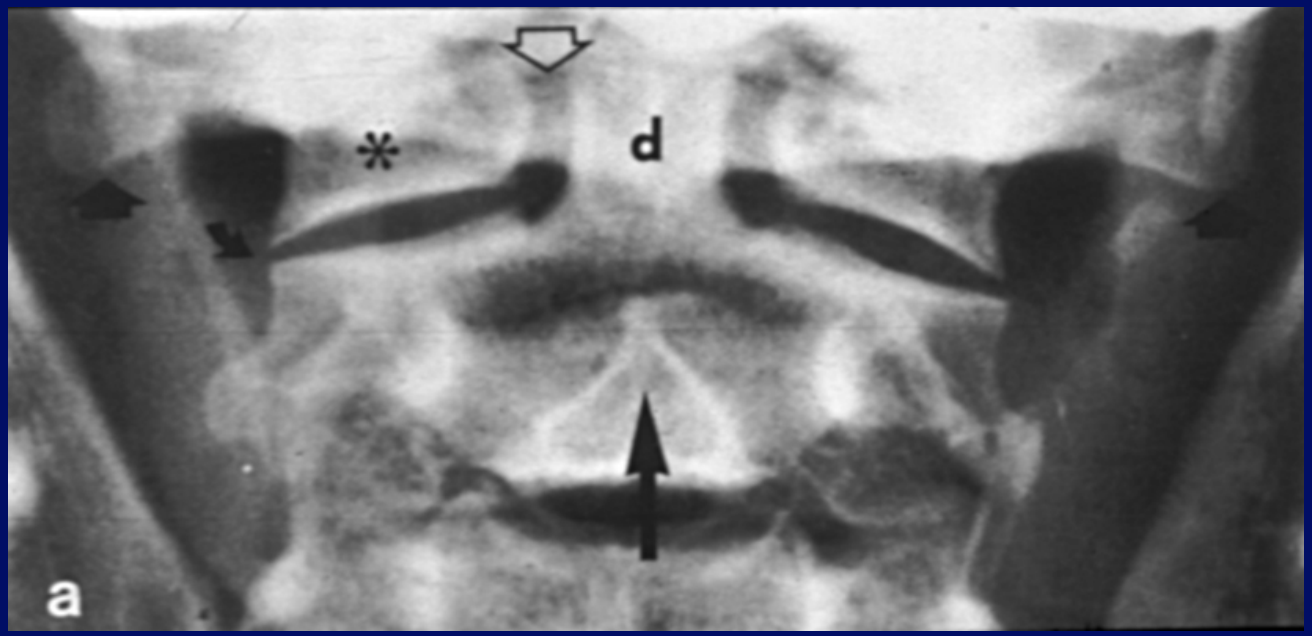
Source Undetermined

Anatomy of the cervicocranium

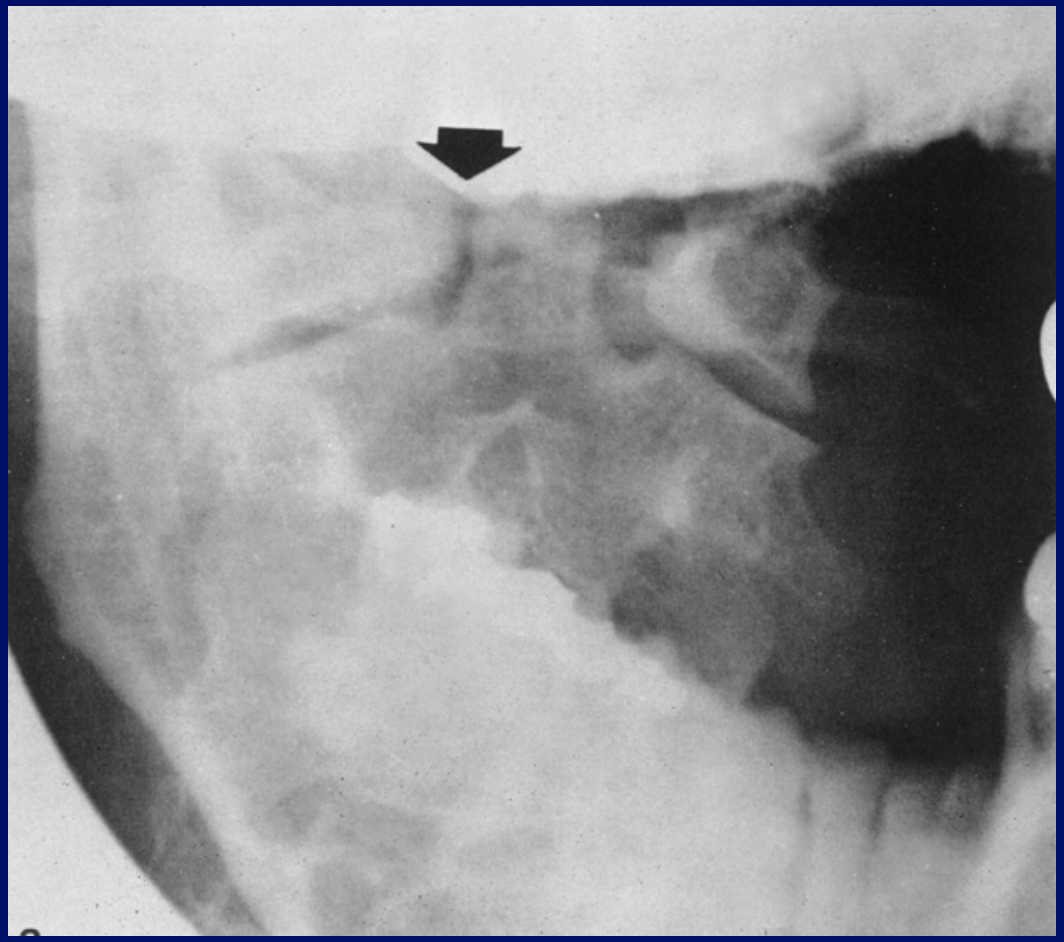


Odontoid view (open mouth) Alignment

- Odontoid process located between lat. masses of axis
- Lateral margins of atlanto-axial facet joints
- Bifid spinous process midline
- w/o tilt or rotation

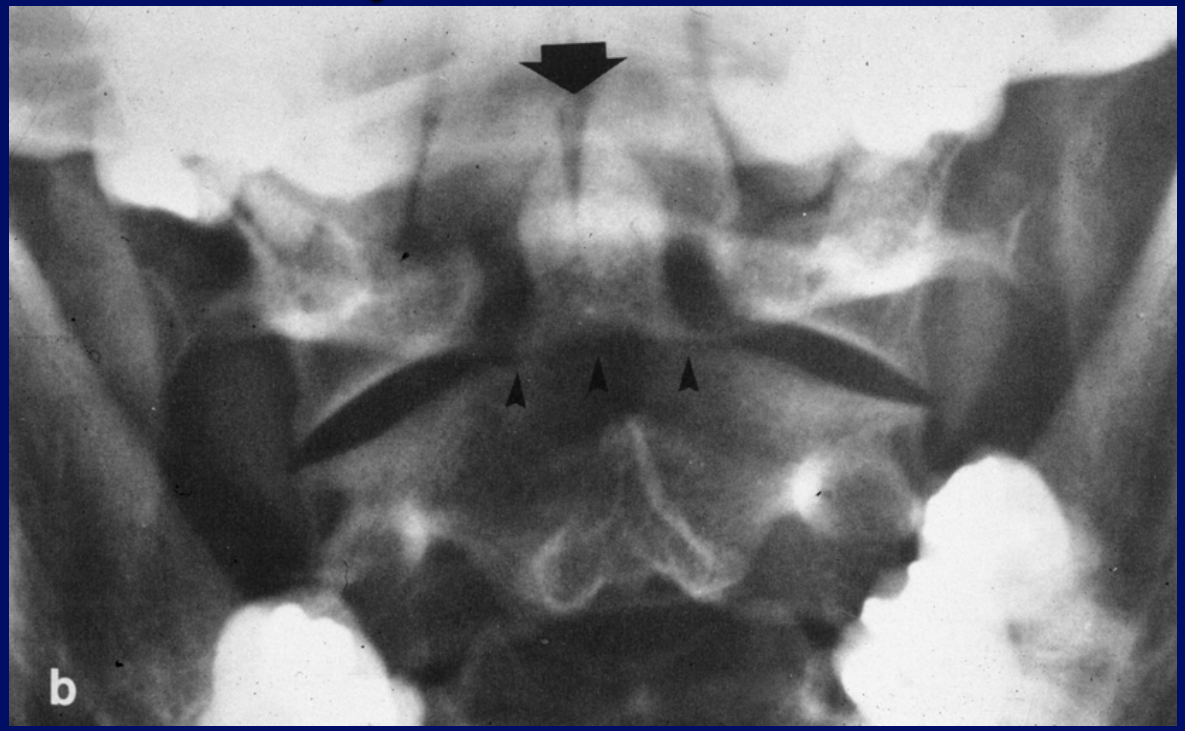


Odontoid view w/ rotation



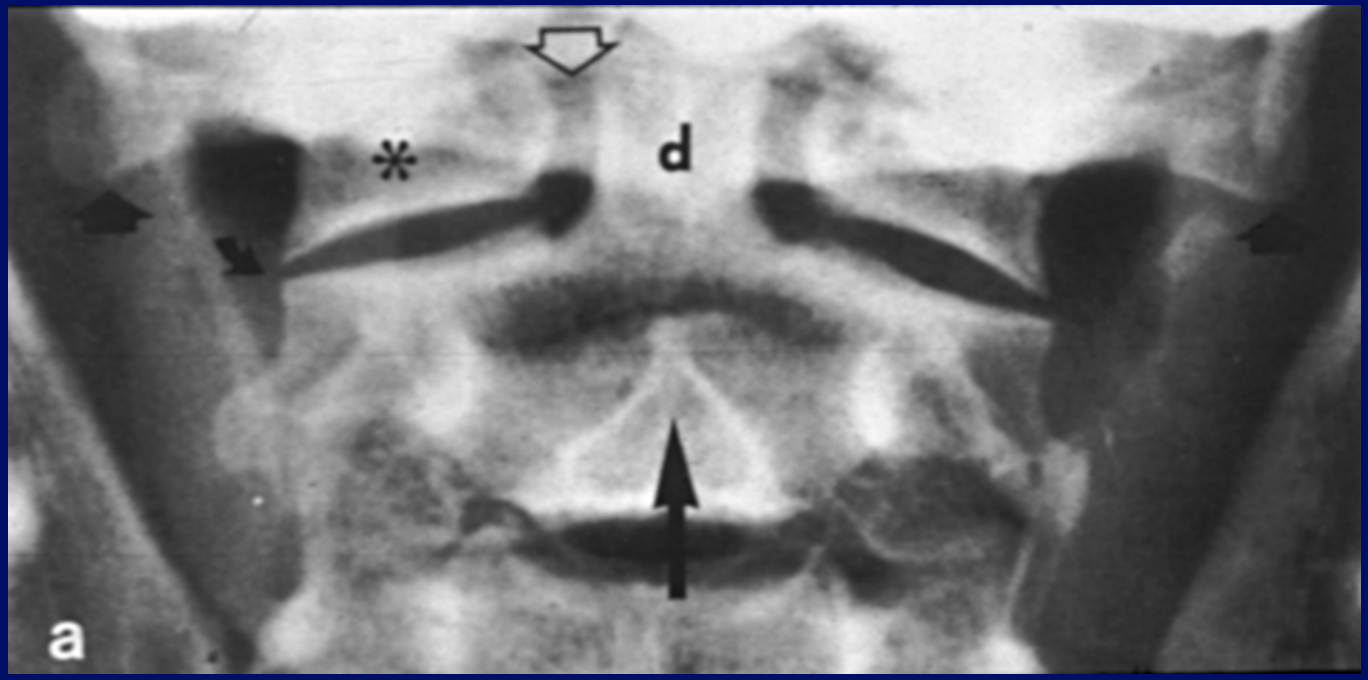
Odontoid view
Bony elements

- Odontoid and artifacts
- C1 lateral masses
- C2 vertebral body



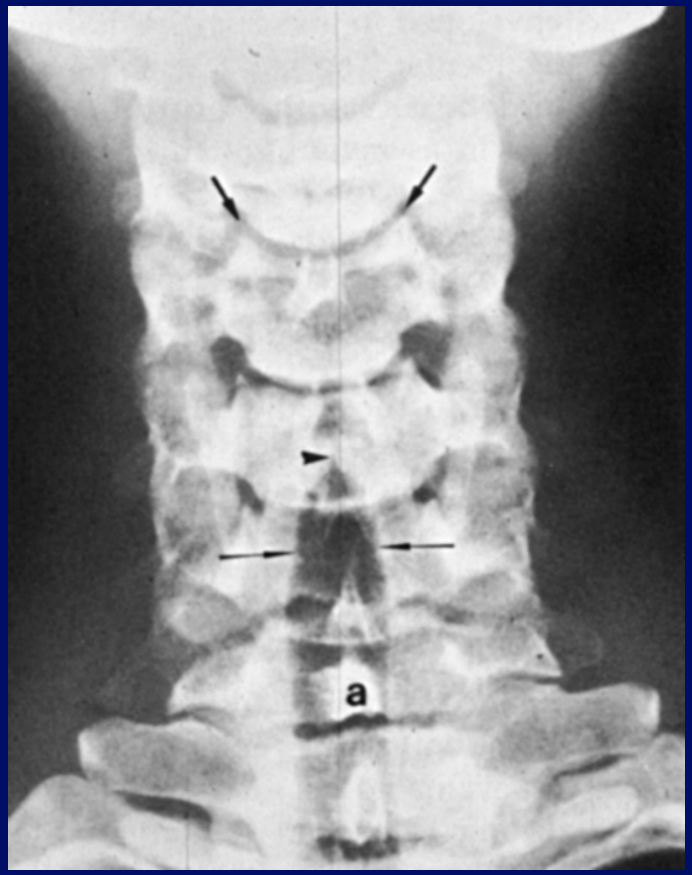
Odontoid view
Cartilage space

- Interfacetal joints



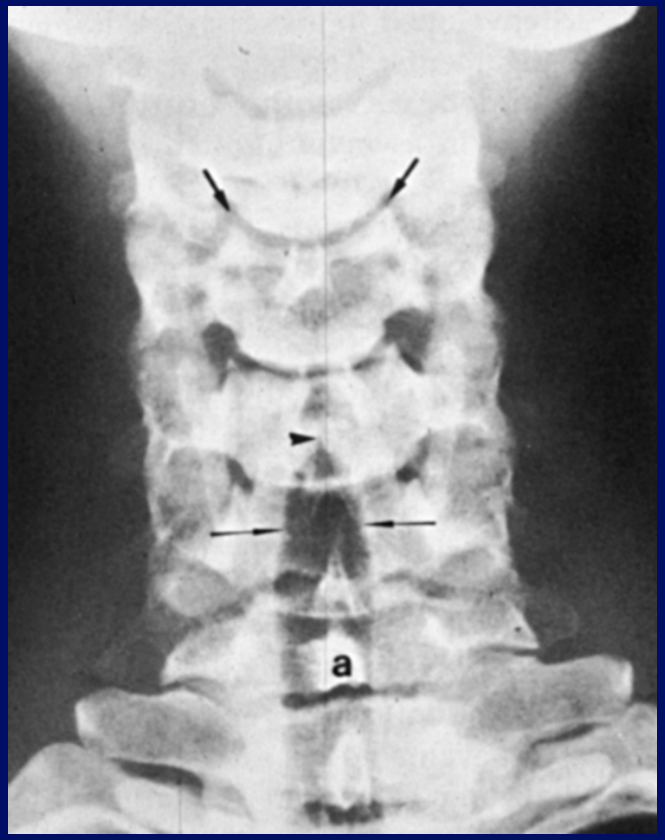
A-P View Alignment

- Spinous processes midline
- Tracheal air shadow



A-P View
Bony elements

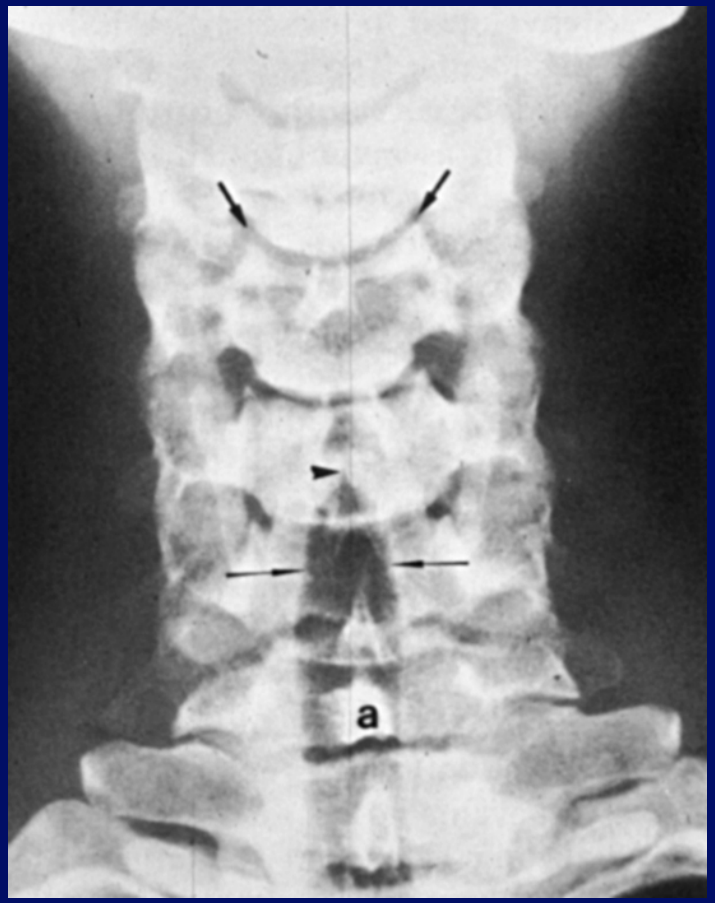
- Vertebral bodies
- Sup. & Inf. Endplates
- Uncinate processes
- Articular masses
  - Lateral columns



A-P view

Cartilage space and connective tissue

- Intervertebral disc space
- Interspinous space
- Joints of Luschka



Swimmer's View

- For evaluation of C7-T1 interface when CTLV is inadequate
- Posterior C7 not well visualized
- Use only when suspicion of injury is low

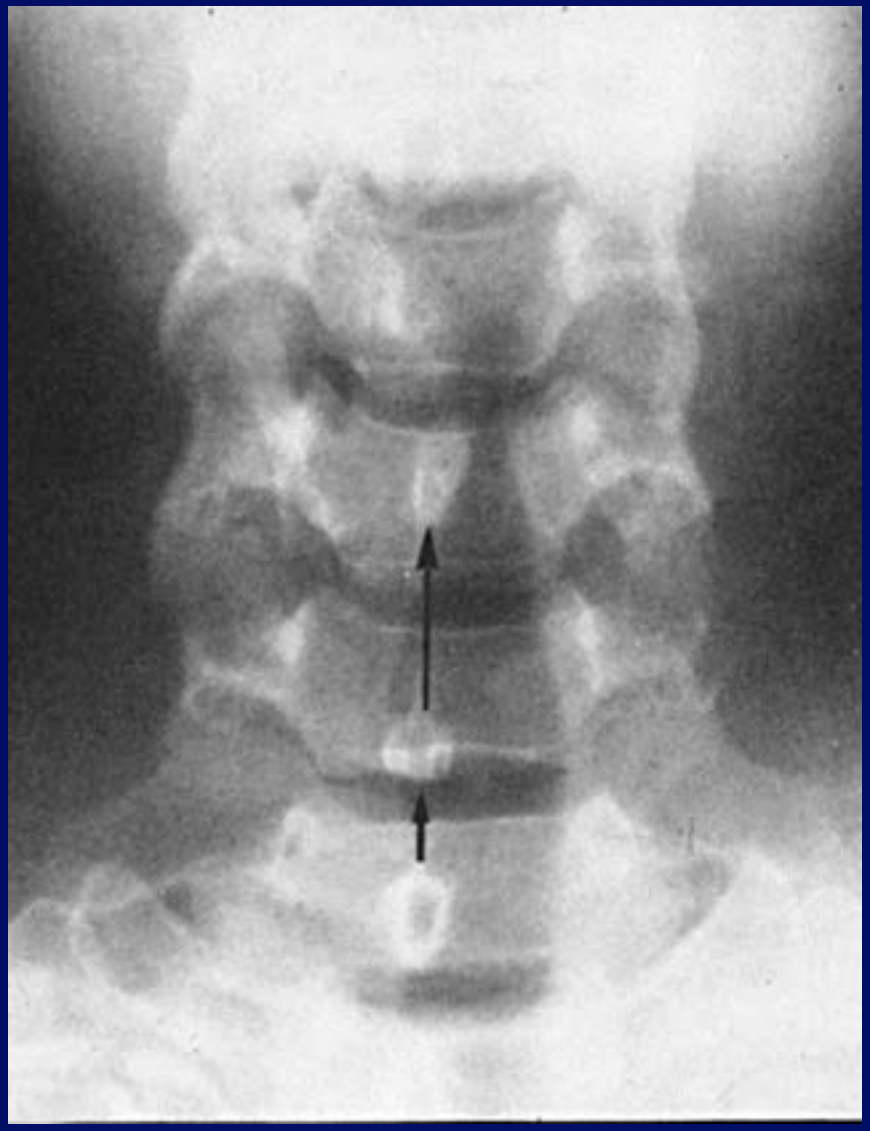
CSI by Mechanism

Hyperflexion

Hyperflexion Strain

- Hyperkyphosis at level of injury
- Ant. displacement Vertebral Body > 2mm
- Disruption post. Ligamentous complex
- Interspinous & Interlaminal fanning
- Disc space widened post. And narrowed ant.

Hyperflexion Strain (cont)

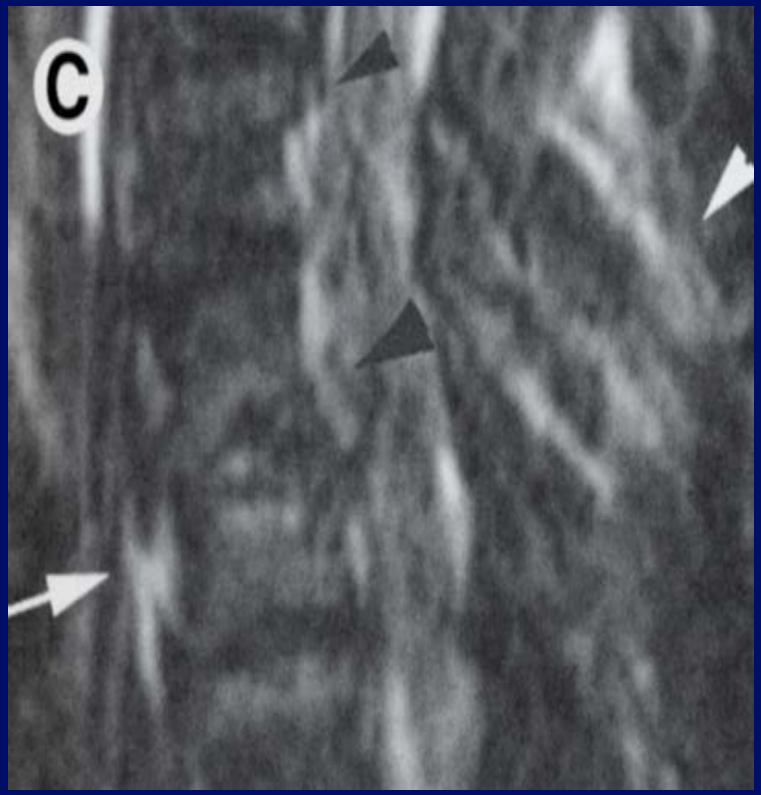


Hyperflexion Strain (cont)

- Soft Tissue Swelling may be only evidence CSI.
- Loss of cervical esophagus highly suspicious of CSI
- Flexion film shows anterolisthesis C4 on C5 with upward and forward movement of inferior facet
- 30% to 50% incidence delayed instability

Hyperflexion Strain
MRI

- Sagittal STIR image
- Ruptured ALL
- Ruptured PLL
- Abnormal signal throughout interspinous and supraspinous ligaments



Bilateral Facet Dislocation

- Dislocation of bilat. facet joints
- All ligamentous structures disrupted
- Ant. Displacement => 50% A-P diameter subjacent vertebral body
- Purely soft tissue injury w/ pre - vertebral STS
- Unstable

Bilateral Facet Dislocation (cont)

Bilateral Facet Dislocation
CT

Flexion Teardrop Fracture

Marked prevertebral STS

Retropulsion of fragments into spinal canal

Anterior Cord Syndrome
- Quadriplegia
- loss pain, pinprick, temp
- preserve post. column
  - (vib.,pressure, proprio)

Hyperflexion with rotation

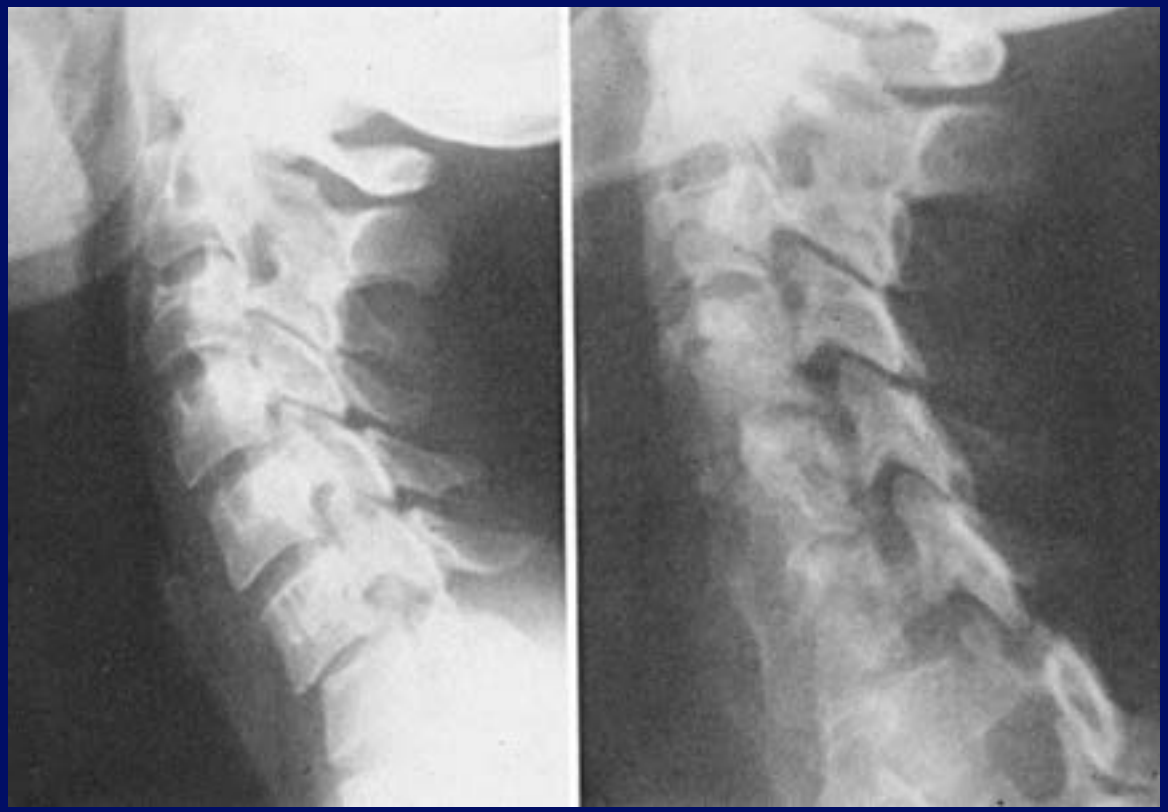
Unilateral Facet Dislocation

Unilateral Facet Dislocation

- Ant. Subluxation of vertebral body <= 25% AP diameter
- Ant. Dislocation of one articular mass inferior facet
- Rarely assoc. w/ neuro deficit of nerve root distribution
- Mechanically stable

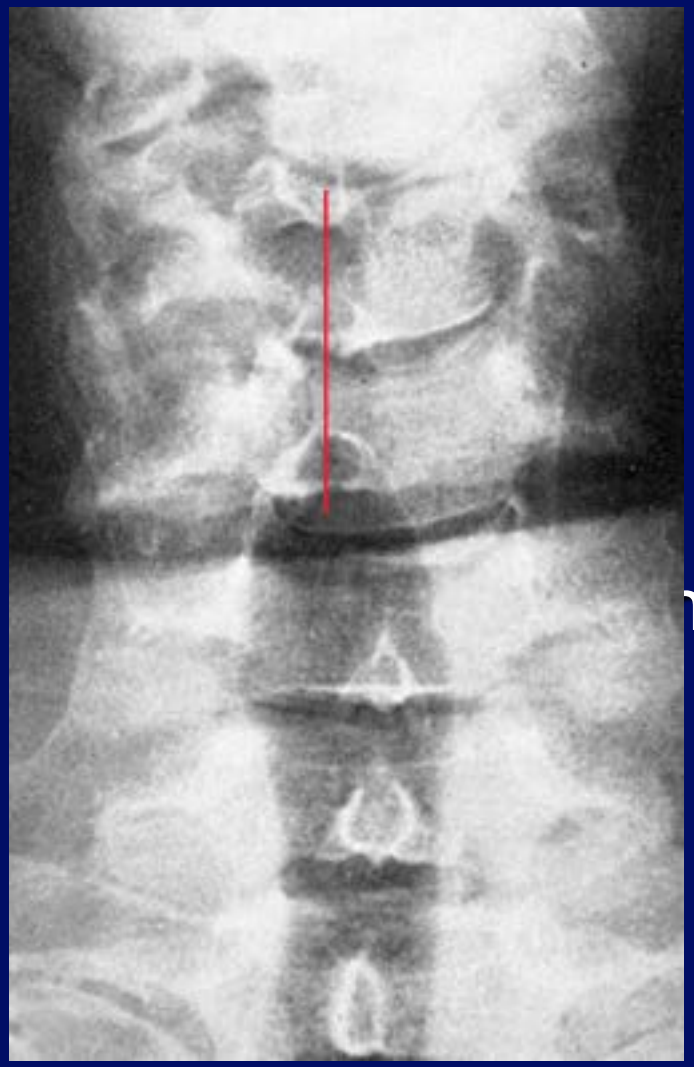
Unilateral Facet Dislocation (cont)

- Dislocated Articular mass stuck in subjacent intervertebral Foramina (locked)
- Obliques to confirm site of dislocation



Unilateral Facet Dislocation (cont)

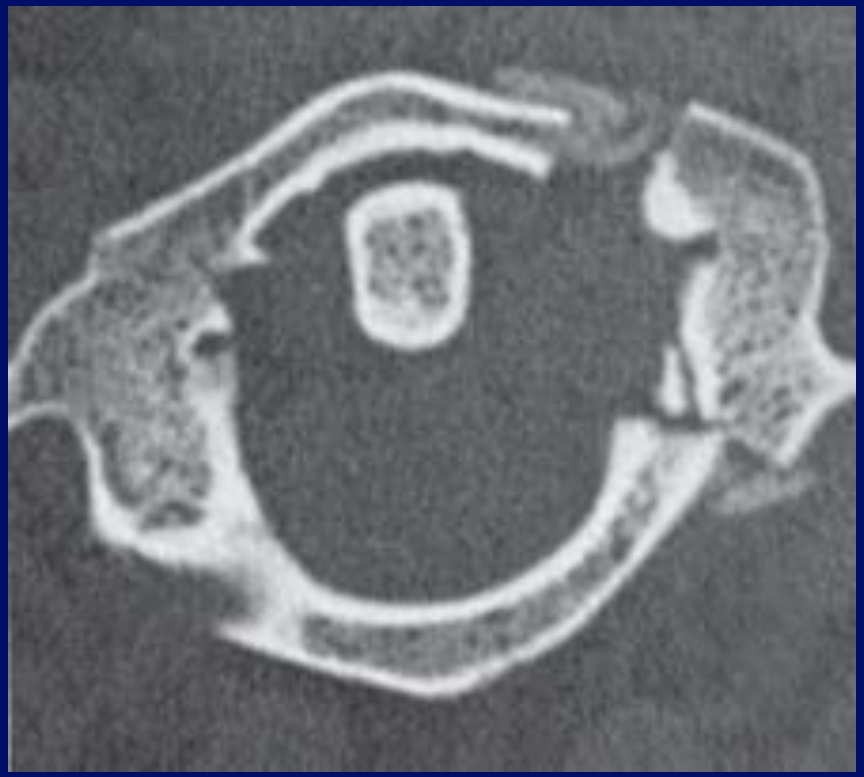
- A-P view – spinous process at level of dislocation displaced towards



Vertical Compression

Jefferson Fracture of C1

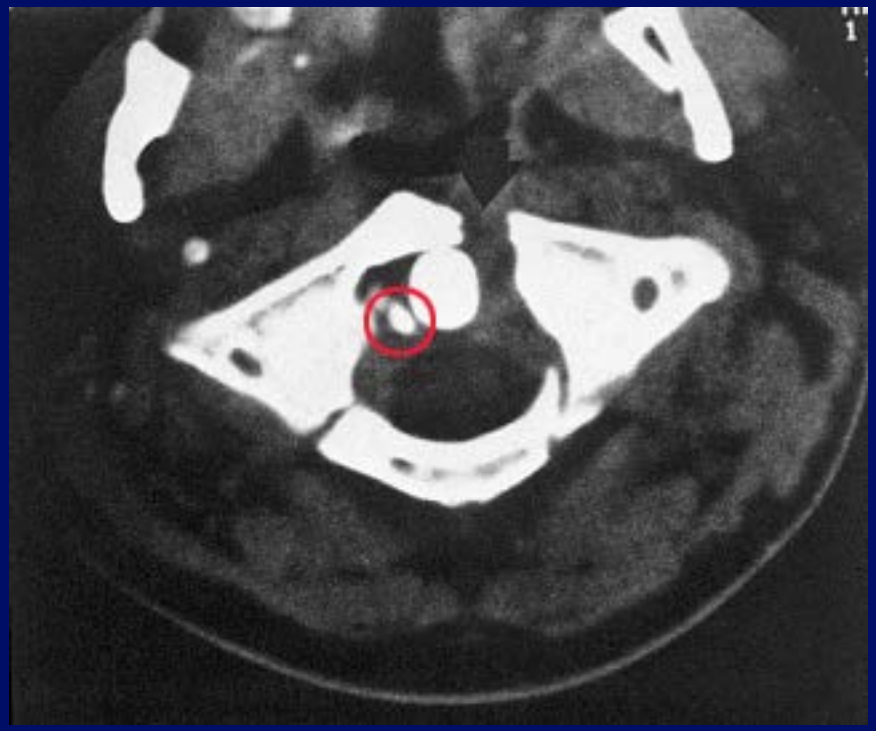
- At least one Fracture through the ant. & post. Arch
- Lateral expulsion of the lateral masses of C1
- TAL avulsion or rupture with increased AADI
- Retropharyngeal swelling



Jefferson Fracture C2 (cont)

- Lat. displacement of C1 articular masses on odontoid view
- Coronal CT reformations – disruption of occiputal-C1 articulation, displacement C1 lat. mass

Jefferson Fracture (textbook)
Odontoid view and axial CT



Burst Fracture

Intrusion of NP into vertebral body

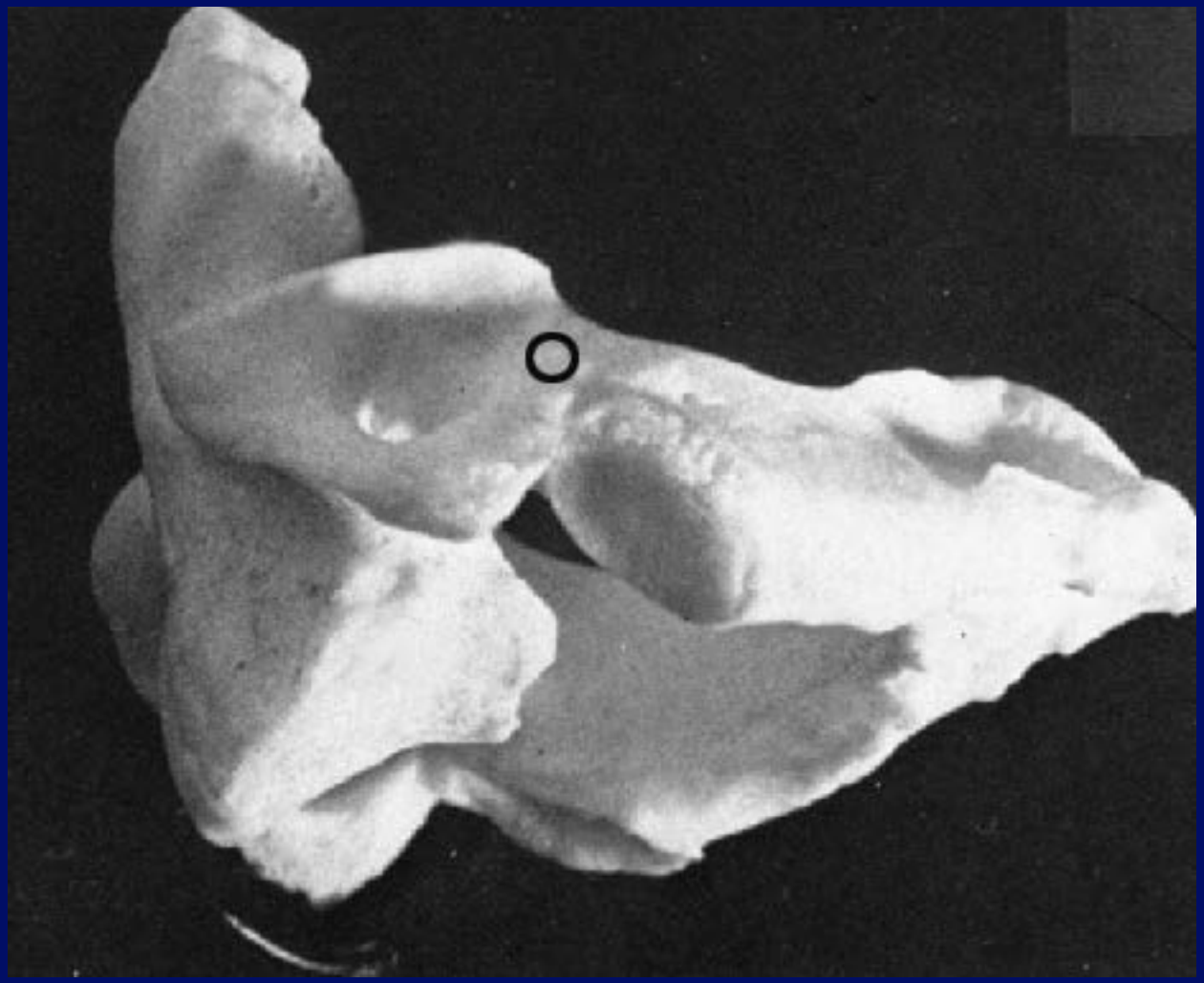
Retropulsion fracture fragments

Hyperextension

Hangman's Fracture
Traumatic Spondylolisthesis

- Bilateral Pars Interarticularis Fx
- Type I – III
- Ant. Displacement C2 vertebral body
- Disruption intervertebral disc
- Dislocation C2-3 Facet Joints
- Displaced & angulated posterior arch
- STS
- Mechanically unstable

Hangman's Fracture



Myelopathy and the Cervicocranium

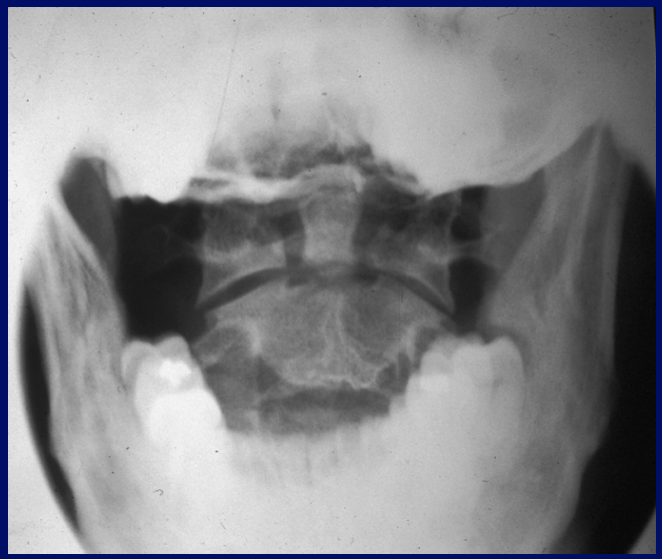
A-P diameter > at this level of the C-spine

Auto decompression

Diverse Mechanisms

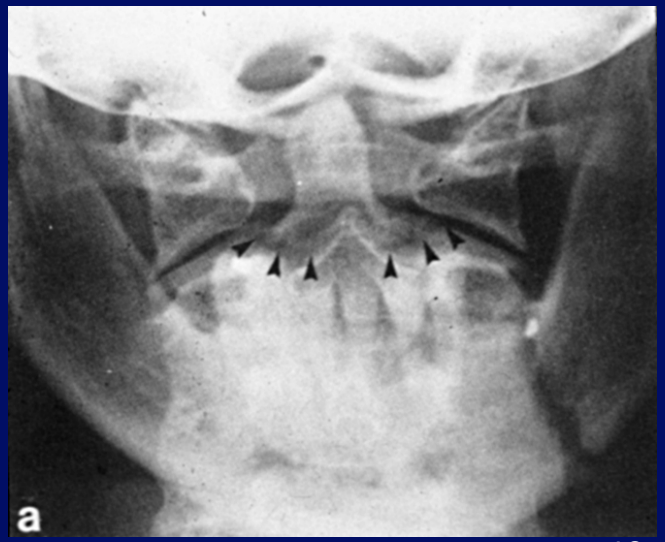
Odontoid Fracture

- Hi (type II) Fracture
- Soft Tissue Swelling
- +/- Odontoid Displacement
- Fracture at base of Odontoid
- Most common type
- Unstable, 26-36% nonunion



Odontoid Fracture

- Low (Type III)
- Disruption “ Ring of C2” on CTLV
- Fracture upper C2 vertebral body
- +/- prevertebral soft tissue swelling
- Unstable, better prognosis than Type II



NEXUS

National Emergency X-Radiography Utilization Study

Validity Of A Set Of Clinical Criteria To Rule Out Injury To The Cervical Spine In Patients With Blunt Trauma

- Hoffman J., et al NEJM 2000;343:94-9
- Prospective, Observational Multicenter Study
- 34,069 patients w/ Blunt Trauma who underwent C-spine imaging
- Examined the performance of a set of 5 clinical criteria to identify patients who have a low probability of cervical spine injury

Patients considered Low Prob. Injury if : Stable and met 5 Criteria

- No Midline Cervical Tenderness
- No Focal Neurological Deficit
- Normal Alertness
- No Intoxication
- No Painful Distracting Injury

Performance of Clinical Criteria

- 818 patients (2.4%) x-ray documented injury : missed 8
- 576 patients w/ clinically significant* injury : missed 2
- Sensitivity 99.0, NPV 99.8; Specificity 12.9 PPV 2.7
- Rate of missed CSI : 1 in 4000 patients
- * spinous, trans. process fx., wedge < 25%, osteophyte fx., type I odontoid, end-plate fx.

Conclusions

- Confirms validity of a decision instrument based on 5 clinical criteria for identifying blunt trauma patients who have extremely low probability of having CSI.
- Sensitivity ~ 100% for clinically significant injury
- Decrease in ordering of radiographs by 12.6%

Sons of Nexus

- Reliability of Standard 3- view series
- Value of F/E views in acute blunt trauma
- Distribution and Patterns of CSI

Use of Plain Radiography to Screen for Cervical Spine Injuries

- Mower WR, et al. AnnEM. July 2001;38;1-7
- 34,069 patients; 818 had total of 1,496 CSI (2.4%)
- Plain radiographs ; 932 CSI in 498 patients (1.4%) missed 564 CSI in 320 patients (.94%)
- Majority missed CSI; x-rays interpreted as abnormal but not dx or inadequate (.80%)
- 23 patients (.07%) had 35 CSI (3 ? Unstable) not visualized on adequate plain films
- 2.81% of all injured patients, 4.13% of 557 w/ adequate 3-view

Use of Plain Radiography (cont.) 35 missed CSI

- 3 (2 patients) dx on MRI
- 8 (6 patients) dx on Flex/Ext
- 29 (18 patients) dx on CT
- 1 detected on risk management review
- Sensitivity adequate 3-view 89%, NPV 99%
- Lamina & Post. arch most common site
- C 6-7 (48%) most common level followed by C 2 (20%)

Use of Plain Radiography (cont.) Conclusions

- Standard 3-view reliable screen in most blunt trauma patients.
- On rare occasions will fail to detect unstable injuries. (.20% of injuries,.008% all patients)
- Difficult to obtain adequate plain radiographic imaging in a substantial # patients. (30%)

Use of Flexion-Extension Radiographs of the Cervical Spine in Blunt Trauma

- Pollack CV Jr,et al. AnnEMJuly2001;38:8-11
- 818 patients w/ CSI, F/E ordered in 86
- 6 patients w/ CSI not seen on 3-view,none clinically significant
- 3 dislocations detected, all seen on 3-view
- 15 of 16 subluxations detected, 4 missed on 3-view*

Use of Flex/Ext (cont.) Conclusions

- Largest prospective study; adds very little to 3-view supplemented when appropriate w/ CT, MRI.
- MRI preferable evaluate Lig. Instability
- CT better to evaluate for occult Fx.

Distribution and Patterns of Blunt Traumatic Cervical Spine Injury

- Goldberg W,et al. Ann EM July 2001;38;17-21
- 34,069 patients, 818 (2.4%) radiographic CSI
- 1,195 Fractures & 231 Subluxations or dislocations

Distributions and patterns (cont) RESULTS

- C2 most common site of fracture (23.9%)
- C3 least likely to be injured
- C5-6 & C6-7 most common level of dislocation
- 240 patients (29.3%) clinical insign. CSI
- 32.3% patients > 50 years, had 45.3% of all atlantoaxial injuries

Advanced Imaging
CT Scan

- CT detects 97-100% of Fractures but accuracy in detecting purely ligamentous injury not documented
- Limited in patients with severe degenerative disc disease
- Inability to detect axially oriented fractures, lig.injury and facet subluxation largely overcome on current scanners if thin cuts and multiplanar reformations (MPR).

Advanced Imaging
MRI

- MRI highly sensitive in detection of ligamentous injury but my be too sensitive
- Much less sensitive than CT in detection of fractures to the posterior arch and injuries to the craniocervical junction.
- In patients with neurologic deficits, MRI is the study of choice to define cord injury or impingement