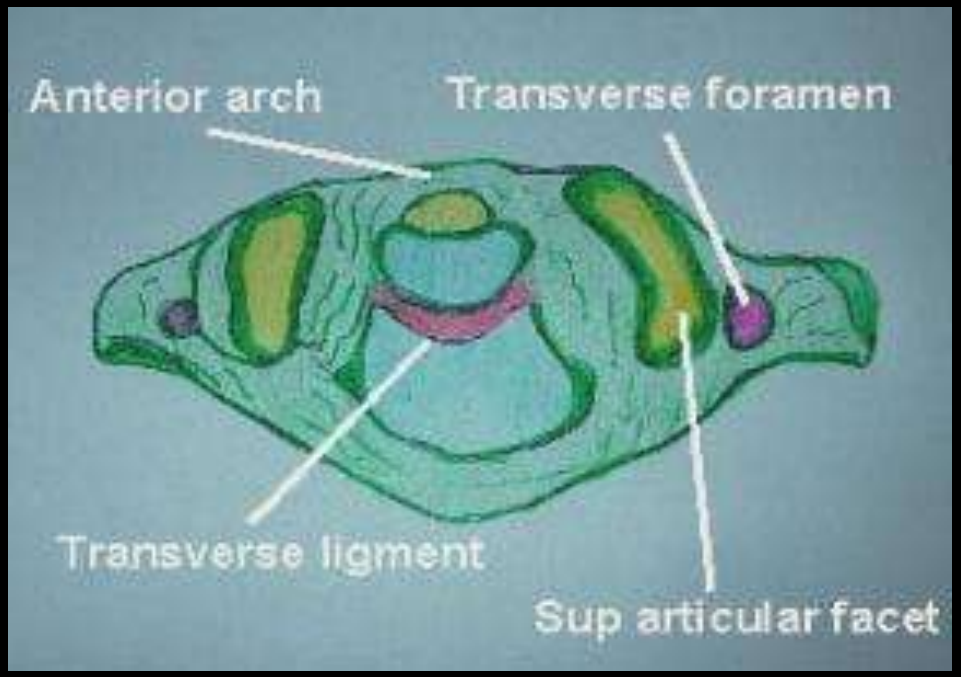
Practical approach to Cervical Spine Trauma

- Dr. Donald E. Olofsson

Acknowledgments

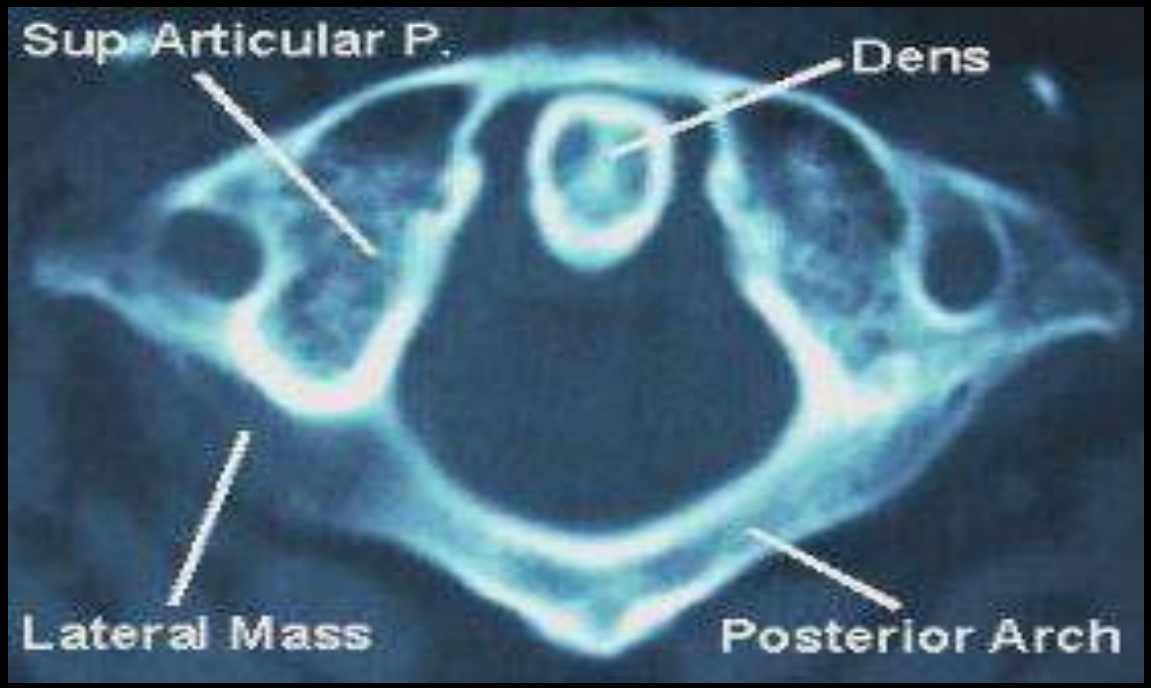
- *A sincere and special thanks to Dr. Tudor Hughes for his inspiration, outstanding teaching and for his images.*

This was my best attempt.



With Tudors help.

- Very professional.



Overview

Overview

- Readout
- Anatomy
- Technique
- Trauma

Overview

- The scout view and reconstruction.
- Plain films: In and out of collar, flexion and Extension views
- CT, series included and reconstructions
- Stable vs. unstable
- A few classifications

Overview

- Reading Algorithm

Reading Algorithm

- The scout view.
- Soft tissues including brain,tubes and lines.
- Bony alignment.
- Facet joint alignment.
- Look at common sites of fractures and the second fracture.
- Other bones, and maximal STS.

The scout view (The hidden view)

- Also known at the Naval Hospital as…The staff view, the overview, the First view.
- Almost always included…Not always pushed to PACS and not always viewed.

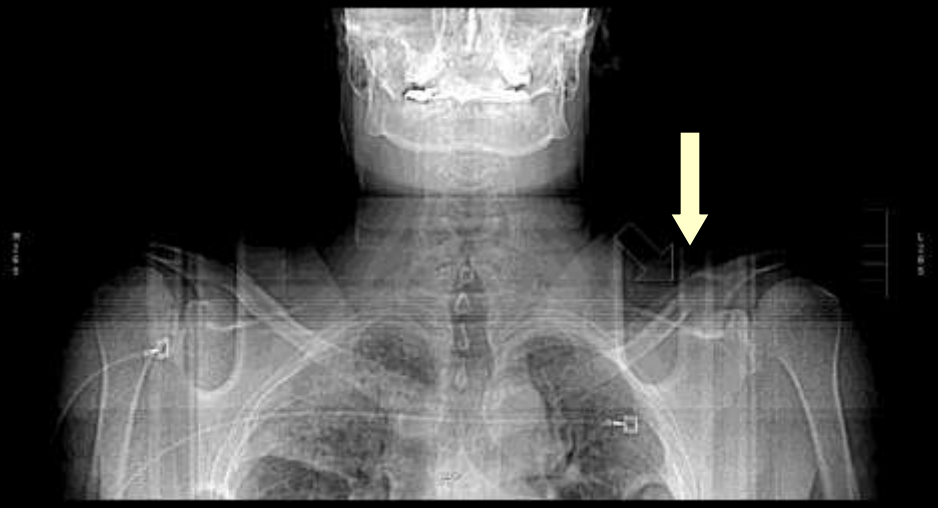
The scout view

- Within voice recognition (AGFA Talk) template you can add. [The scout view is unremarkable.]

There may be a free lateral view.

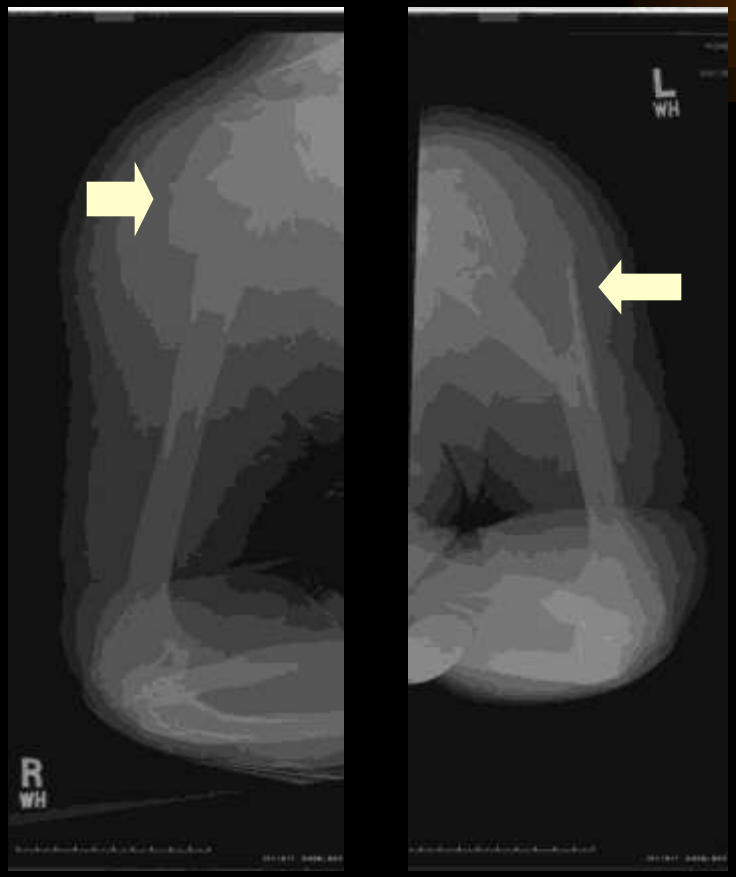
A nice frontal view.

You may find the cause of pain.



Scout view with humeral fractures

These were known fractures.



Scout view unremarkable

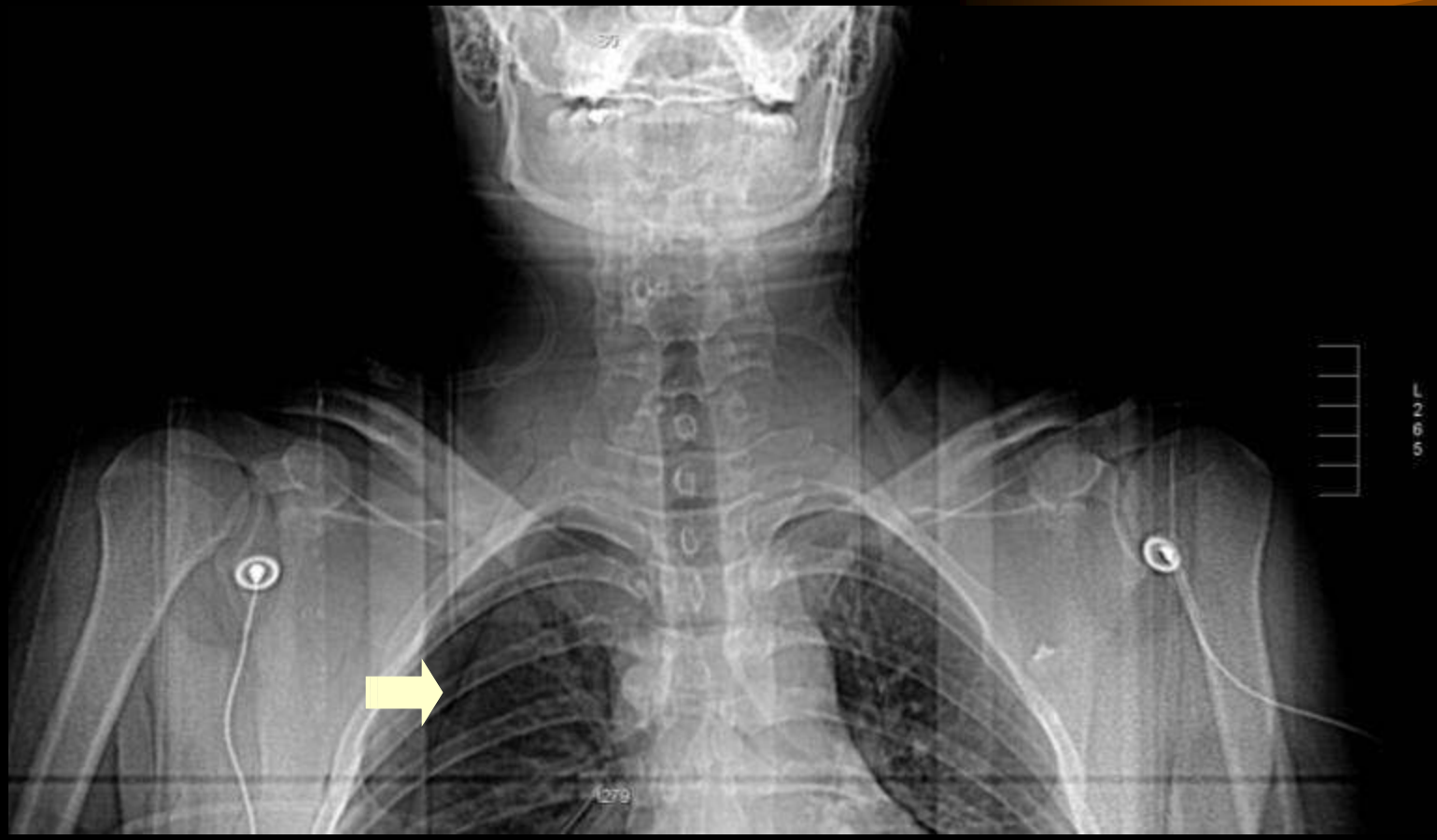
You can window and level the scout.

The Scout View

You will have to select the window/level from a different image.

You can enlarge the scout.
The Scout View

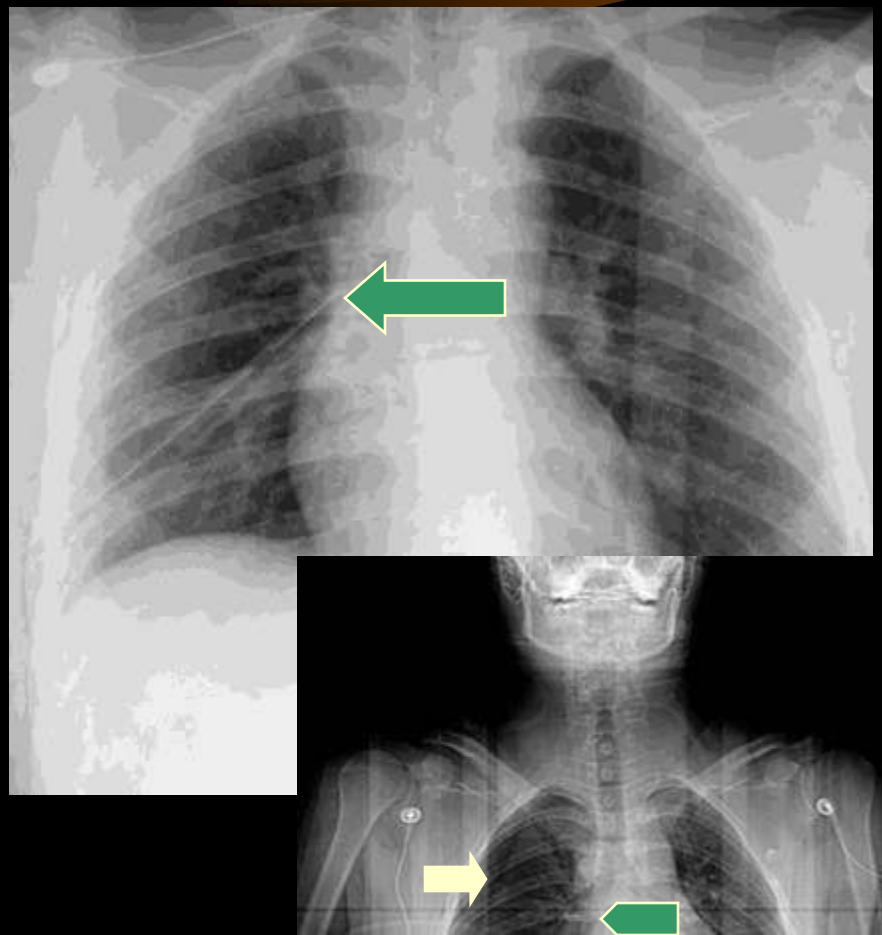
Discover unexpected findings.
The Scout View



Pneumothorax

CXR several hours prior to CT with Chest tube. The Scout View

- The lung was up prior to CT. The tube was either clamped for CT or not functioning.
- No AM CXR ordered.
- Ward team notified.
- Note: all of these scout views are from the same morning.



Pulling the scout view on AGFA

- Including the statement [The scout view is unremarkable.] in your template may help remembering to do this.
- You are responsible for the image anyway so the statement will not hurt you, and it may serve as a reminder to pull and look at the image.

What the scout view can show.

- Fractures/Dislocations
- Tubes and lines
- Associated injuries
- Pneumothorax
- Foreign bodies

Reconstructing the CT images

- Bring up the CT.
- Reconstruct the thin axial images.
- Bring up the sagittal images.
- Rotate to create a true axial.

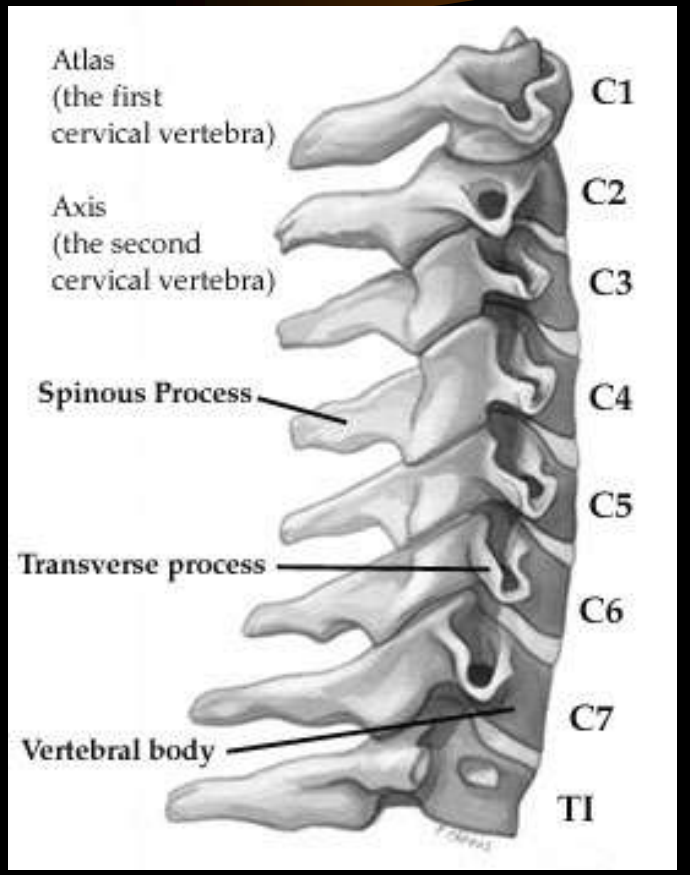
Reconstructing the CT images

- Level the axial from the coronal view.
- Double click the axial image to enlarge.
- Scroll the axial images C1 to about C3.
- Rotate off the sagittal for C4.
- Scroll
- Rotate off the sagittal for C5-T1.

Anatomy

Anatomy

- The anatomy of C3-C6 is basically the same.
- The anatomy of C1,C2 and C7 are special.



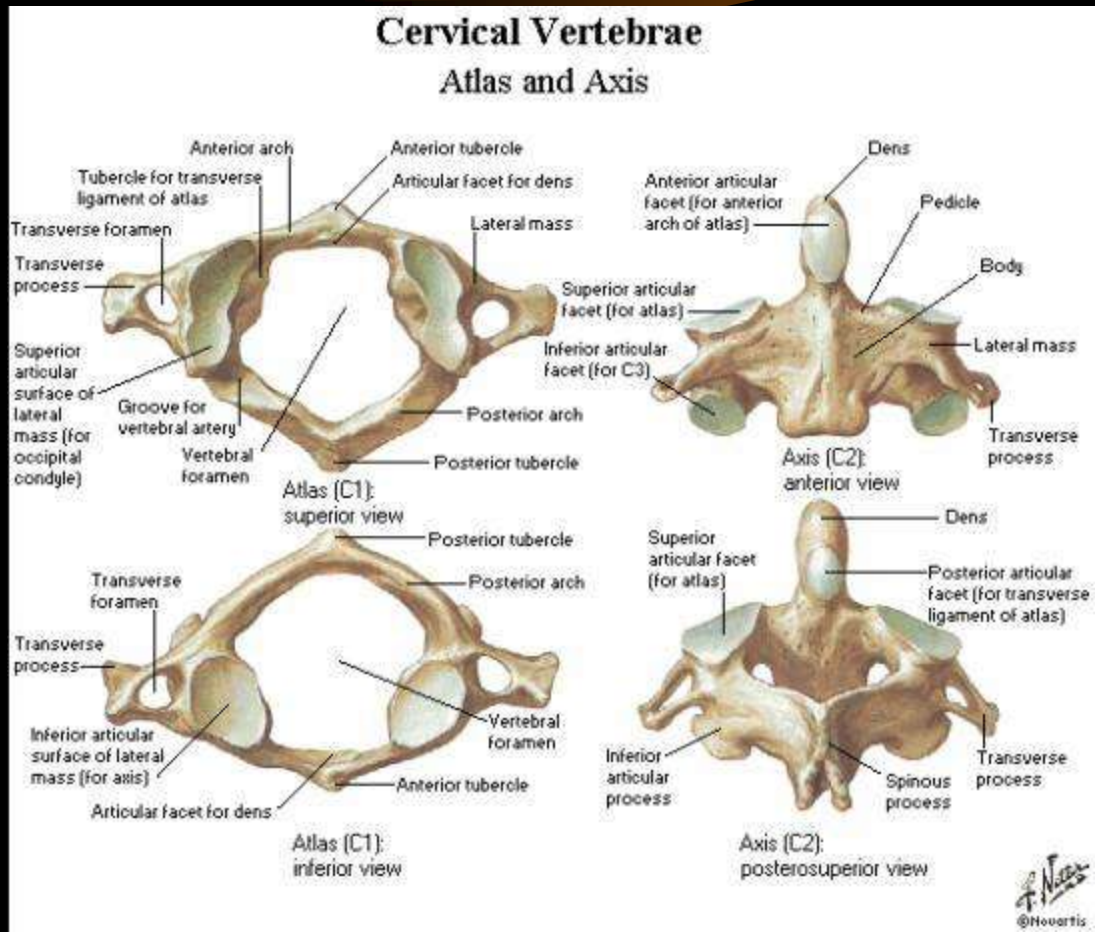
Normal C-SPINE
The Atlas & Axis

C1 the Atlas:

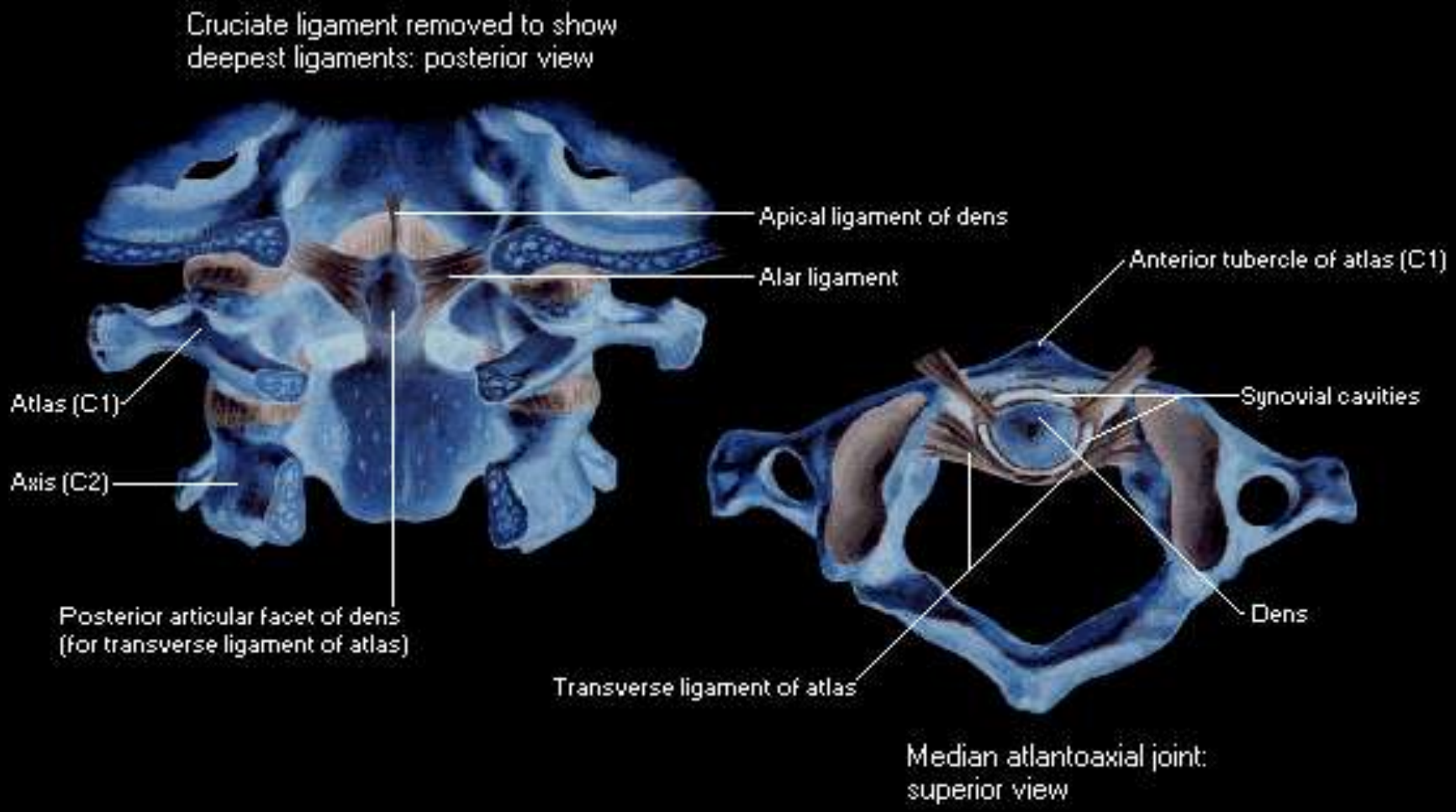
Anterior and posterior arch & Lat Masses, Small transverse process (contains transverse foramen)

C2 the Axis:

Body, lat masses, lamina, spinous process and Ondontoid process (dens).

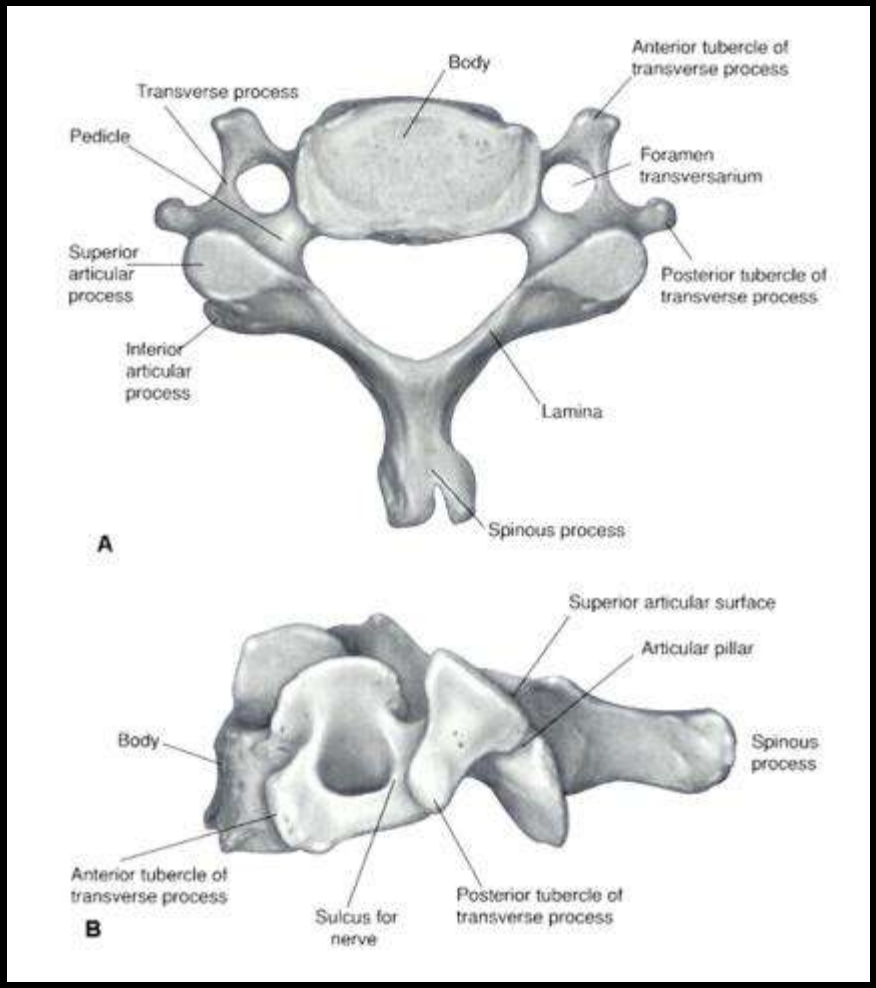


Craniocervical Ligaments



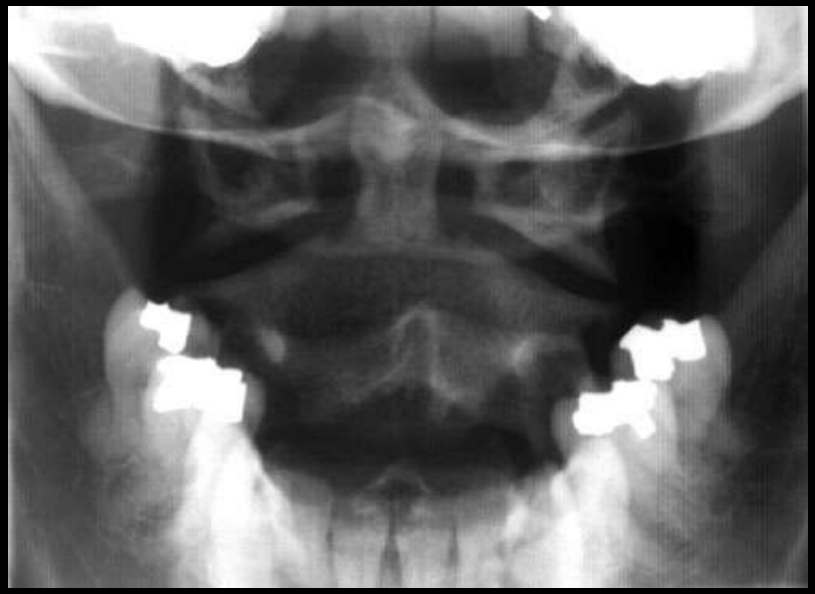
Netter

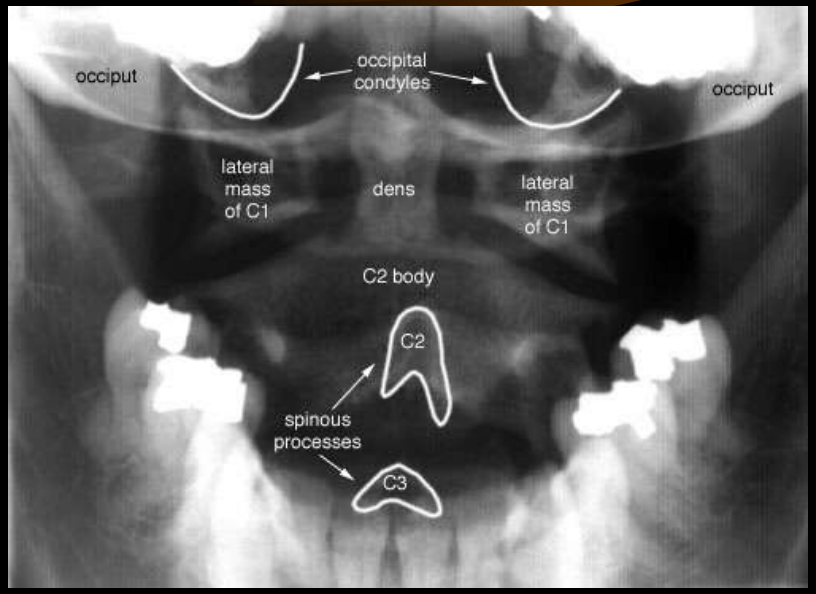
C3-C6



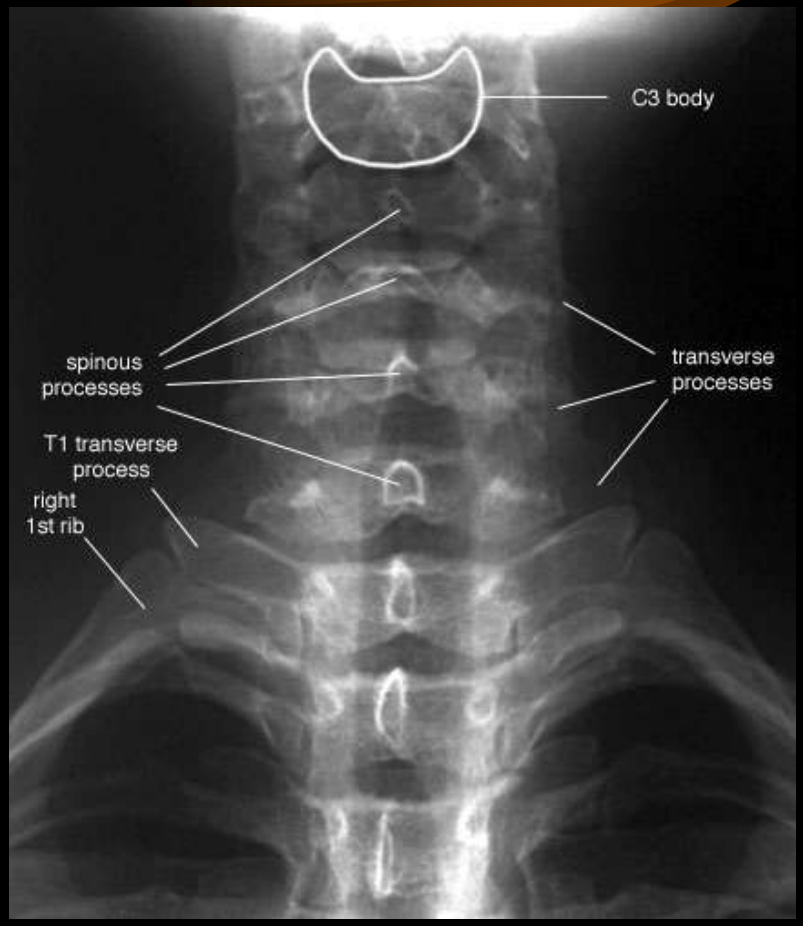
- Body
- Lamina
- Spinous Process
- Transverse process
- Pedicle & Transverse process
- Articulating facets

Anatomy

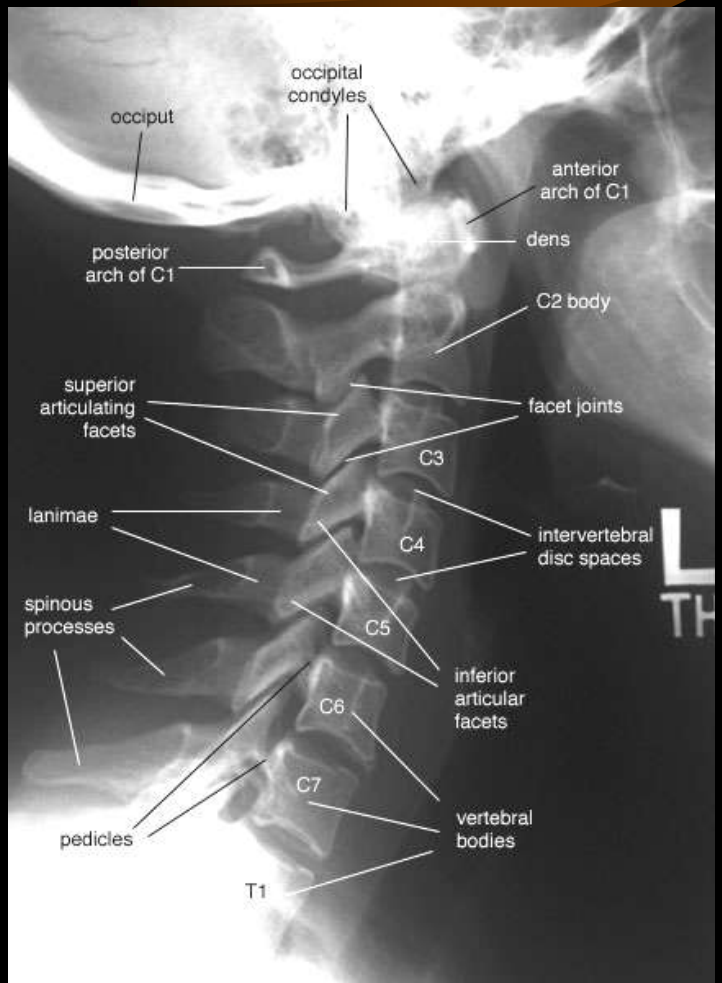



occiput
occipital condyles
occiput
lateral mass of C1
dens
lateral mass of C1
C2 body
C2
spinous processes
C3

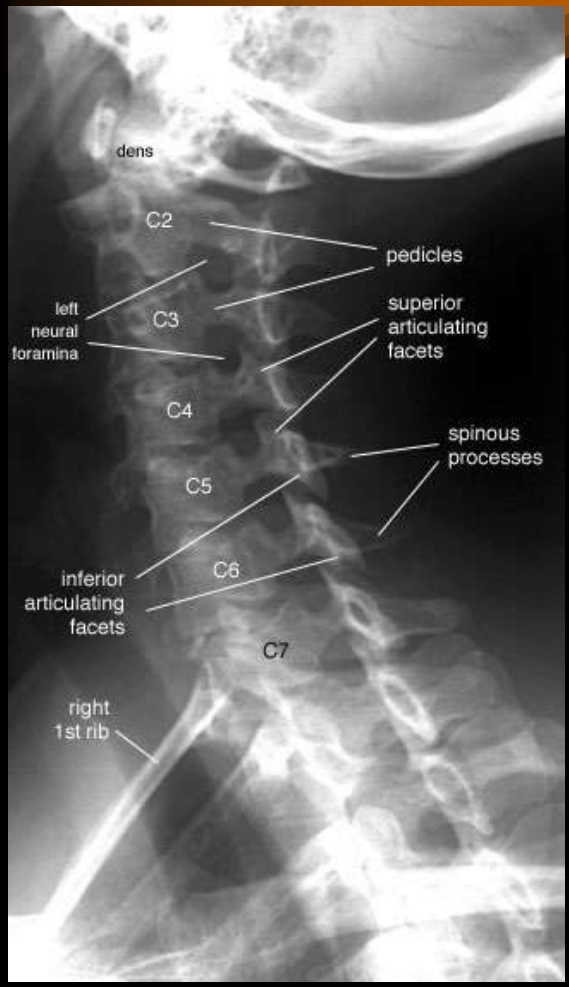
C-Spine AP


C3 body
spinous processes
transverse processes
T1 transverse process
right 1st rib

Lateral view: Anatomy

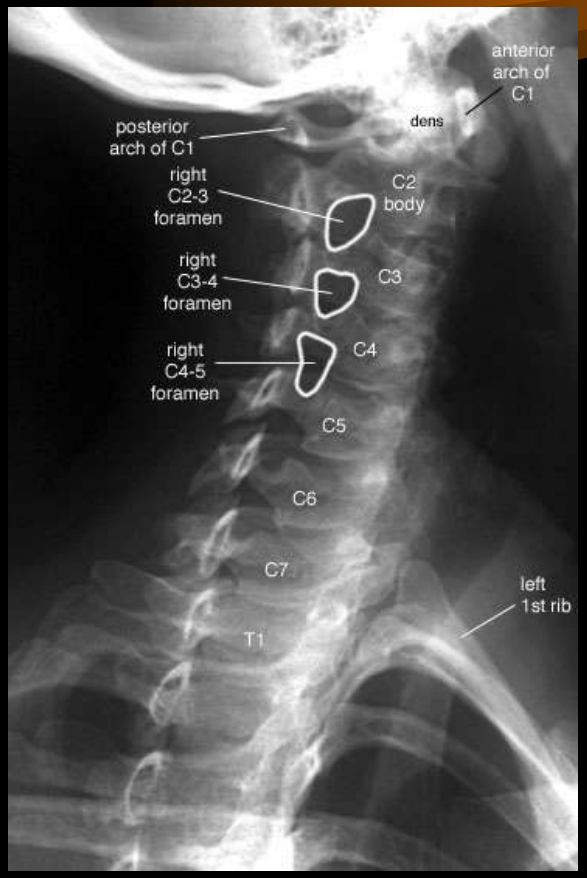


Oblique View: Anatomy



Greenspan

Oblique View: Anatomy



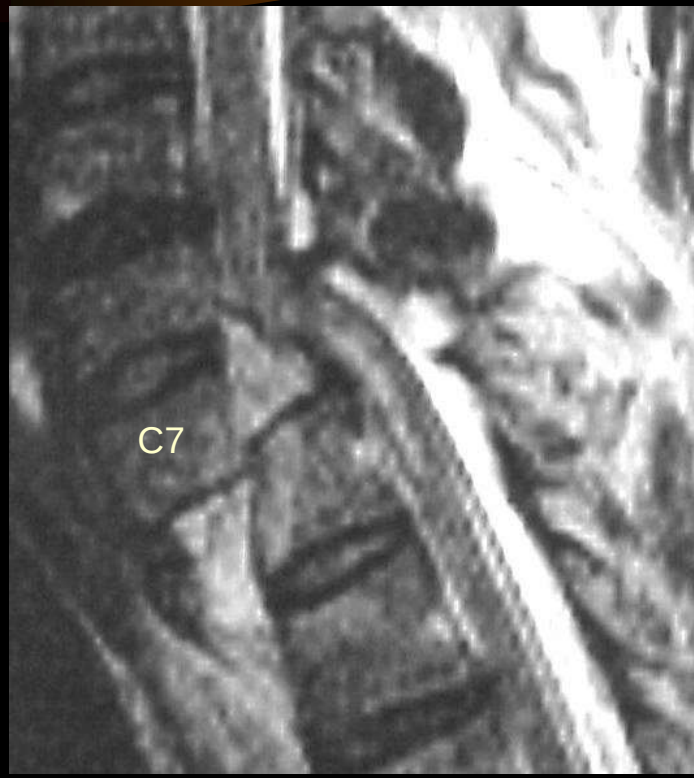
Technique

Technique - Routine

Lateral view: Technique

30M MVA Thought to be paraplegic

Lateral view: Technique



C7-T1 Fracture Dislocation

30M MVA Thought to be paraplegic

Technique - Flexion / Extension

Open C1 posterior arch

Technique - Flexion / Extension

30F post trauma acute films

Technique - Flexion / Extension

30F post trauma 8d later

Flexion and Extension

Extension

Peg # hard to see 37M

Flexion and Extension

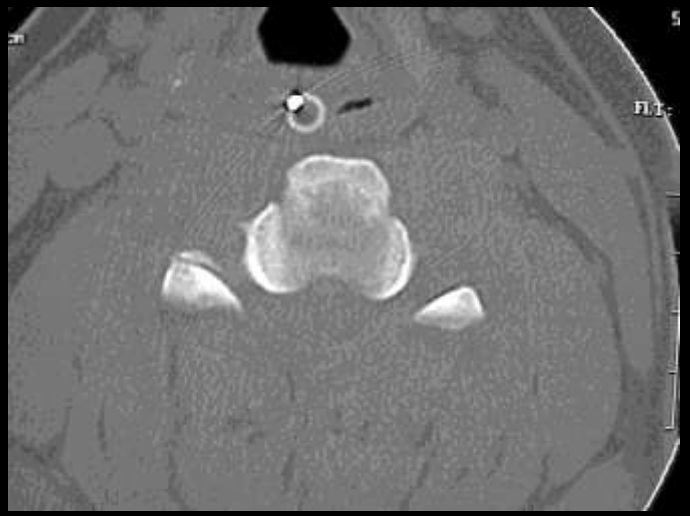
Flexion

Peg # hard to see 37M

Technique - CT

- Excellent visualization of fractures

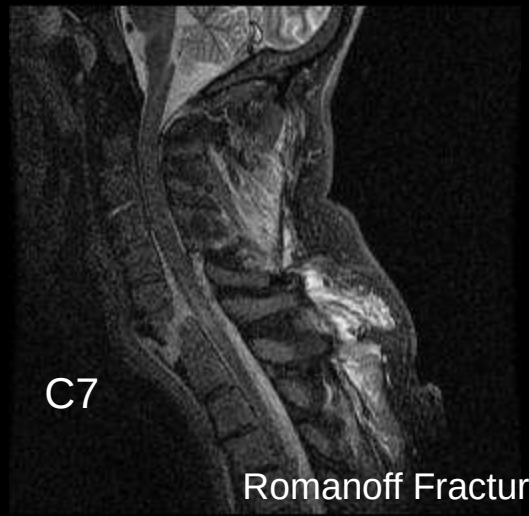
- Must be optimized
  - Thin slices 1 - 1.25 - 2mm
  - Bone and soft tissue algorithm / window
  - Orthogonal planes
    - Thin recons
  - Use workstation
  - 3D for alignment



Bifacet Dislocation

Technique - MRI

- Poor visualization of fractures
- Good for soft tissue injury
- Good for spinal cord injury assessment
- Good for spinal cord injury prognosis
- Good for root avulsion



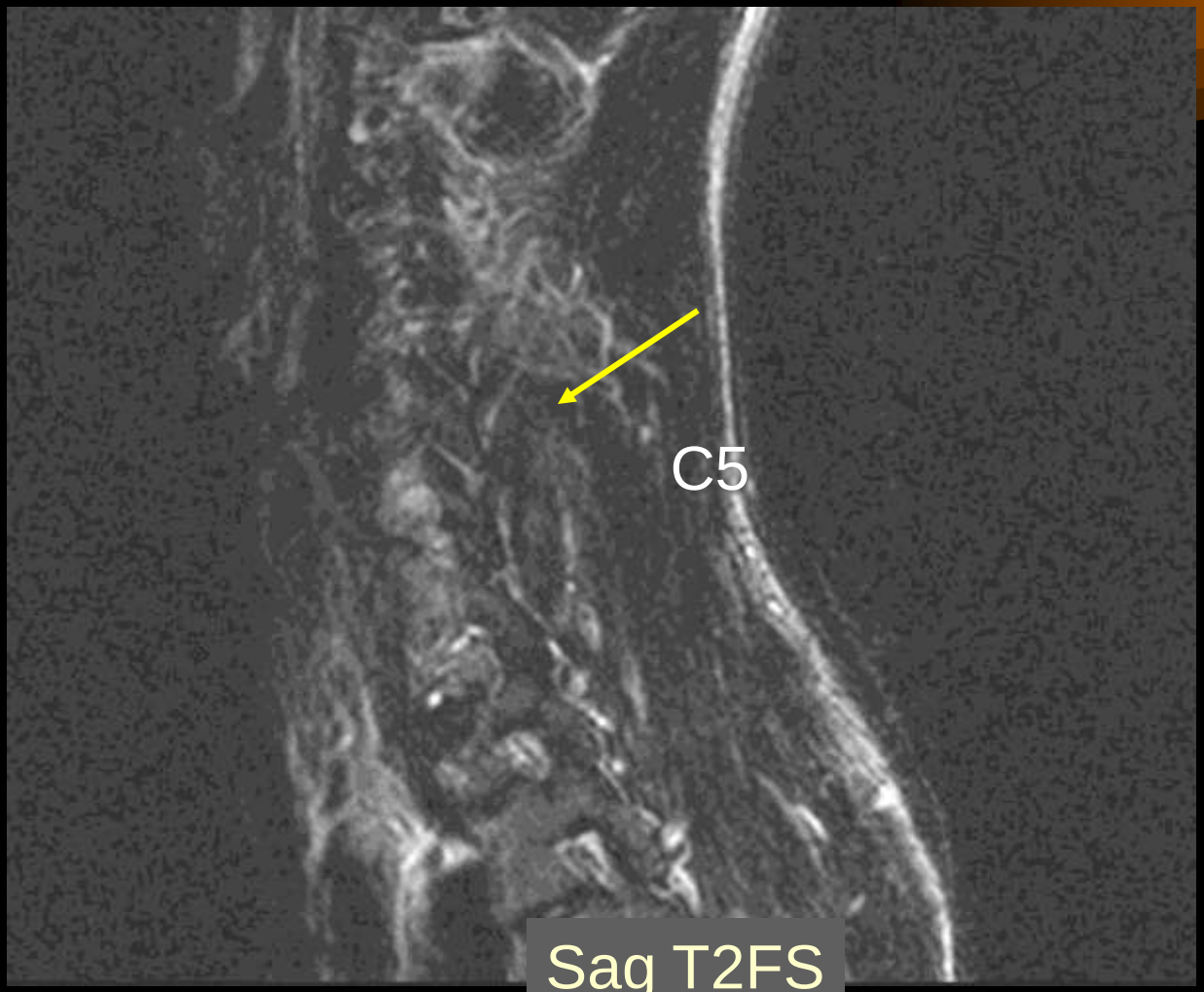
Romanoff Fracture

C-5 facet fracture not well seen on plain films

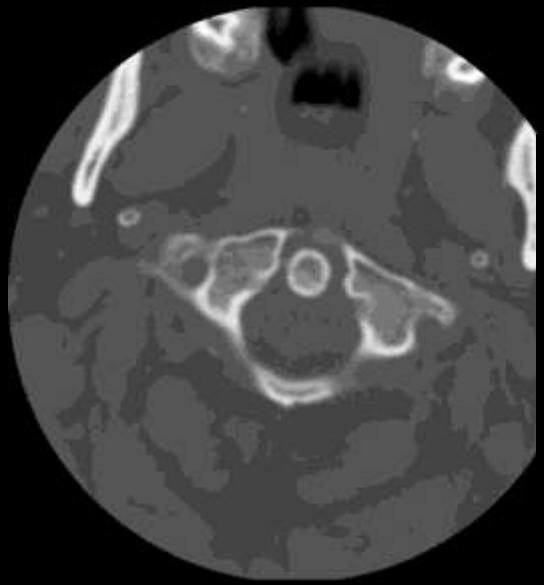
Technique - CT

C-5 facet fracture not well seen on plain films

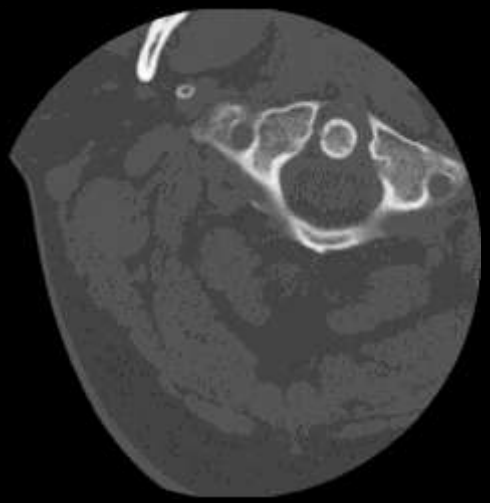
Technique - MR



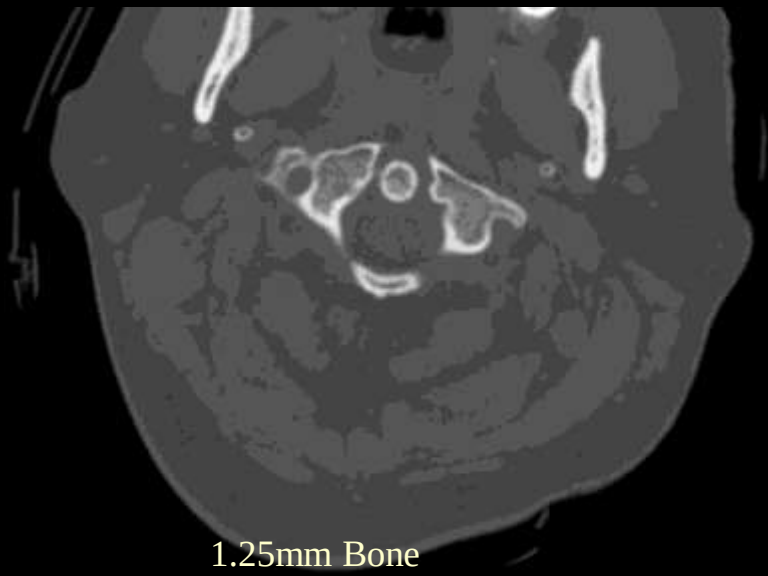
CT: Type l Odontoid Fracture
Technique - CT



2.5mm Standard algorithm



2.5mm Bone



1.25mm Bone

Optimizing CT

- Half axial acquisition.
- Reducing dose.
- Altering pitch.
- Slice thickness.

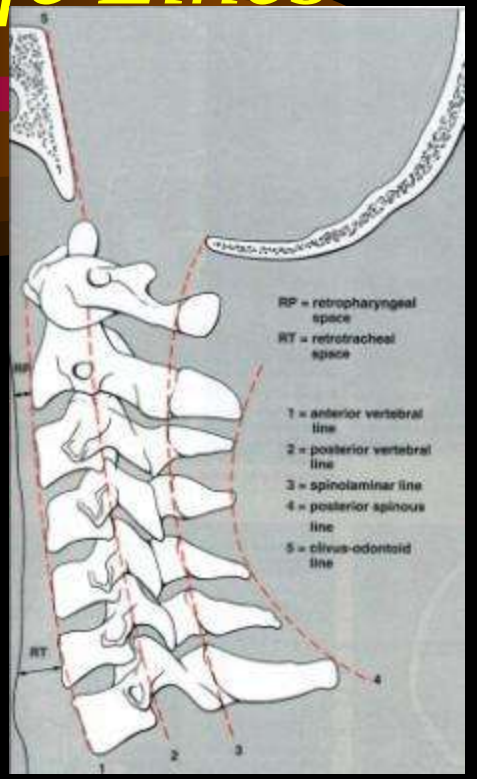
Fractures

Life lines

Reading Algorithm

Life Lines

1. Anterior vertebral body line
2. Posterior vertebral body line
3. Spinolamina line
4. Posterior spinous process line



Evaluate C1-C2 Area

Adults: <3mm

Child: <5mm

Greenspan

Stable vs. Unstable

Flexion	Anterior Subluxation	Stable
	Unilateral facet dislocation	Stable
	Bilateral facet dislocation	Unstable
	Wedge compression fracture	Stable
	Flexion teardrop fracture	Unstable
	Clay-shoveler's fracture	Stable
Extension	Posterior arch C1 fracture	Stable
	Hangman's fracture	Unstable
	Laminar fracture	Stable
	Pillar fracture	Stable
	Extension teardrop fracture	Stable
	Hyperextension dislocation fracture	Unstable
Compression	Jefferson fracture	Unstable
	Burst fracture	Stable
Complex	Odontoid fractures	Unstable
	Atlantooccipital disassociation	Unstable

Compression Fractures

- Stable
- Burst fracture

- Unstable
- Jefferson fracture

Flexion: stable vs. unstable

- Stable
- Unilateral facet dislocation
- Wedge Compression
- Clay Shovel's

- Unstable
- Bilateral facet dislocation

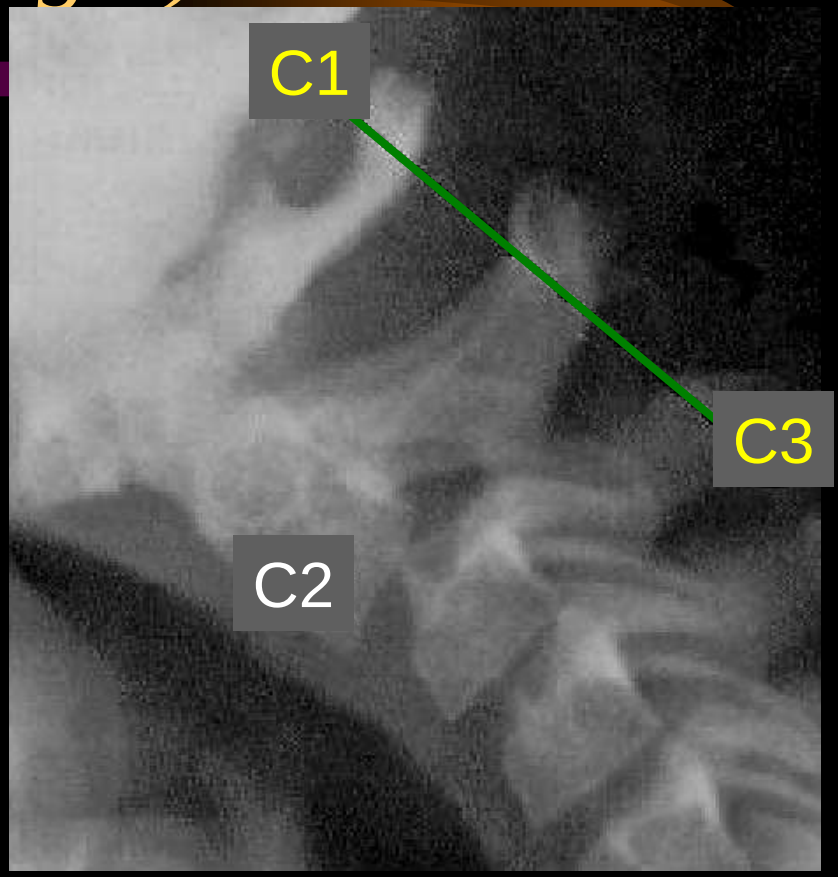
Extension: stable vs. unstable

- Posterior arch C1
- Laminar
- Pilar
- Extension tear drop

- Hangman's
- Hyperextension dislocation fracture

Pseudo (physiologic) Subluxation

- In children
- Ligament laxity
- Check Posterior Spinal (cervical) Line
- More than 2-3mm offset (SLL anterior to PSL at C2) must be considered traumatic.



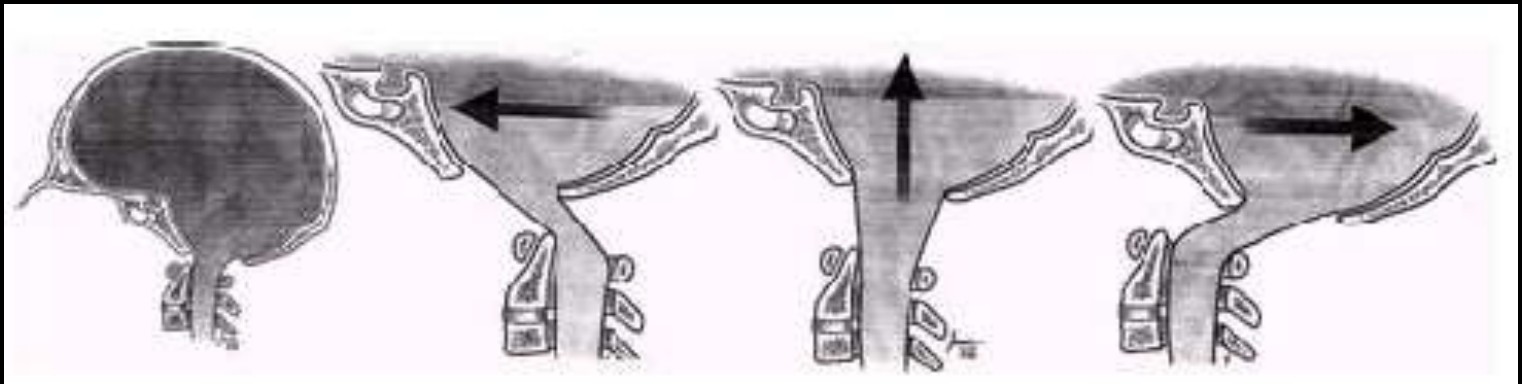
Caffey and Swischuk

Atlas

- Atlanto Occipital Dislocation

Atlanto Occipital Dislocation

- 40% missed dx at presentation
- STS +/- Retropharyngeal air
- Avulsion fractures occipital condyle or lower tip of clivus
- Classification:



Normal I II III

Atlanto Occipital Dislocation

Causes:

- Traumatic

- Nontraumatic
  - RA
  - Congenital Skeletal Abnormalities
  - Down's
  - Infection
  - CPPD

- Prognosis not good
  - (but 20% may have no deficit!)

Atlantooccipital subluxation

- BDI (Basion Dental Interval)
  - Vertical distance of basion above dens <12 mm
- BAI (Basion Axial Interval)
  - Anterior distance of basion from PSL 4 – 12 mm
- Powers ratio:
  - Basion to C1 Posterior lamina line / Opisthion to posterior cortex of the anterior C1 tubercle <1
- X method of Lee
- Clival line

Occipito atlas separation

Power's ratio

BC should be less than AO

Powers B, et al. Neurosurgery. 1979 Jan;4(1):12-7.
Traumatic anterior Atlanto-occipital dislocation.

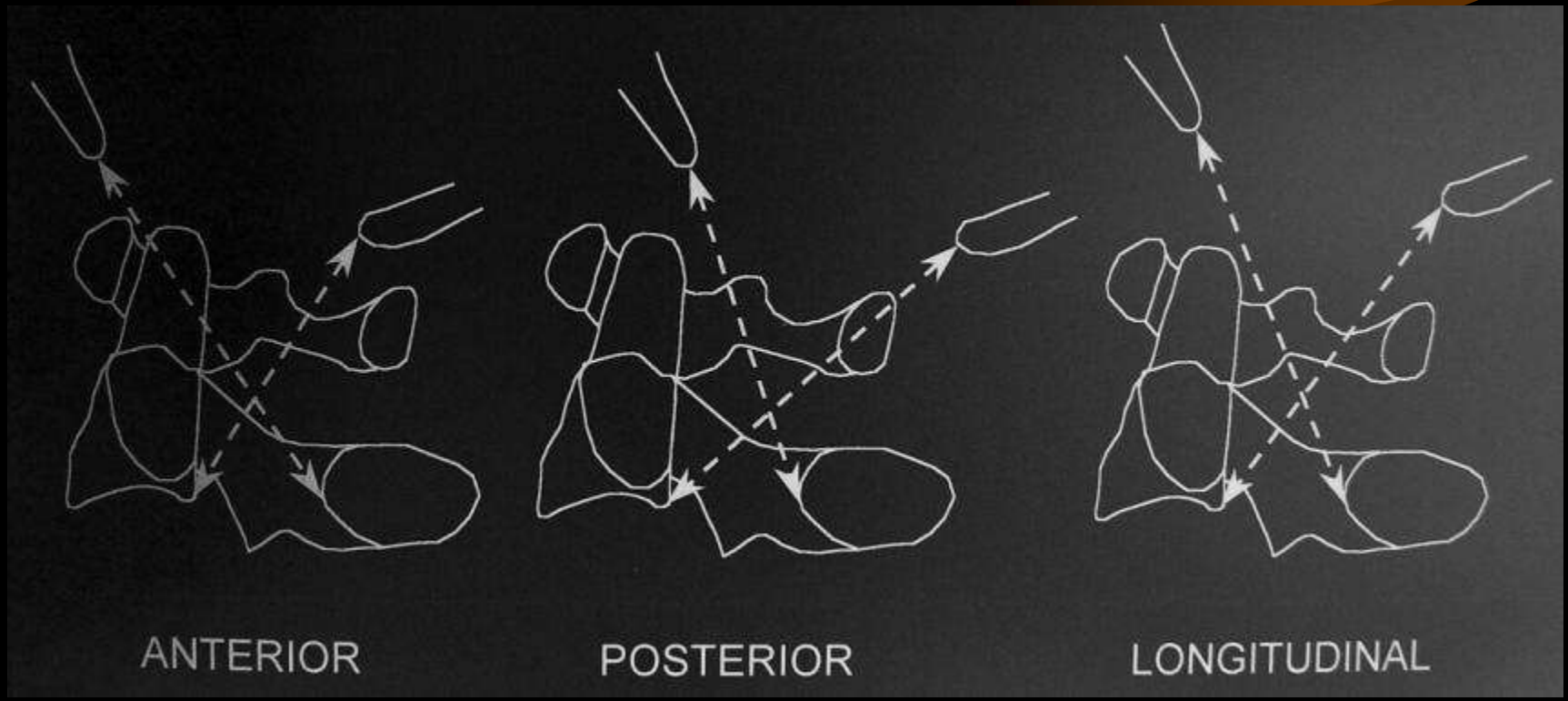
The X-line


GENETIC CODE
X-MEN MOVIE FANLISTING
X-MEN
FANLISTING MOVIE SITE MAIN

X

Occipito atlas separation

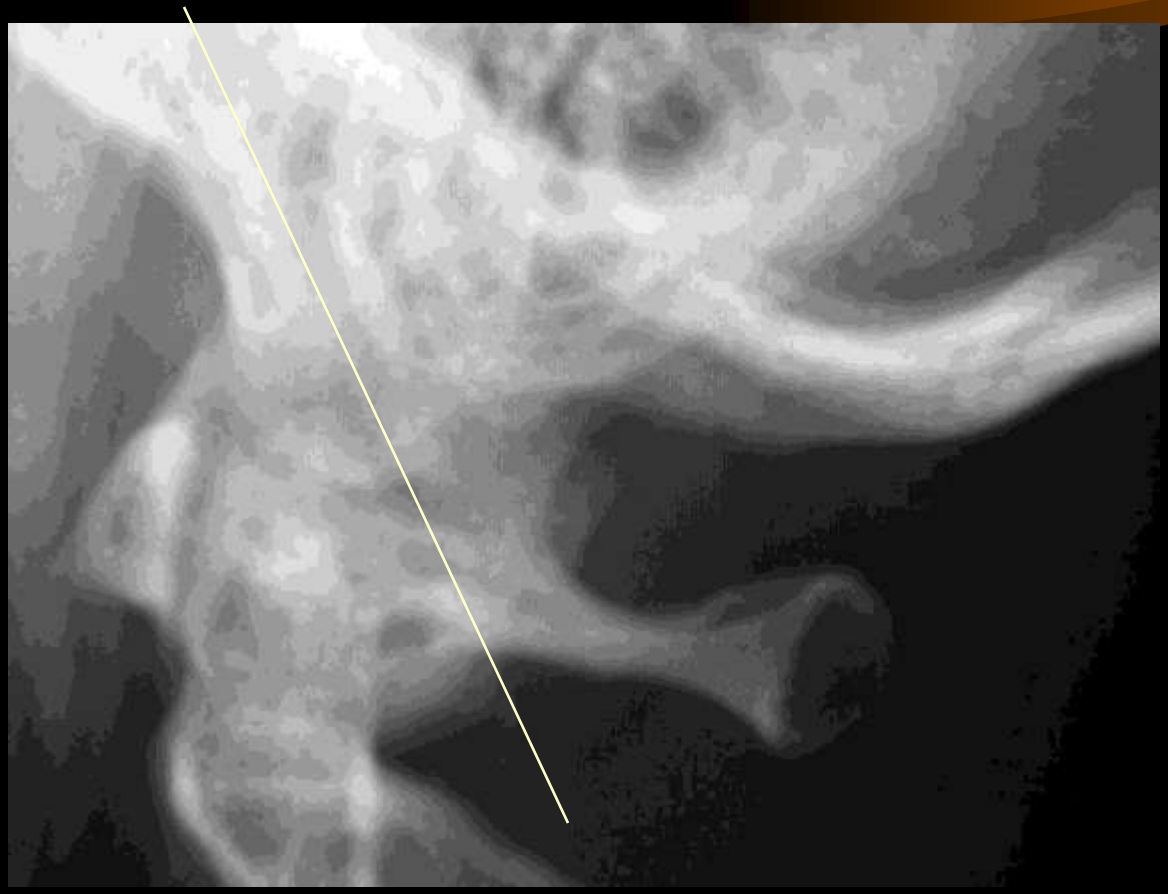
X Line



Lee C, et al AJNR Am J Neuroradiol. 1994 May;15(5):990.
Evaluation of traumatic atlantooccipital dislocations.

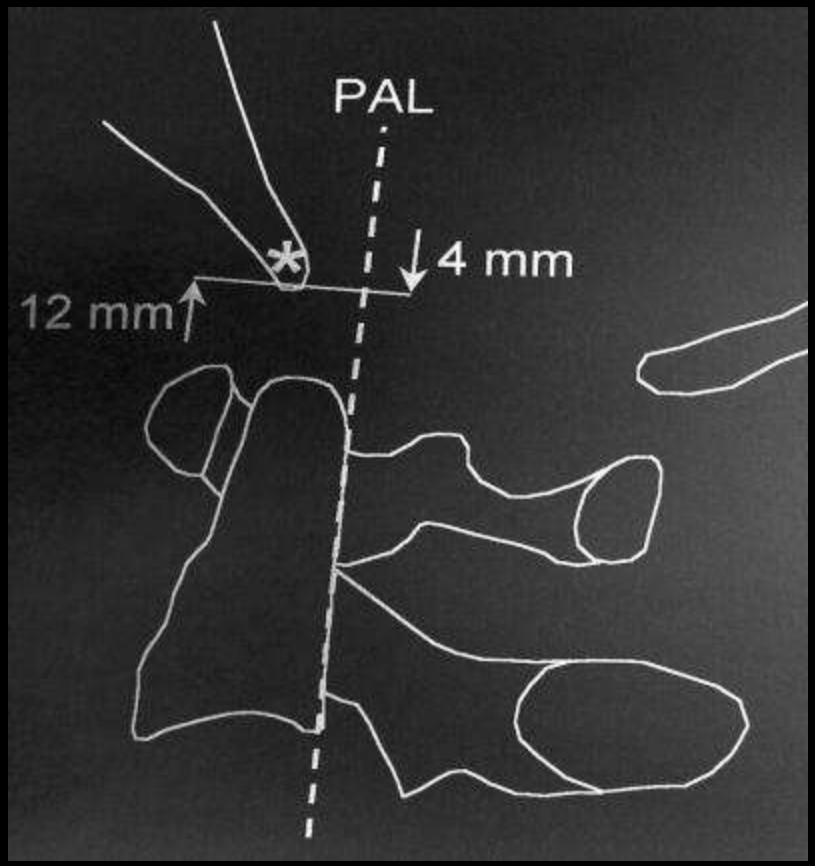
Occipito atlas separation

Clival Line - Normal



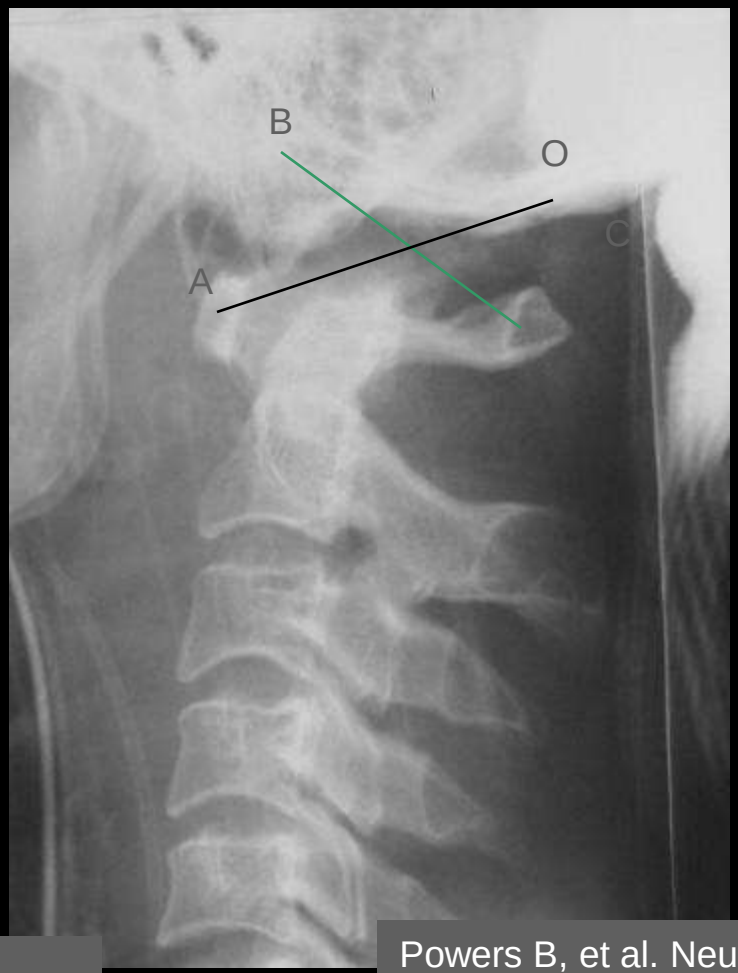
Occipito atlas separation

Basion Axial Interval



Harris JH Jr
AJR Am J Roentgenol. 1994 Apr;162(4):887-92.
Radiologic diagnosis of traumatic occipitovertebral dissociation:

Atlanto-occipital Dislocation.

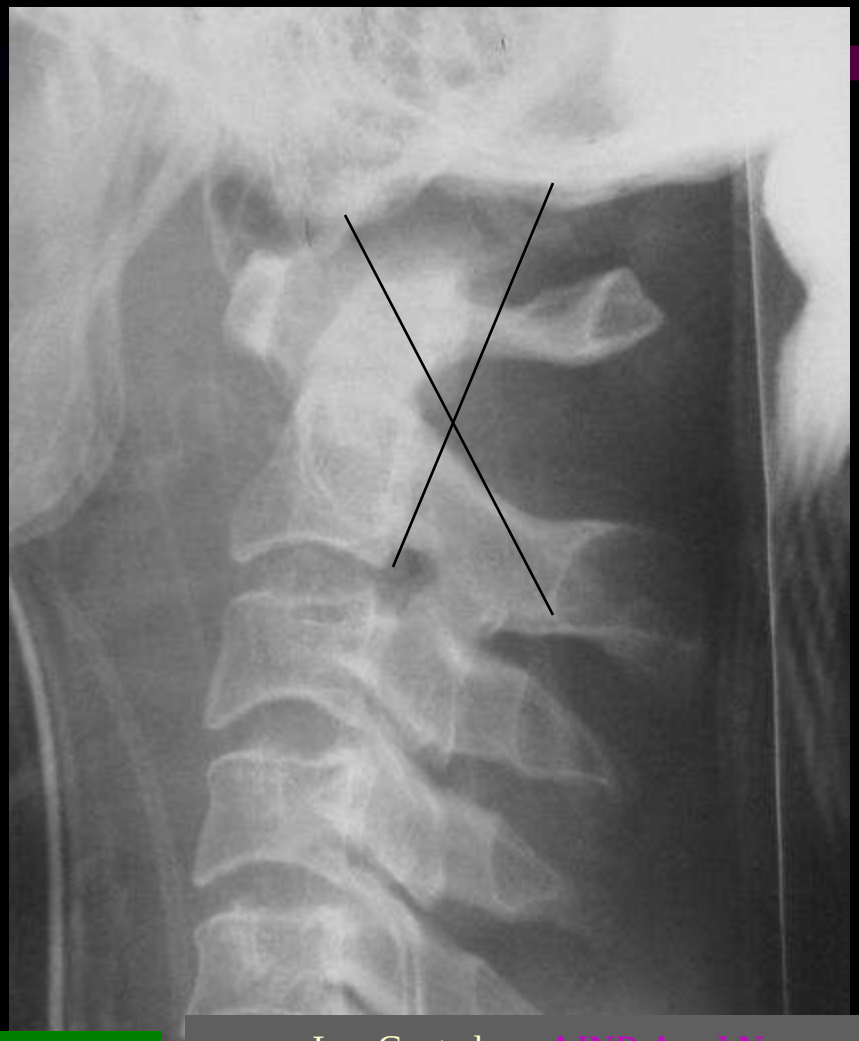


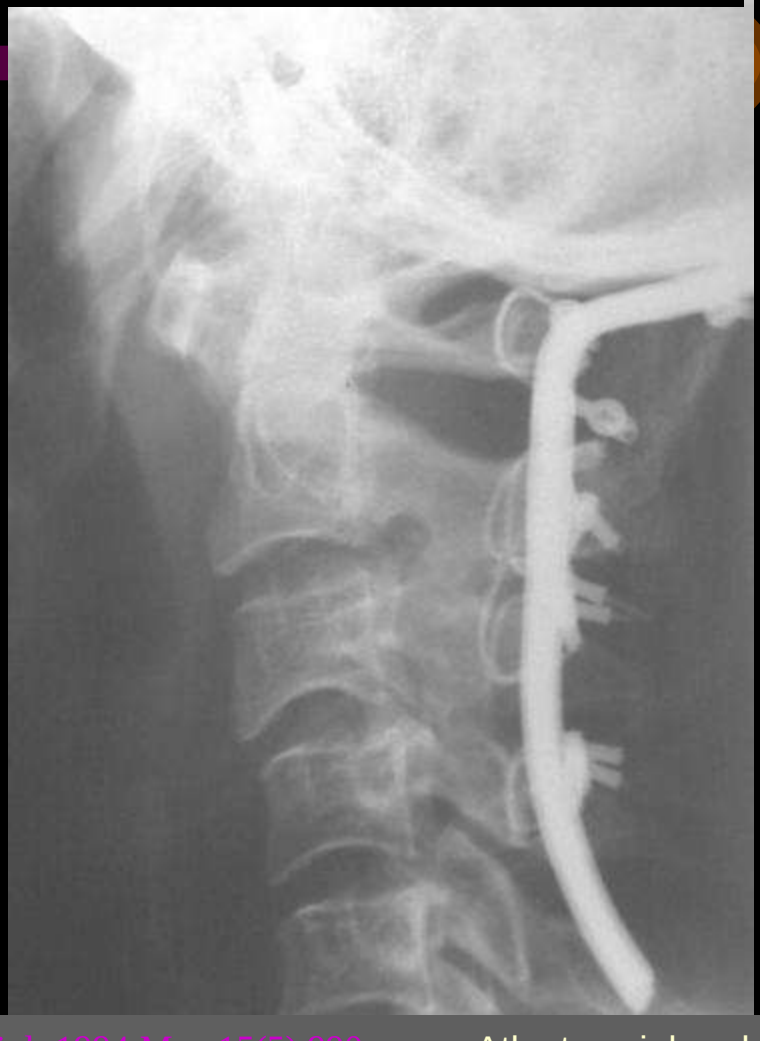
Powers

Powers B, et al. Neurosurgery. 1979 Jan;4(1):12-7.
Traumatic anterior Atlanto-occipital dislocation.

Atlanto axial and cranial atlas separation 32M

Atlanto-occipital Dislocation.





X method

Lee C, et al AJNR Am J Neuroradiol. 1994 May;15(5):990.
Evaluation of traumatic atlantooccipital dislocations.

Atlanto axial and cranial atlas separation 32M

Atlanto-occipital Dislocation.

Clival line

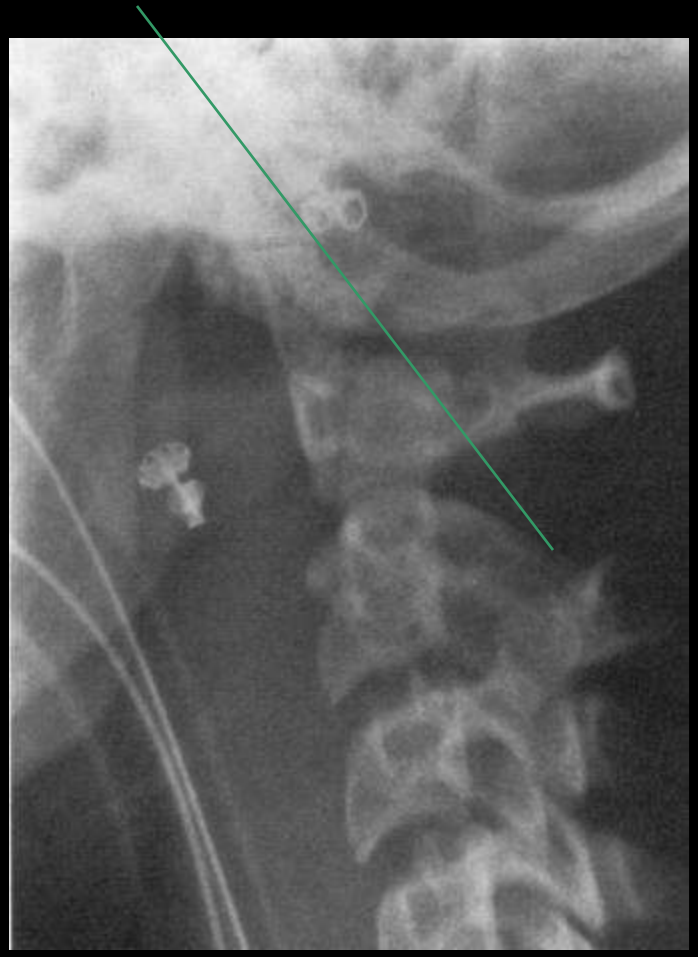
Atlanto axial and cranial atlas separation 32M

Atlanto-occipital Dislocation.

Basion Dens interval

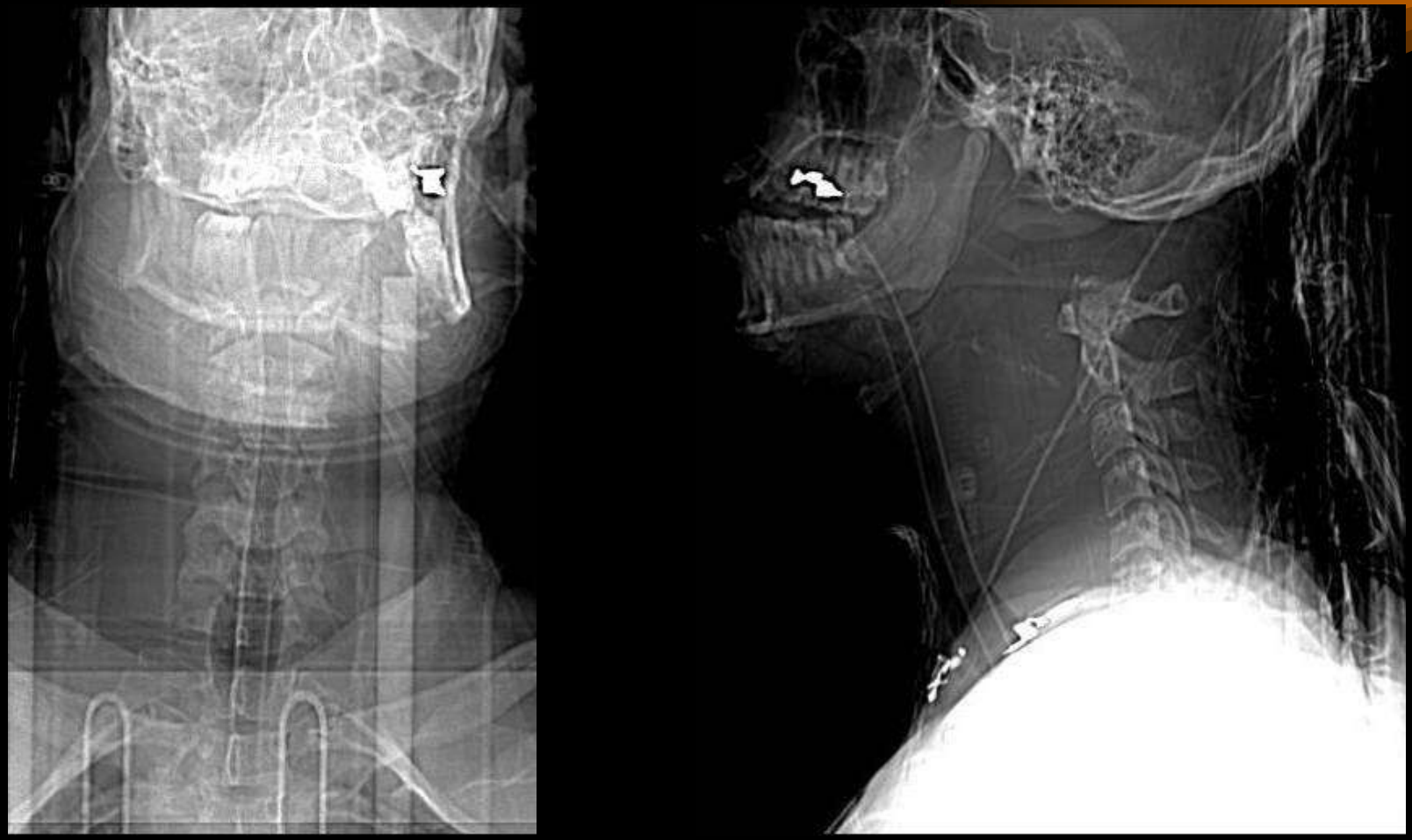
Harris JH Jr AJR Am J Roentgenol. 1994 Apr;162(4):887-92.
Radiologic diagnosis of traumatic occipitovertebral dissociation:

Atlanto-occipital Dislocation.



13 y.o girl s/p MVA unconscious

Atlanto-occipital Dislocation.



Atlantooccipital subluxation

Atlas

Fractures

- Jefferson
- Isolated posterior arch

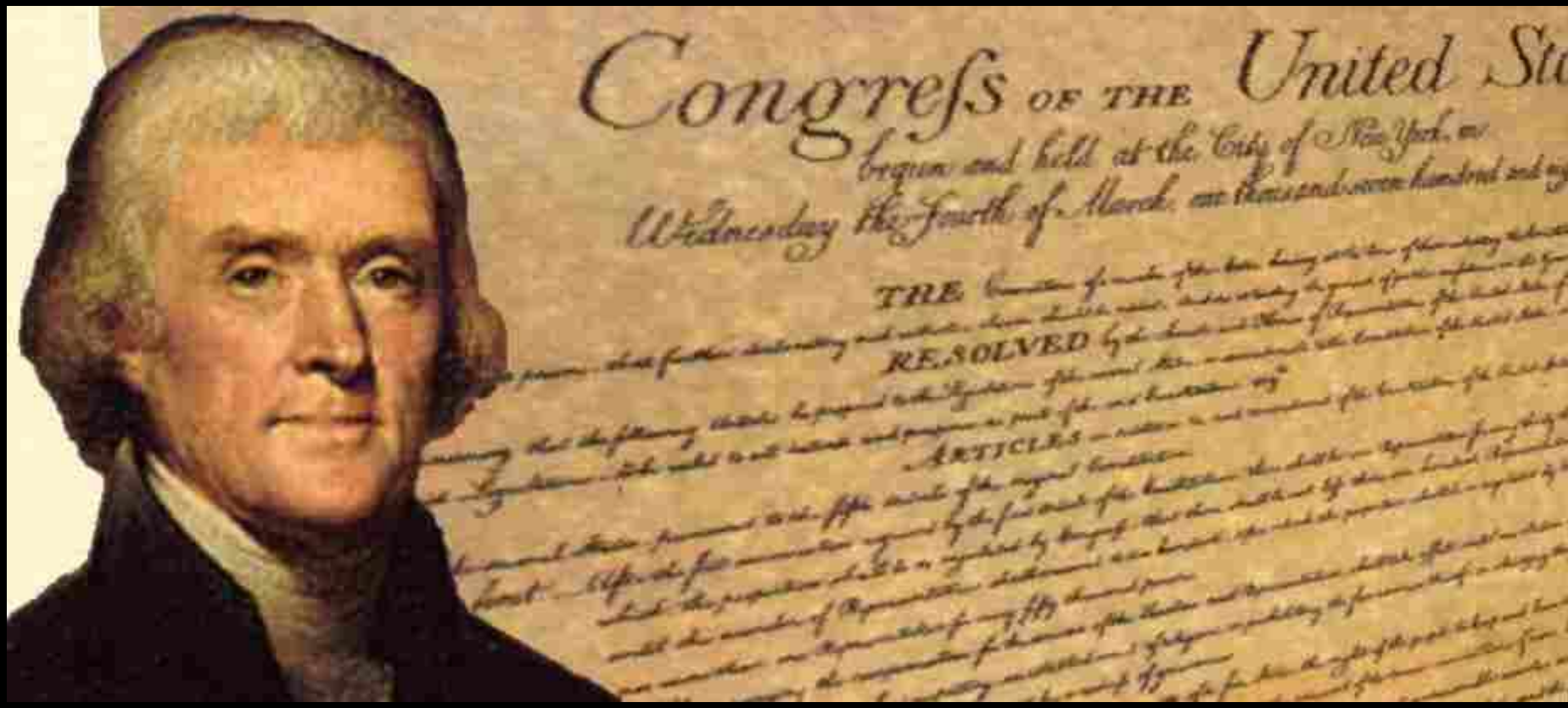
Subluxation

- Atlanto axial
- Rotary

Atlas – C1

- Jefferson Fracture

Jefferson Fracture



Jefferson Fracture (Burst Fracture of C1)

- Compression to vertex
- Diving injury
- Rx. Halo for 3m

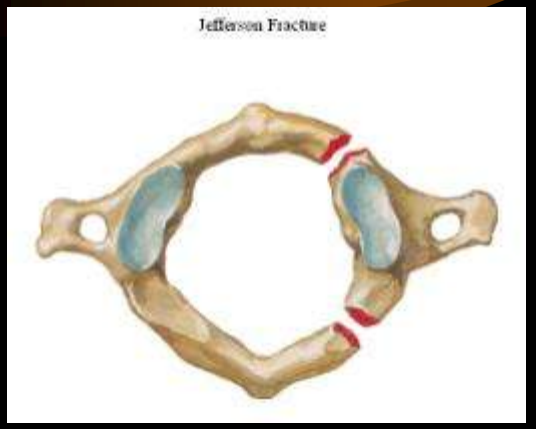
Jefferson Fracture (Burst Fracture of C1)

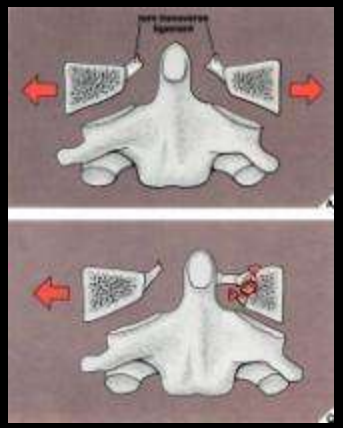
- Radiographic findings
  - AP open mouth is key
  - C1 lateral masses laterally displaced
  - >2mm bilaterally always abnormal
  - 1-2mm unilaterally may be head tilt

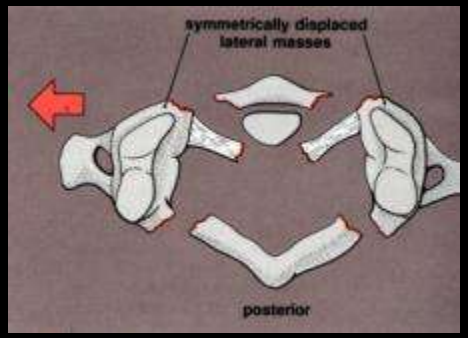
Jefferson Fracture (Burst Fracture of C1)

Vertical Compression – Unstable

1. Unilateral or Bilat FX's of both ant and post arches of C1
2. Displacement of lateral masses.
3. CT required for defining full extent of fracture and detecting fragments in spinal cord/canal
4. Treatment: Halo placement for 3 months







Greenspan

Jefferson Fracture (Burst Fracture of C1)

Vertical Compression – Unstable

1. Unilateral or Bilat FX's of both ant and post arches of C1
2. Displacement of lateral masses.
3. CT required for defining full extent of fracture and detecting fragments in spinal cord/canal
4. Treatment: Halo placement for 3 months

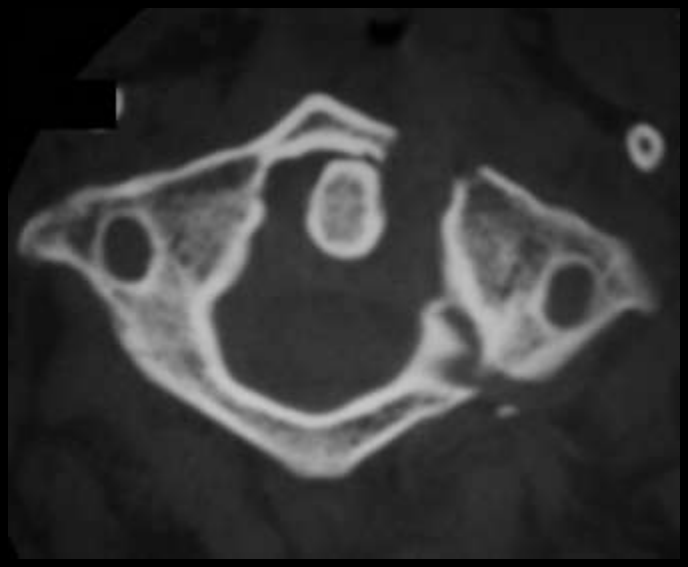
Normal

Direction of forces

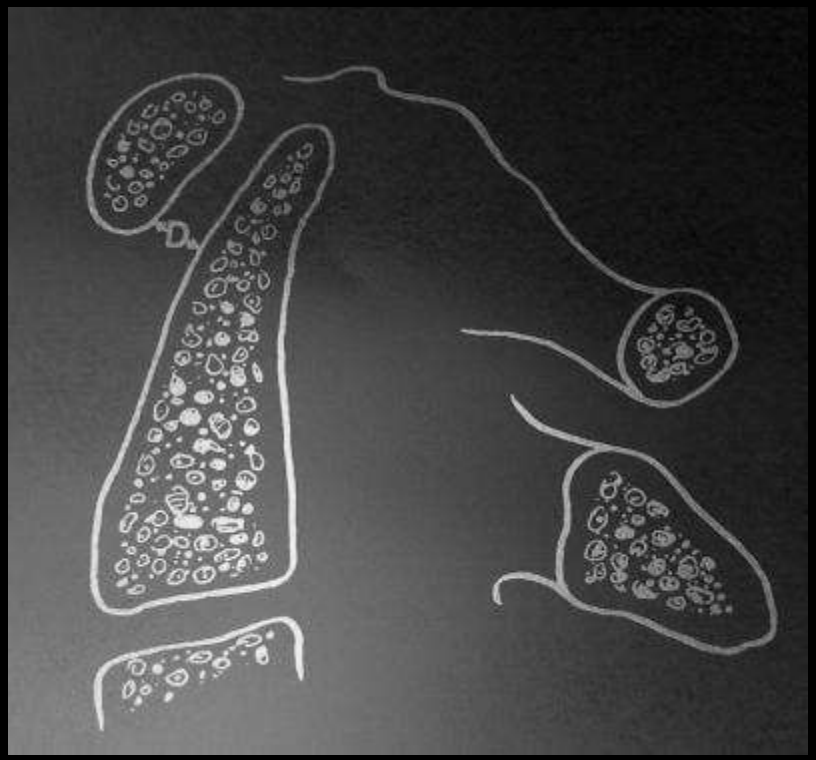
Jefferson Fracture

- Axial loading
- Often 4 part Fx, or single both side fractures
- Splaying of lateral masses
- Disruption of transverse ligament
- Best seen on AP odontoid and axial CT

Jefferson Fracture



Atlanto Axial Distance



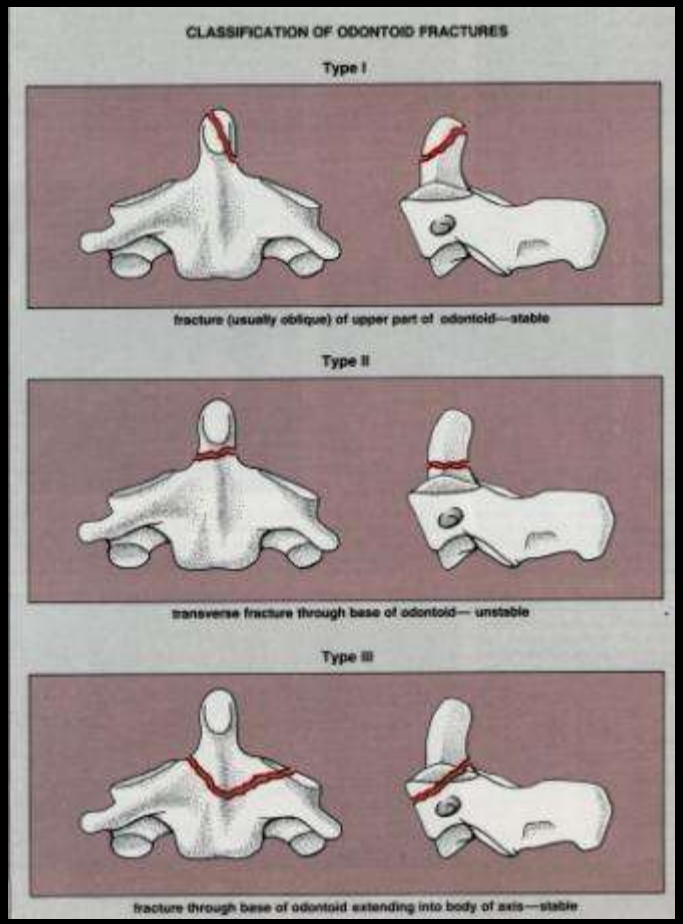
- Females < 2mm
- Males < 3mm
- Children < 4mm

Hinck 1966

Axis

- Odontoid Fracture

Dens Fractures



TYPE 1 - Avulsion fx of the tip.

Considered Stable

TYPE II - Fx at Base of Dens.

Most Common

Poor blood supply

Unstable

TYPE III - Fx into body of axis

Best Prognosis

Unstable

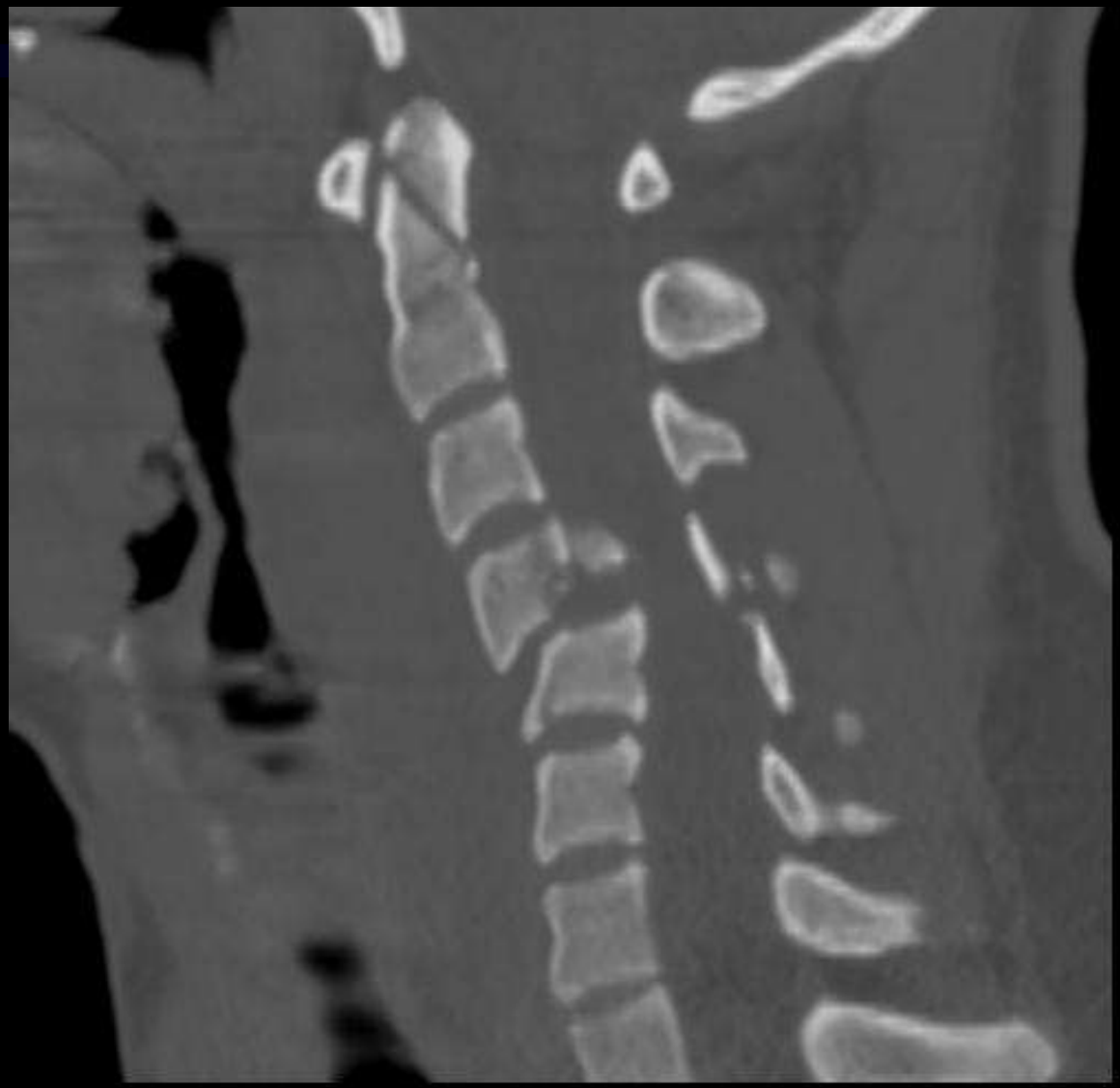
Greenspan

Anderson and D'Alonzo

Type l Odontoid Fracture

22M MVA

Type l Odontoid Fracture



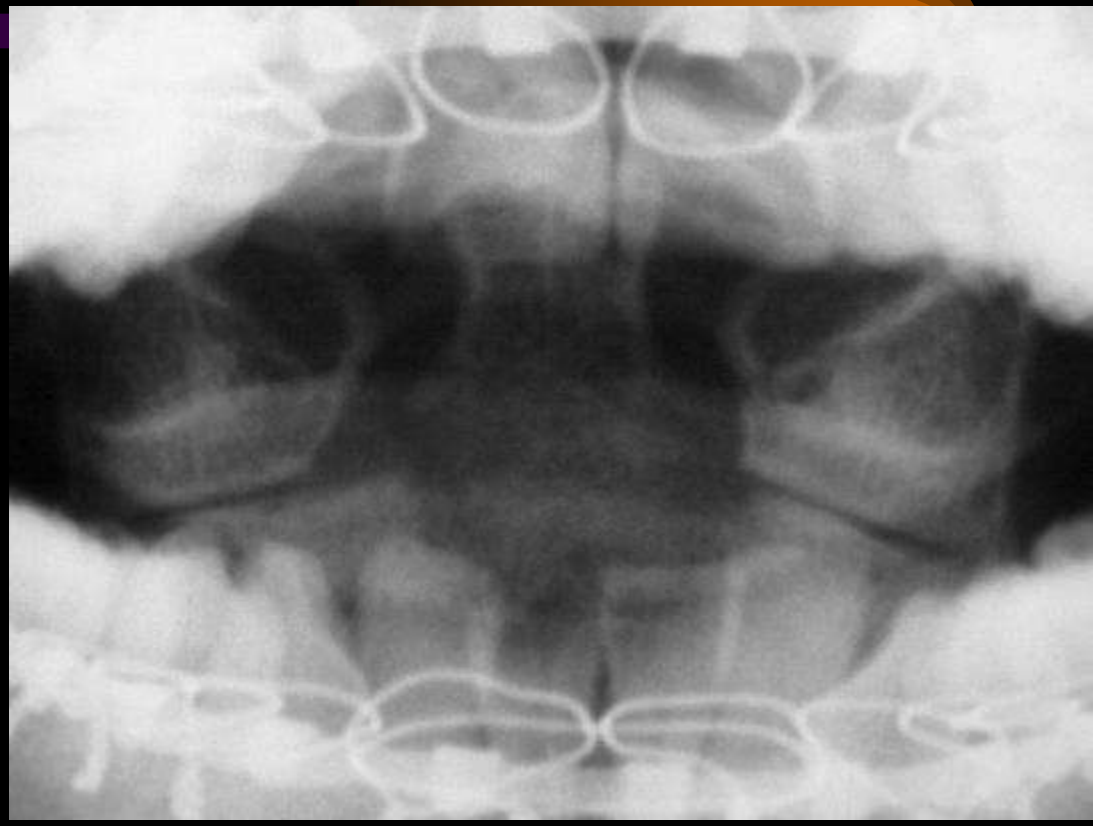
22M MVA

Axis

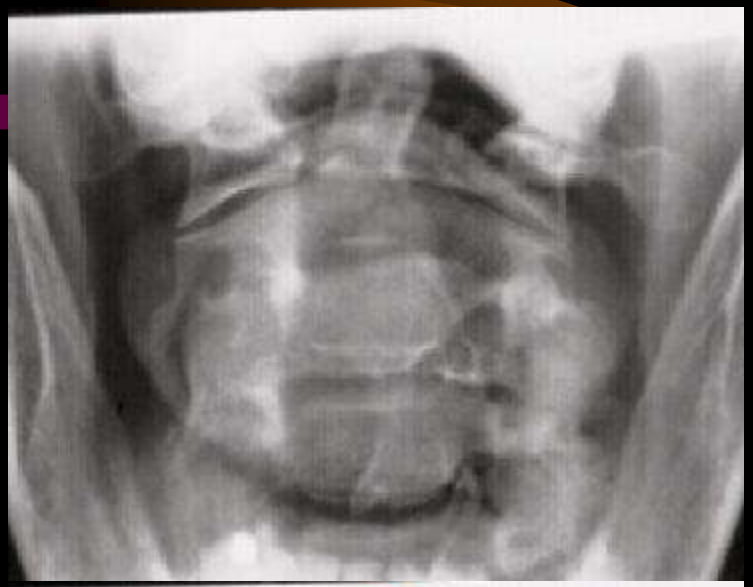
- Type 2
- Odontoid Fracture

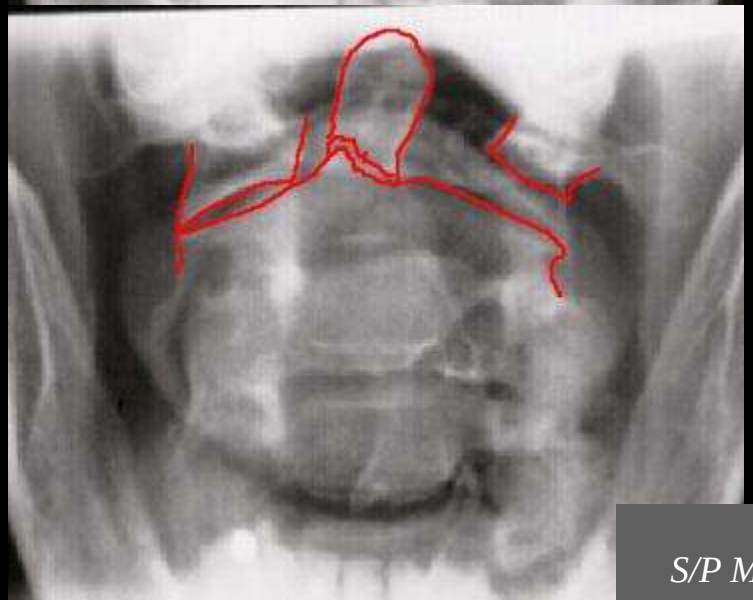
Type ll Odontoid Fracture

Type ll Odontoid Fracture



Type ll Odontoid Fracture





S/P MVA

? Type ll Odontoid Fracture

Axis

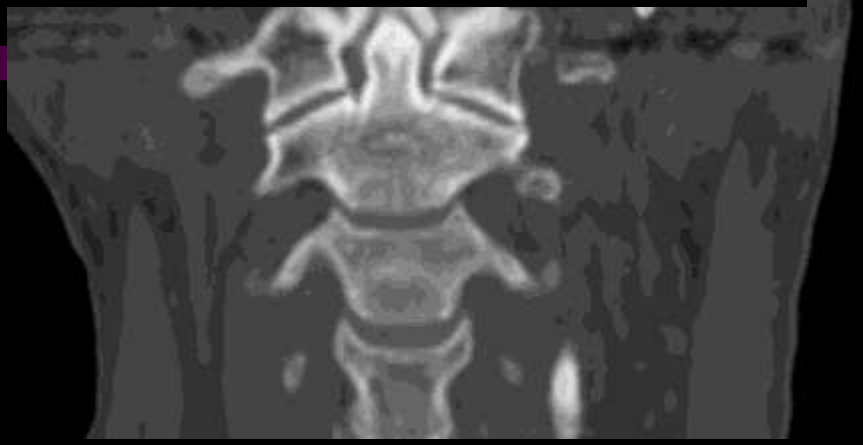
- Type 3
- Odontoid Fracture

Displaced type 3 odontoid fx

Low Type lll Odontoid fracture

26M

Type lll Odontoid Fracture



57M

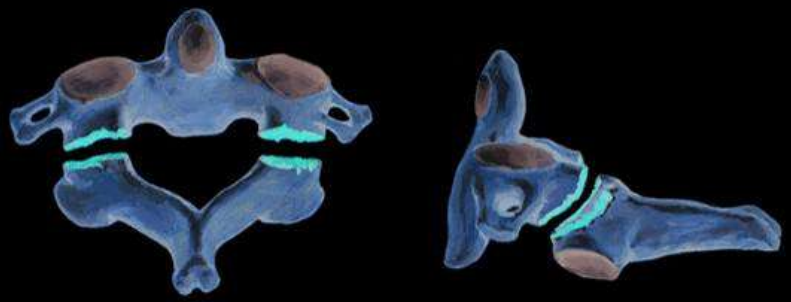
Type lll Odontoid Fracture

Axis

- Hangman Fracture

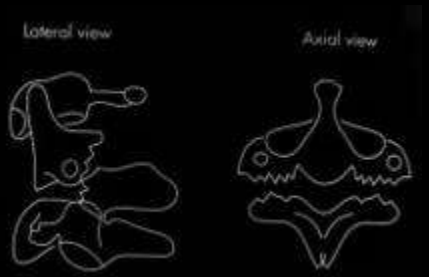
Hangman Fracture - Unstable

- Traumatic Spondylolisthesis of the Axis
- Bilateral C2 pars (common) or Pedicle (less common)
- Hyperextension and traction injury of C2
  - MVA (chin to dashboard)
  - Hanging
- The odontoid and its attachments are intact.
- Nerve damage is uncommon owing to the width of the canal at this level.



Hangman Fracture - Unstable

- Traumatic Spondylolisthesis of the Axis
- Bilateral C2 pars (common) or Pedicle (less common)
- Hyperextension and traction injury of C2
  - MVA (chin to dashboard)
  - Hanging
- The odontoid and its attachments are intact.
- Nerve damage is uncommon owing to the width of the canal at this level.



Effendi classification

Grade 1: extension injury, displacement < 2mm. Rx flexion.

Grade 2: extension injury, displacement >2mm and angulation. Rx flexion.

Grade 3: flexion injury, C2-3 facet joint subluxation/ dislocation. Rx extension.

Effendi classification

Type I: bilateral pars fractures, normal C2/C3 disc space and minimal / no displacement of C2 body. LE1

Type II: displacement of anterior fragment, abnormal C2/C3 disc LE2b

Type III: anterior displacement of the anterior fragment, body of C2 in flexed position, bilateral facet dislocation LE2a/LE3

Hangman Fracture - Unstable

Levin and Edward's

Type 1: Neural arch fracture, < 3mm displacement, no angulation

Type 2: A; + angulation

Type 2: B; + >3mm displacement

Type 3: + bilateral facet dislocation C2-3

Type I

Type II

Type IIA

Type III

- Hangman Effendi 1

Hangman Fx

Hangman Fracture – Effendi l

32 Y.O. Drunk, fell off cliff

- Hangman effendi 2

Hangman Fracture – Effendi ll – LE2a

Posterior arch C1 Fx

Hangman Fracture – Effendi lll – LE3

C3-7

- Fractures
  - Tear drop
    - Flexion
    - Extension
    - Posterior
  - Burst
  - Posterior arch
  - Clayshoveller's Fracture
- Dislocations
  - Unifacet
  - Bifacet
- Fracture Dislocations
  - Unilateral
  - Bilateral
  - Floating lateral mass

- Wedge
- Compression

Wedge Compression Fracture

- Usually stable
- Loss of height anterior vertebral body
- Buckled anterior cortex
- Anterosuperior fracture of body
- Differentiate from Burst
  - Lack of vertical fracture component
  - Posterior cortex intact

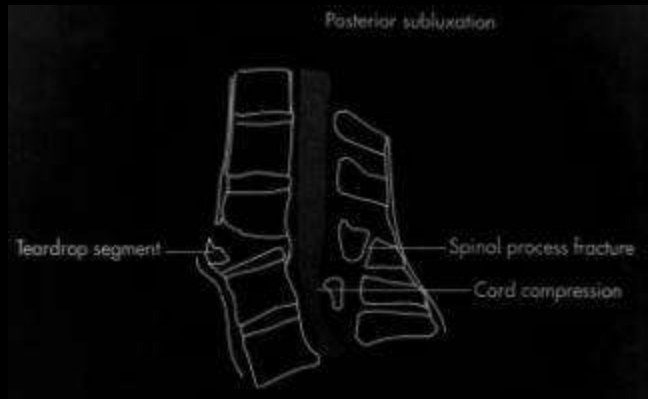
- Flexion Teardrop

Flexion Teardrop

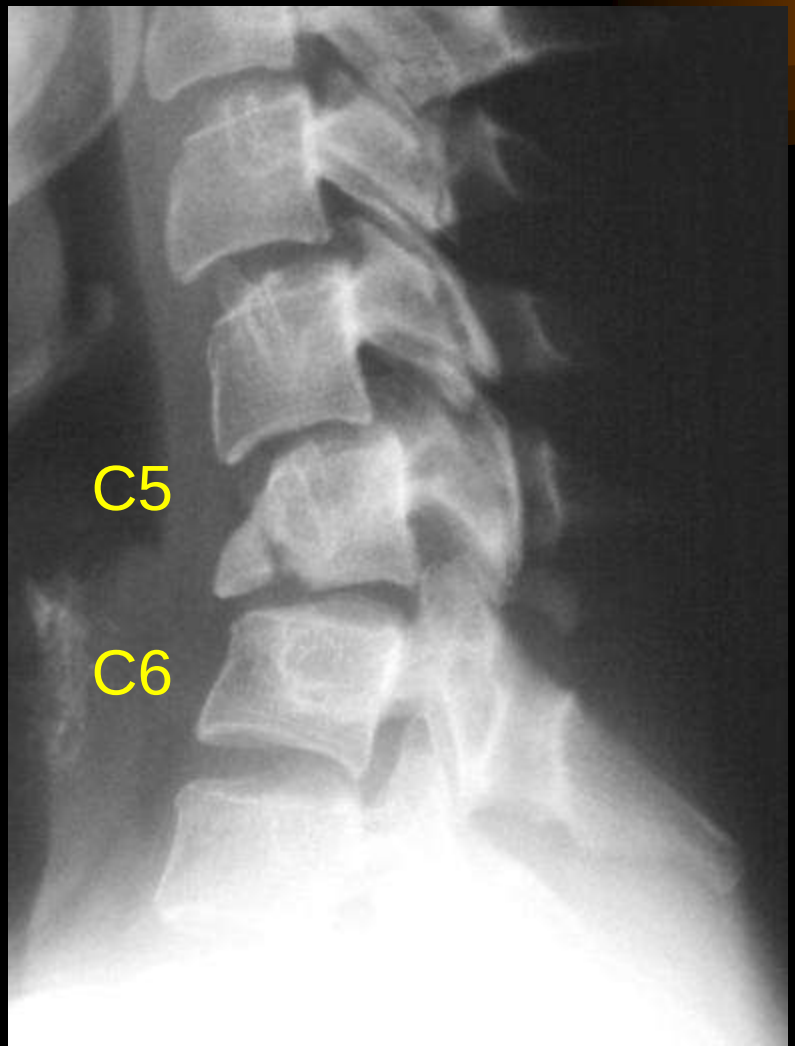
- Flexion Fracture Dislocation
- Unstable
- Most severe Cervical spine injury
- Anterior cord syndrome
  - Quadriplegia
  - Loss of anterior column senses
  - Retention of posterior column senses
- Associated with Tx or Lx spine Fx in 10%

Flexion Teardrop

- Teardrop fracture – anteroinferior
- All ligaments disrupted
- Posterior subluxation of vertebral body
- Bilateral subluxated or dislocated facets
- Spinal canal compromise



C5-C6 Flexion Distraction Teardrop



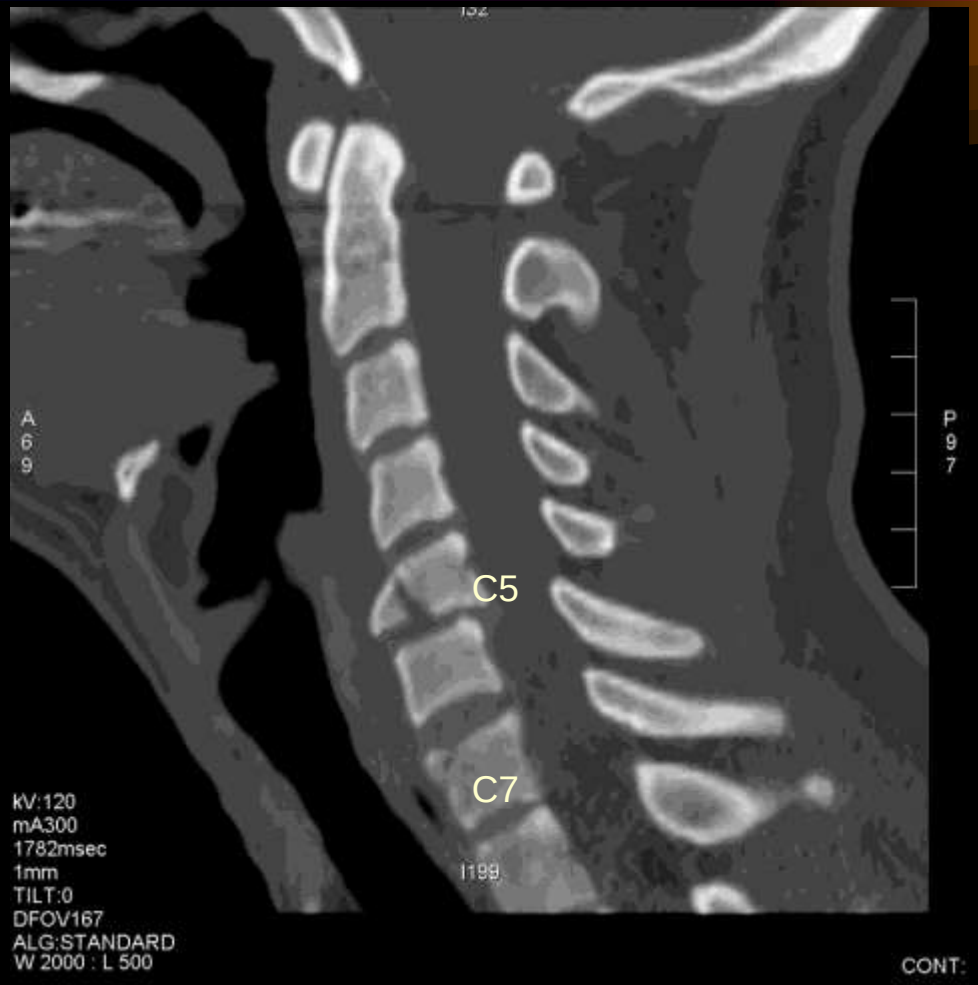
35M MVA

C4 Flexion Teardrop

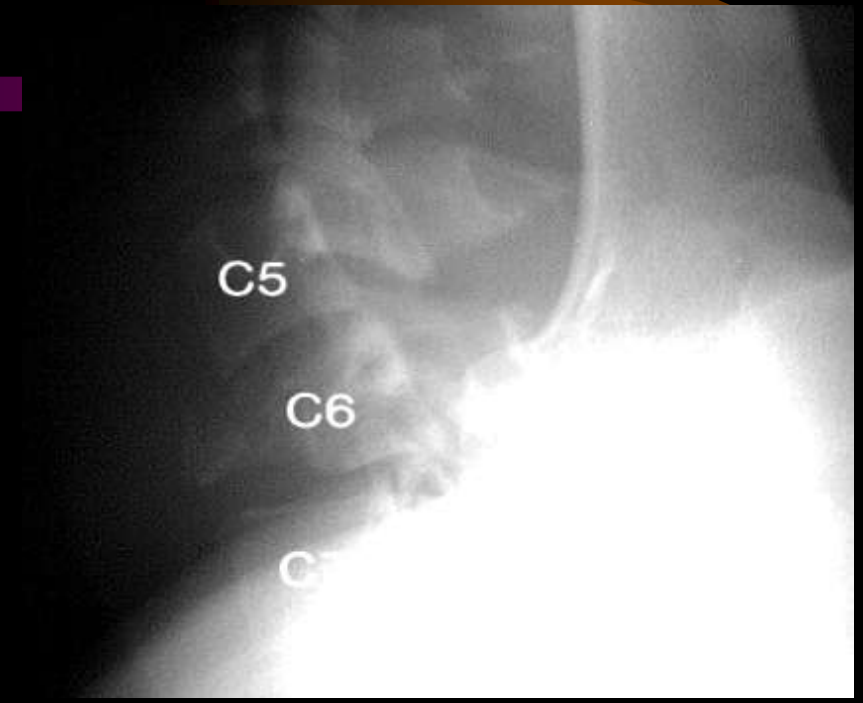
Tear drop 2 level dislocation

C5 and C7 tear drop fractures

C5 and C7 tear drop fractures



C6 Flexion Teardrop



1. Significant Prevert ST Swelling
2. Comminuted Fx of body of C6 with Anterior displacement of a teardrop fracture fragment.

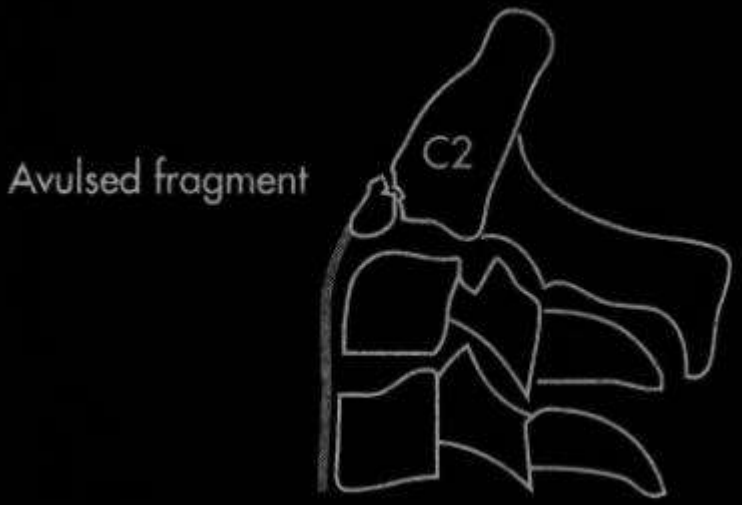
19y.o s/p mva

- Extension Teardrop

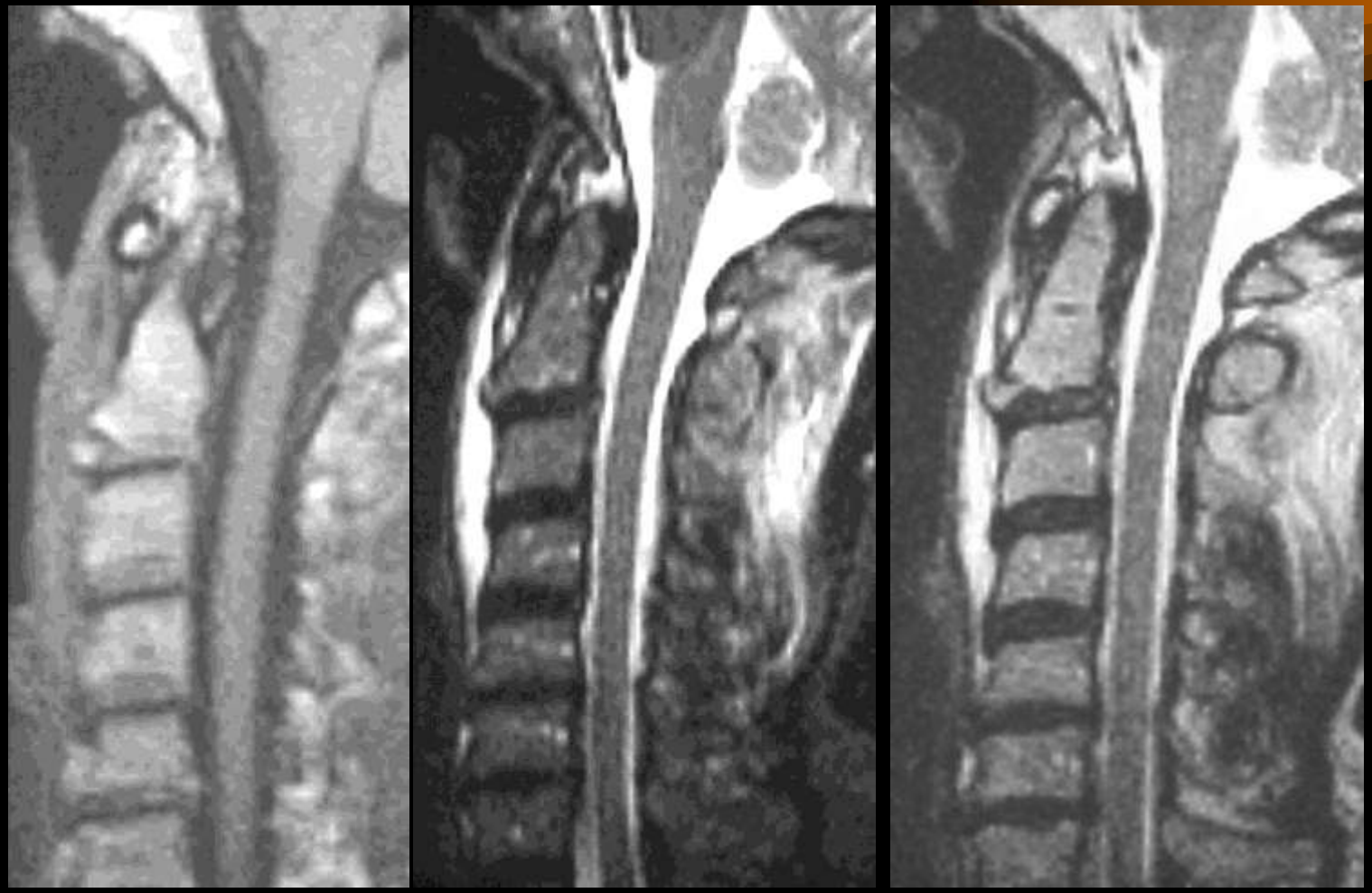
Extension Teardrop Fracture

- Avulsion fracture of anteroinferior corner of C2>C3>C4

- Radiographic findings
  - Teardrop pulled off by ALL
  - Vertical height of fragment >= width



C2 Extension Teardrop



C3 Extension Teardrop

C5 Extension Teardrop

C3-7

- ALL
- Rupture

Anterior Longitudinal Ligament Rupture

- Posterior Teardrop

C6 Posterior Teardrop

C6 Posterior Teardrop

C6 Posterior Teardrop

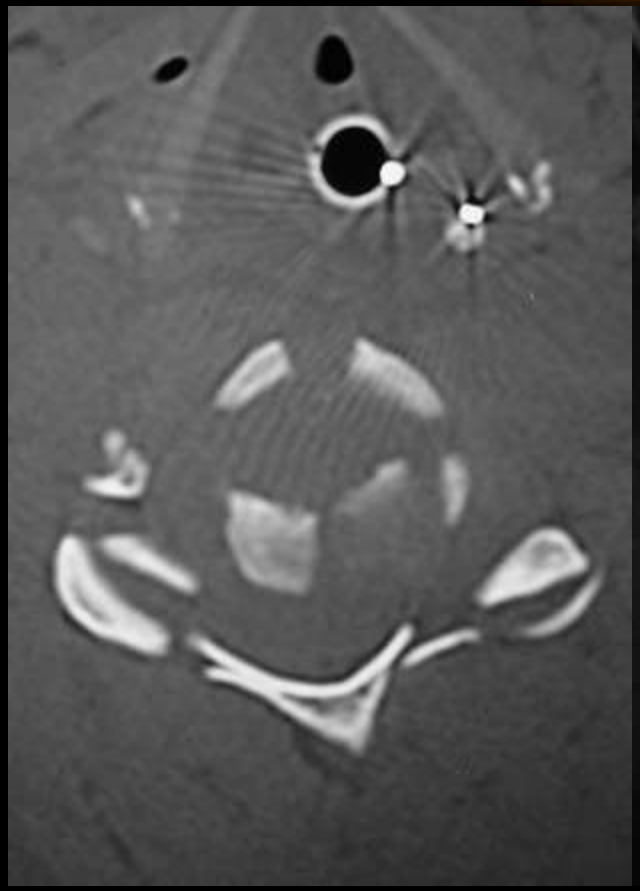
C3-7

- Burst Fracture

Burst Fractures

- Same mechanism as Jefferson Fx but located at C3-C7.
- Injury to spinal cord (due to displacement of posterior fragments) is common.
- Requires CT to evaluate.
- Stable

C5 Burst Fracture

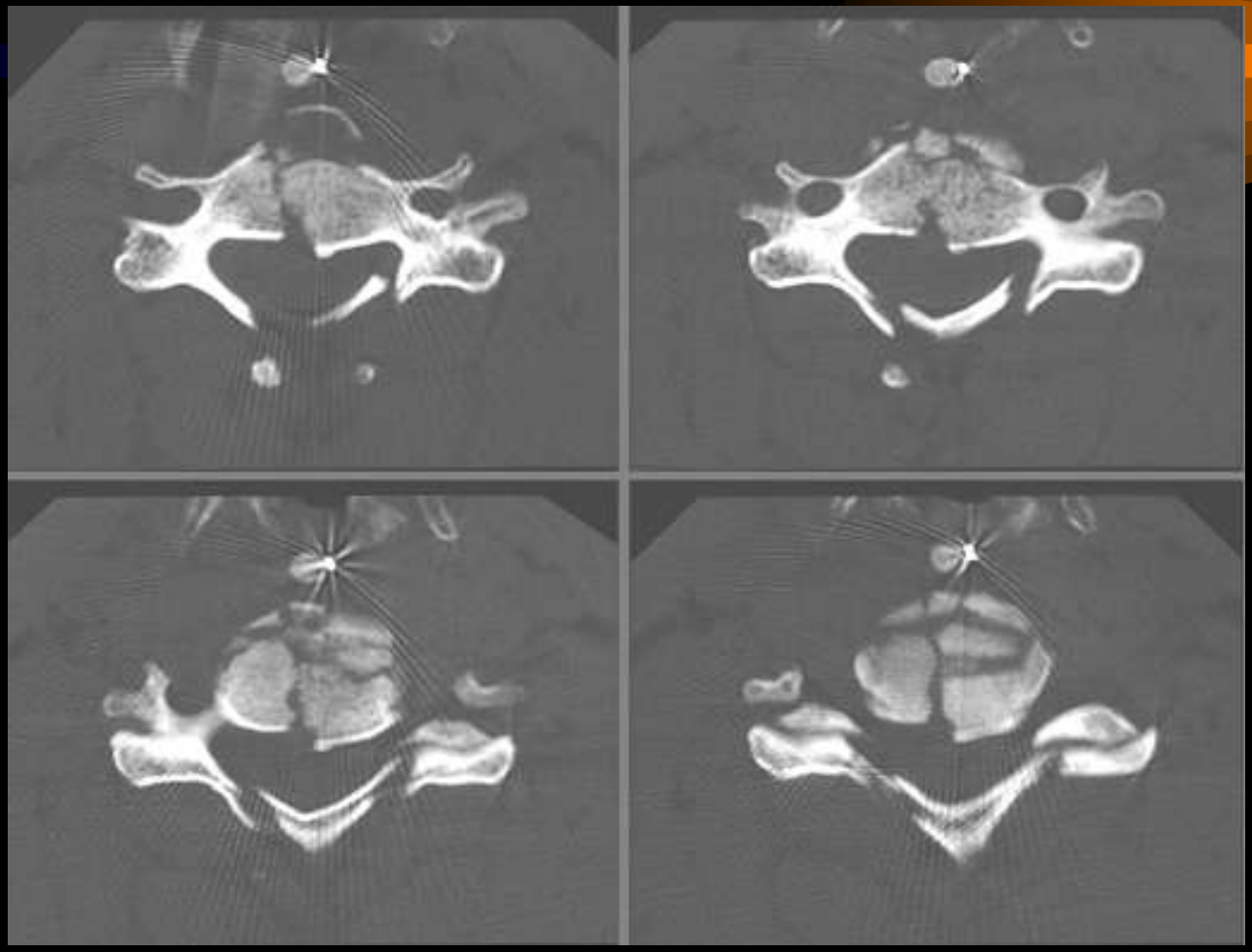


Burst FX of C5 Flexion teardrop mechanism

1. Prevert ST Swelling
2. Comminuted FX of C5 w/slight retrolisthesis of C5/6
3. Extension of Fx into the posterior elements

48 y.o s/p mva with quadriplegia

CT, Burst FX of C5

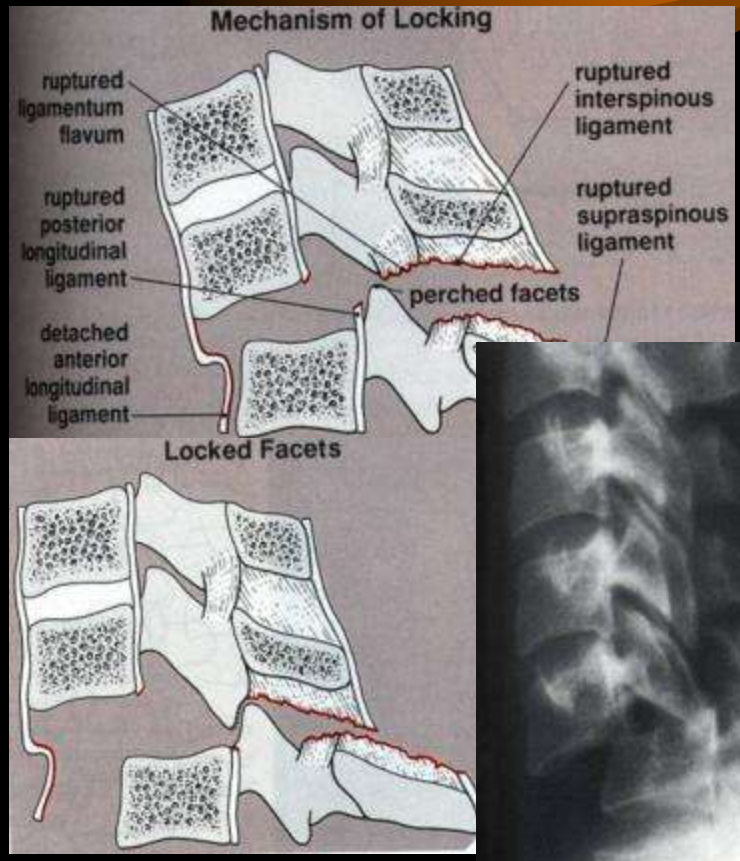


48 y.o s/p mva with quadriplegia

- Facet Dislocation

Facet Dislocation - Subluxations

- Anterior subluxation (hyperflexion strain)
  - The Posterior Ligament complex is disrupted. (30-50% can show delayed instability)
- Unilateral facet dislocation (stable)
  - Results from simultaneous flexion and rotation
- Bilateral Facet Dislocation (unstable)
  - Results from extreme flexion of head and neck without axial compression



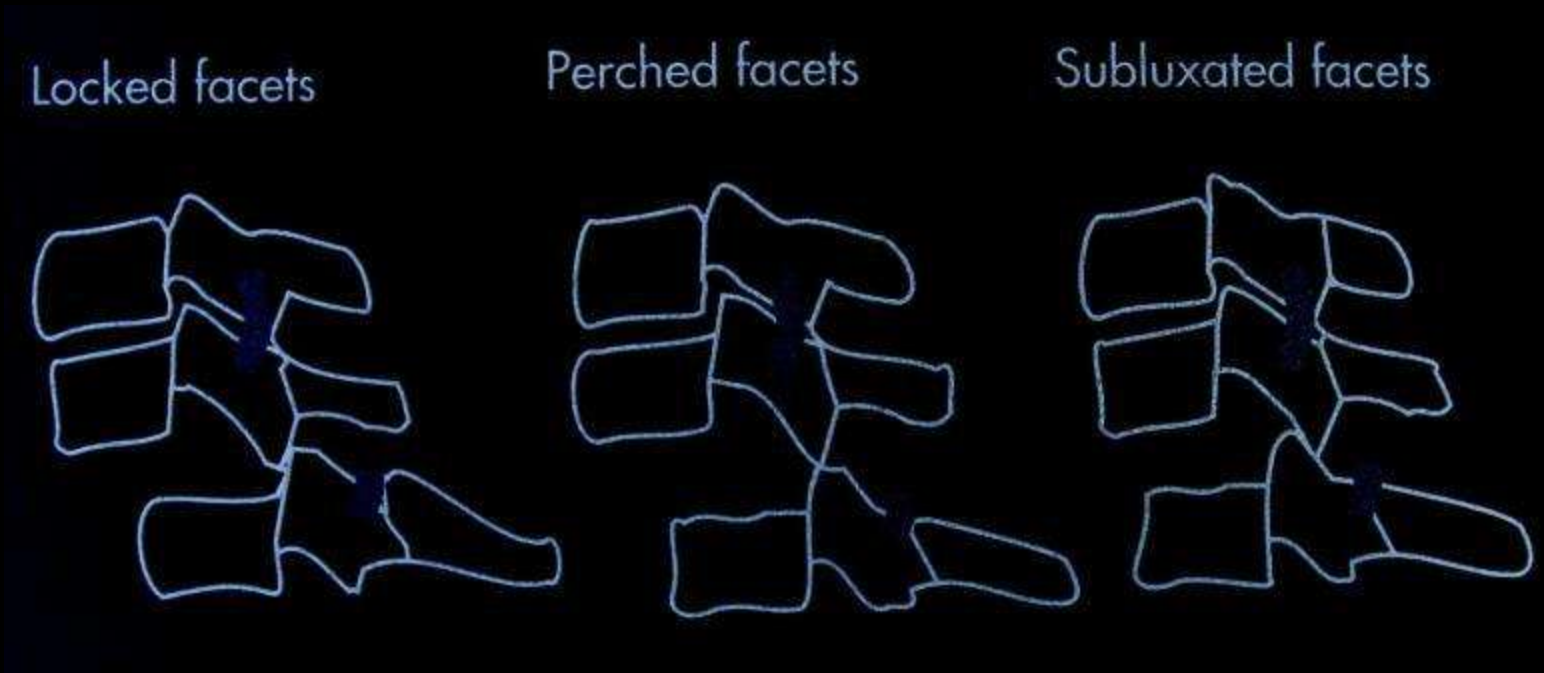
Greenspan

Facet Dislocation - Subluxations

- Anterior subluxation (hyperflexion strain)
  - The Posterior Ligament complex is disrupted. (30-50% can show delayed instability)
- Unilateral facet dislocation (stable)
  - Results from simultaneous flexion and rotation
- Bilateral Facet Dislocation (unstable)
  - Results from extreme flexion of head and neck without axial compression

Facet Dislocation - Subluxations

- Anterior subluxation (hyperflexion strain)
  - The Posterior Ligament complex is disrupted. (30-50% can show delayed instability)
- Unilateral facet dislocation (stable)
  - Results from simultaneous flexion and rotation
- Bilateral Facet Dislocation (unstable)
  - Results from extreme flexion of head and neck without axial compression



- Unilateral
- Facet Dislocation

Unilateral Facet Dislocation

- Simultaneous flexion and rotation
- Best seen on lateral and oblique views
- Vertebral body subluxation < ½ of AP width
- Disrupted “shingles on a roof” on oblique view
- Facet within foramen on oblique view
- Disrupted posterior ligaments
- Disrupted SP line on AP
- Butterfly appears

Rotational Subluxation

1. Prevert ST Normal
2. Normal Alignment
3. Abrupt change in rotation at level of C4-C5.
4. Facets superimposed at C5-6-7.

33 y.o. s/p MVA

Rotational Subluxation

33 y.o. s/p MVA

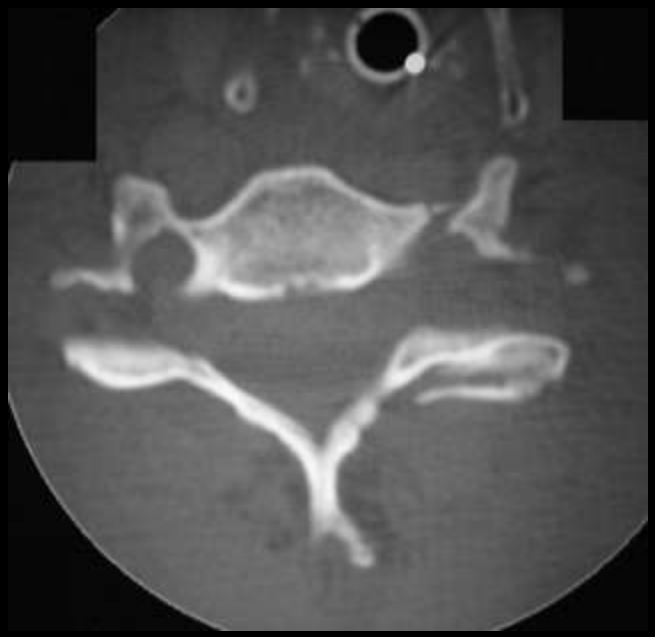
C2-3 Unilateral jumped facet

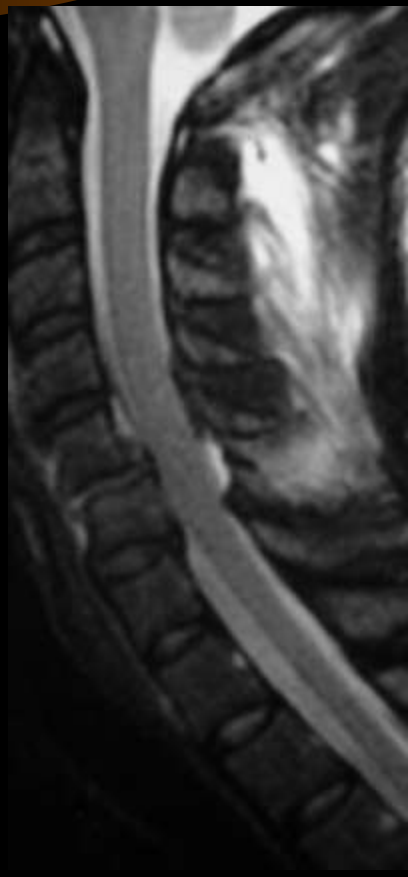
C6-7 Unilateral jumped facet

Butterfly

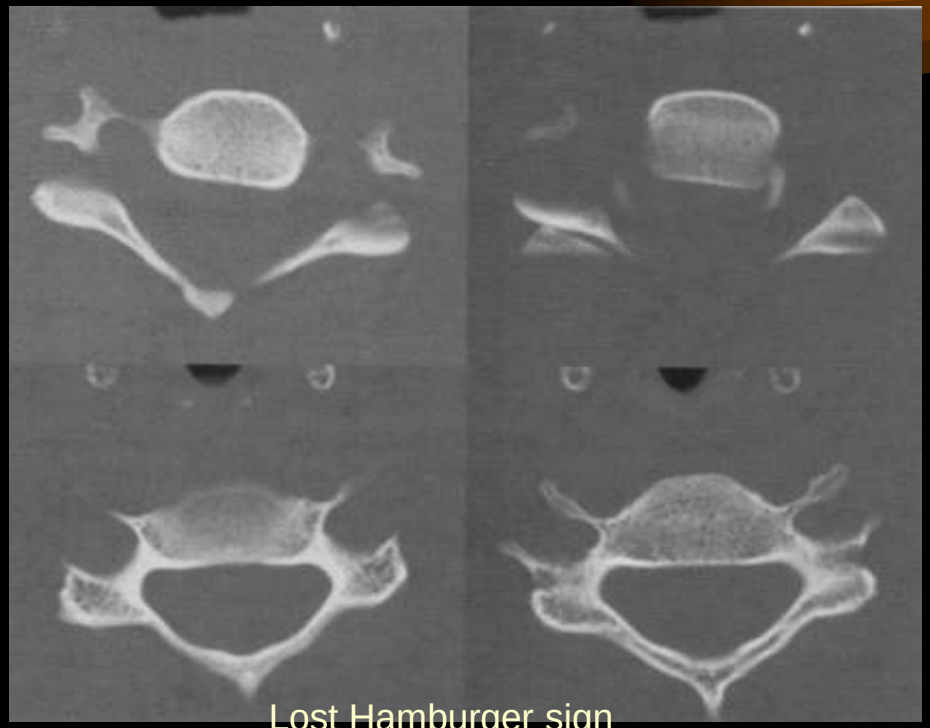
C5-6 Unilateral jumped facet

C5-6 Unilateral jumped facet





C5-6 Unilateral locked facet



Lost Hamburger sign

33 y.o s/p MVA

C6-7 Unilateral locked facet

1. Prevert ST Normal
2. Gd I anterolisthesis of C6 on C7
3. Facets of C7 and T1 superimposed while facets of C6 are abruptly obliqued on C7

22 Y.O. S /P MVA

Unilateral facet lock, C6 on C7

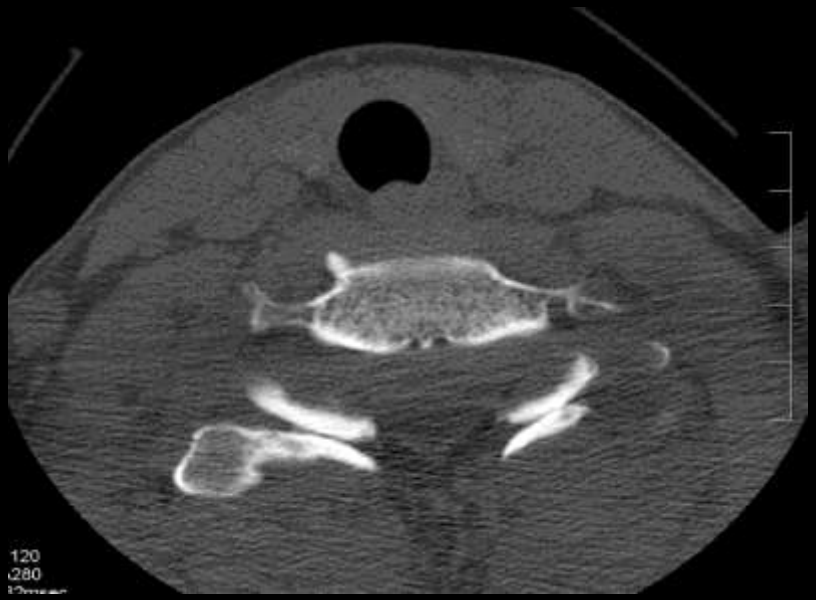
22 Y.O. S /P MVA

- Bifacet Dislocation

Bifacet Dislocation

- Extreme flexion without compression
- Unstable
- Vertebral body anterolisthesis > ½ AP body
- Batwing or bowtie appearance of adjacent facets
- Wide SP on AP view
- Disrupted ALL, disc and posterior ligaments

C7-T1 Bifacet dislocations



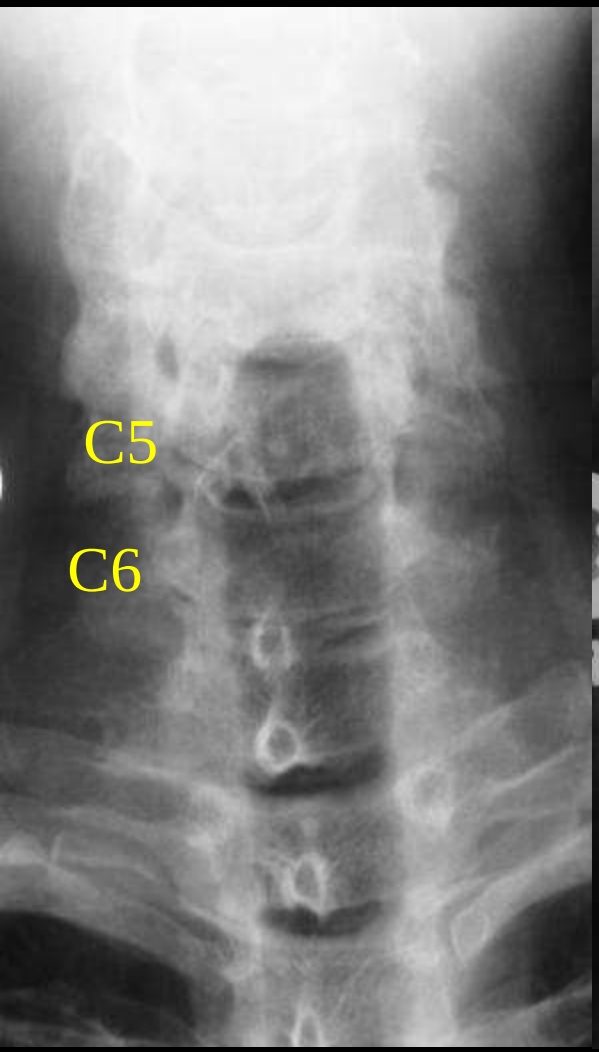
C7-T1 Bifacet dislocations

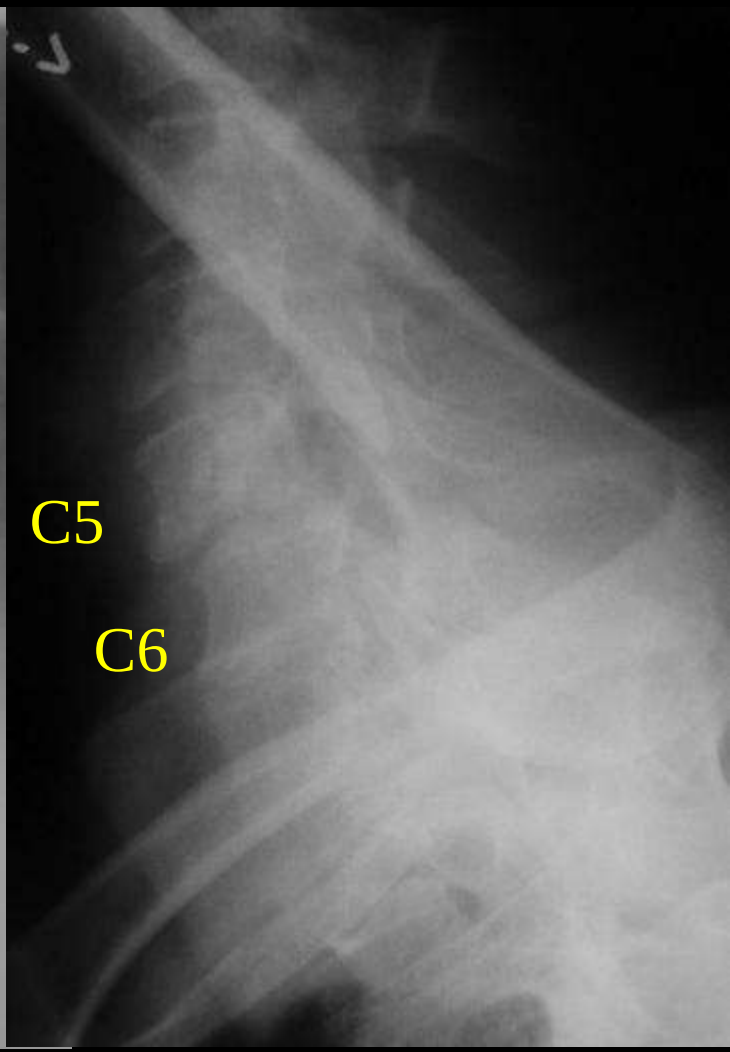
- Unifacet Fracture Dislocation

Unifacet Fracture Dislocation

- More common than pure dislocation
- Signs as before + fracture
- Fracture of facet often not seen on radiographs

C5-6 Uni Facet Fracture Subluxation

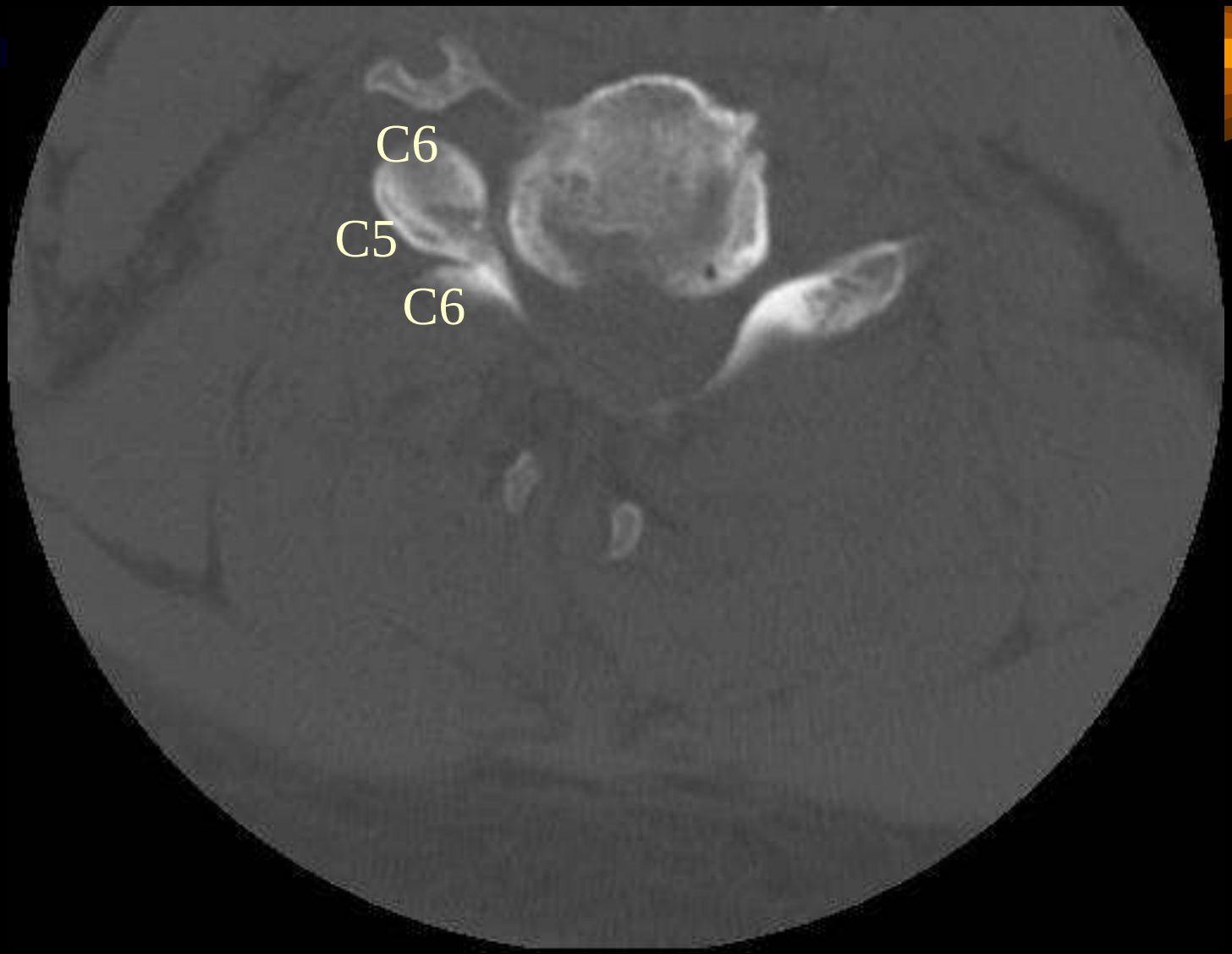




1+4+6+3+1

61M MVA

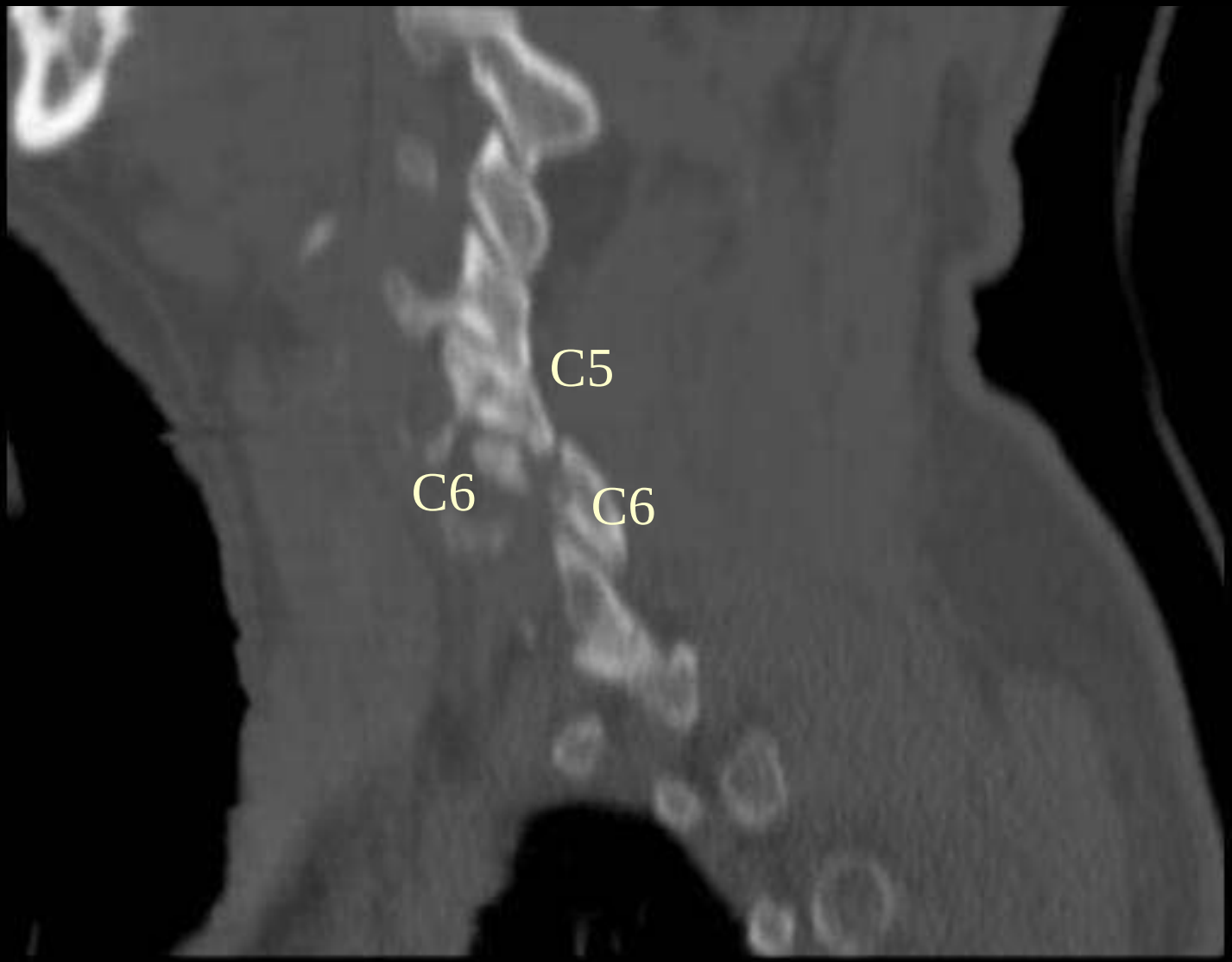
C5-6 Uni Facet Fracture Subluxation



3+6+3+1

61M MVA

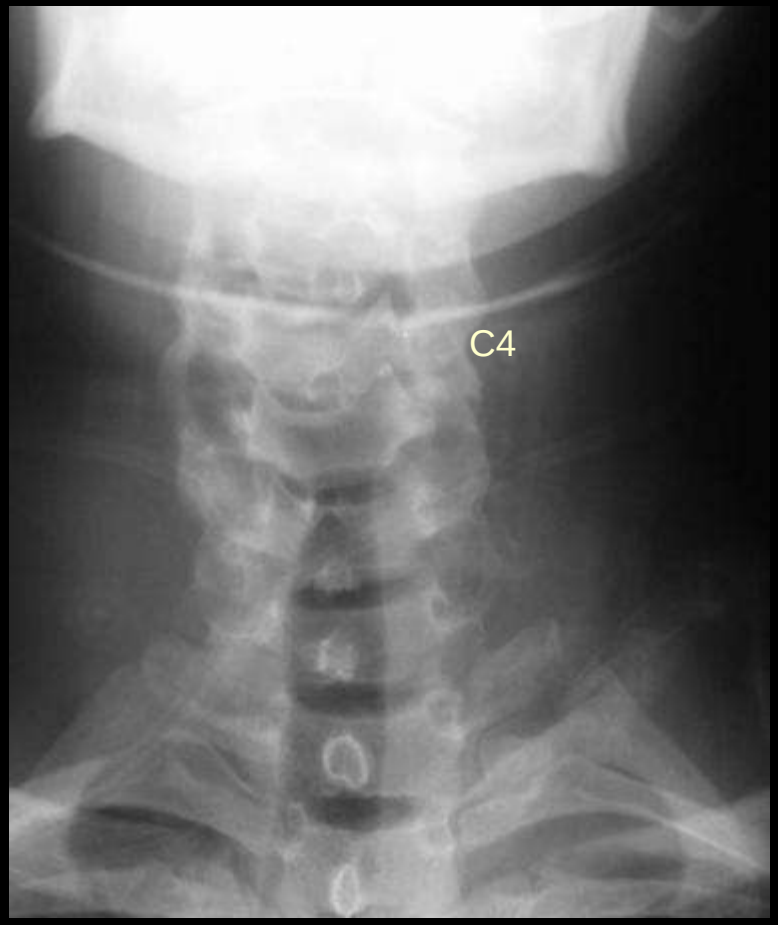
C5-6 Uni Facet Fracture Subluxation



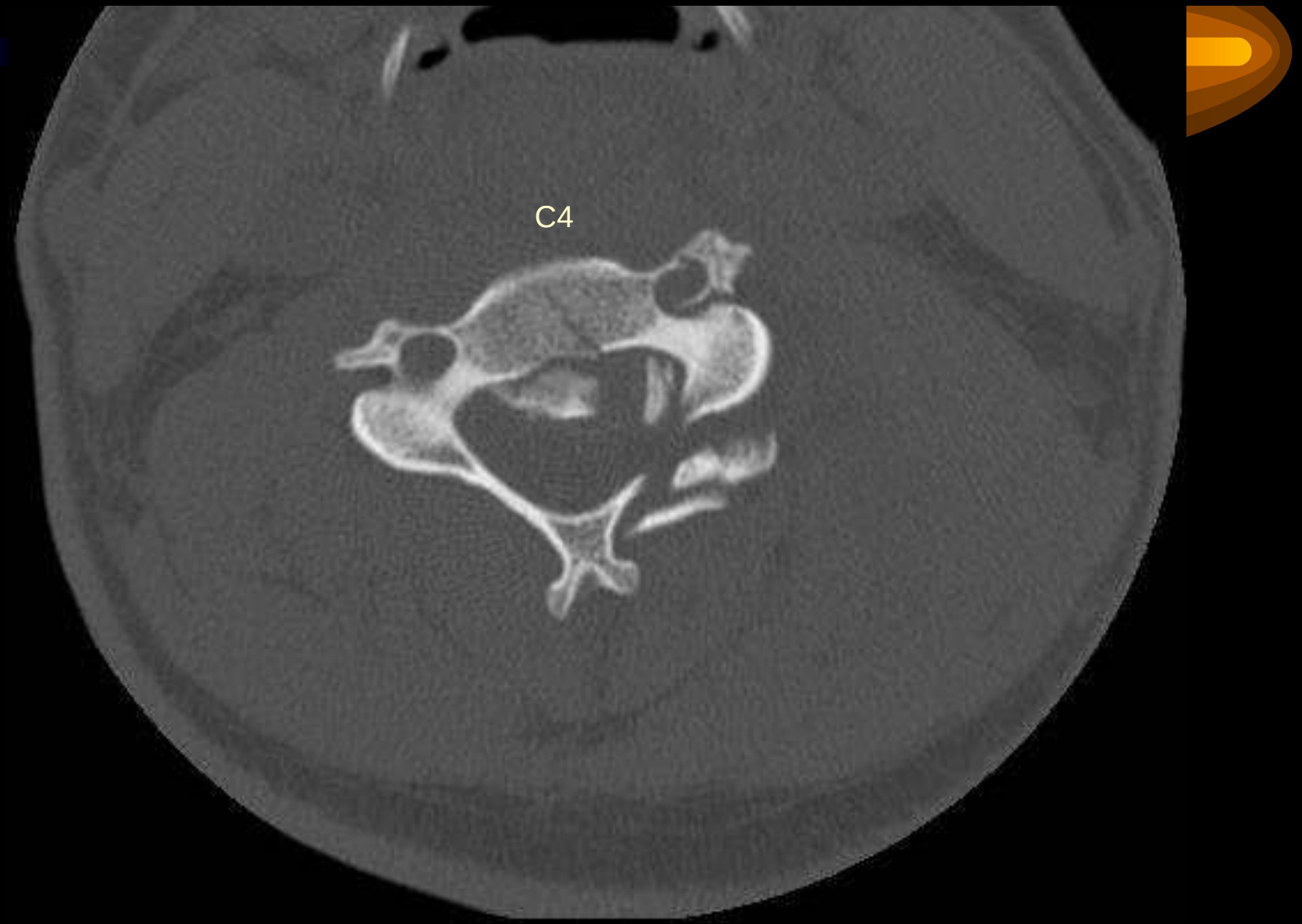
6+3+1

61M MVA

C4-5 Fracture Dislocation

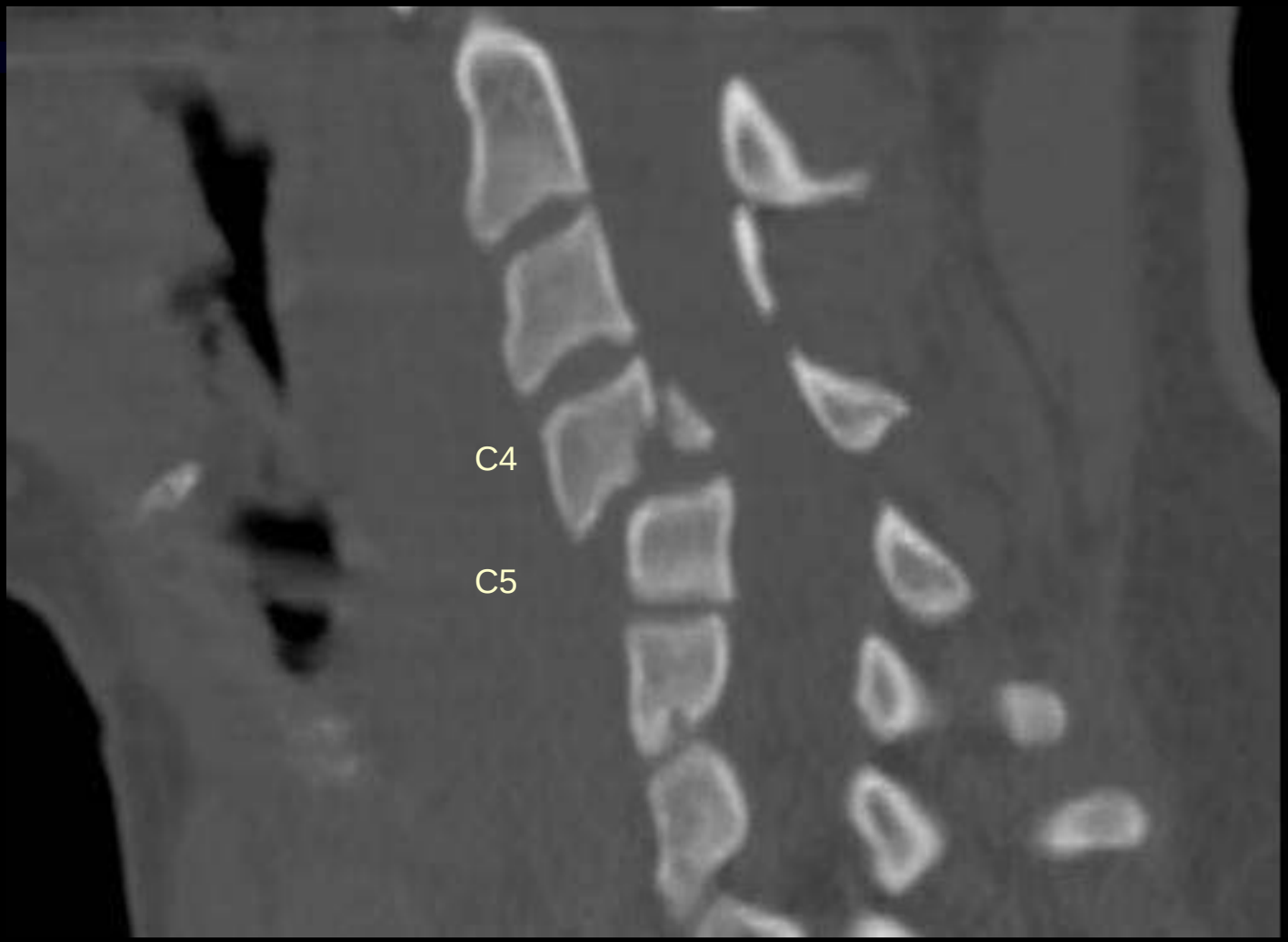


C4-5 Fracture Dislocation



22M

C4-5 Fracture Dislocation



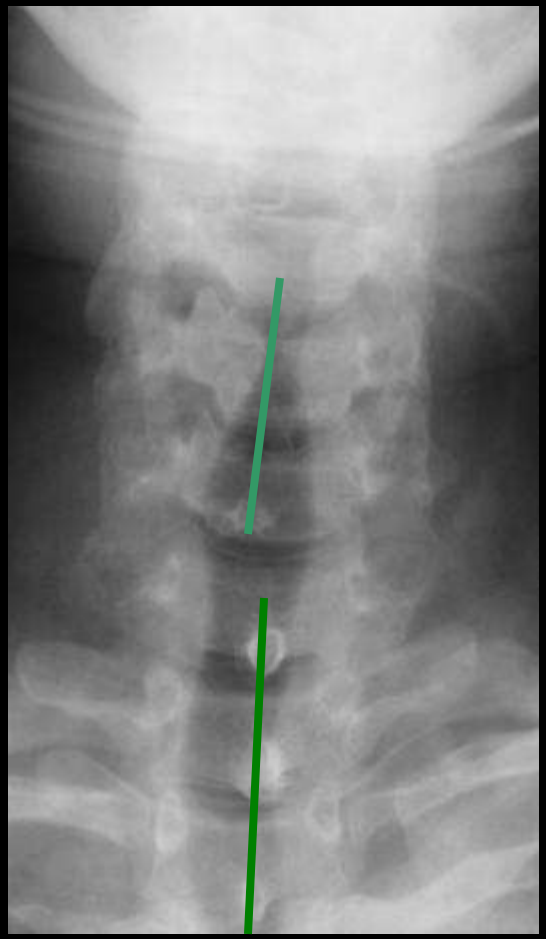
22M

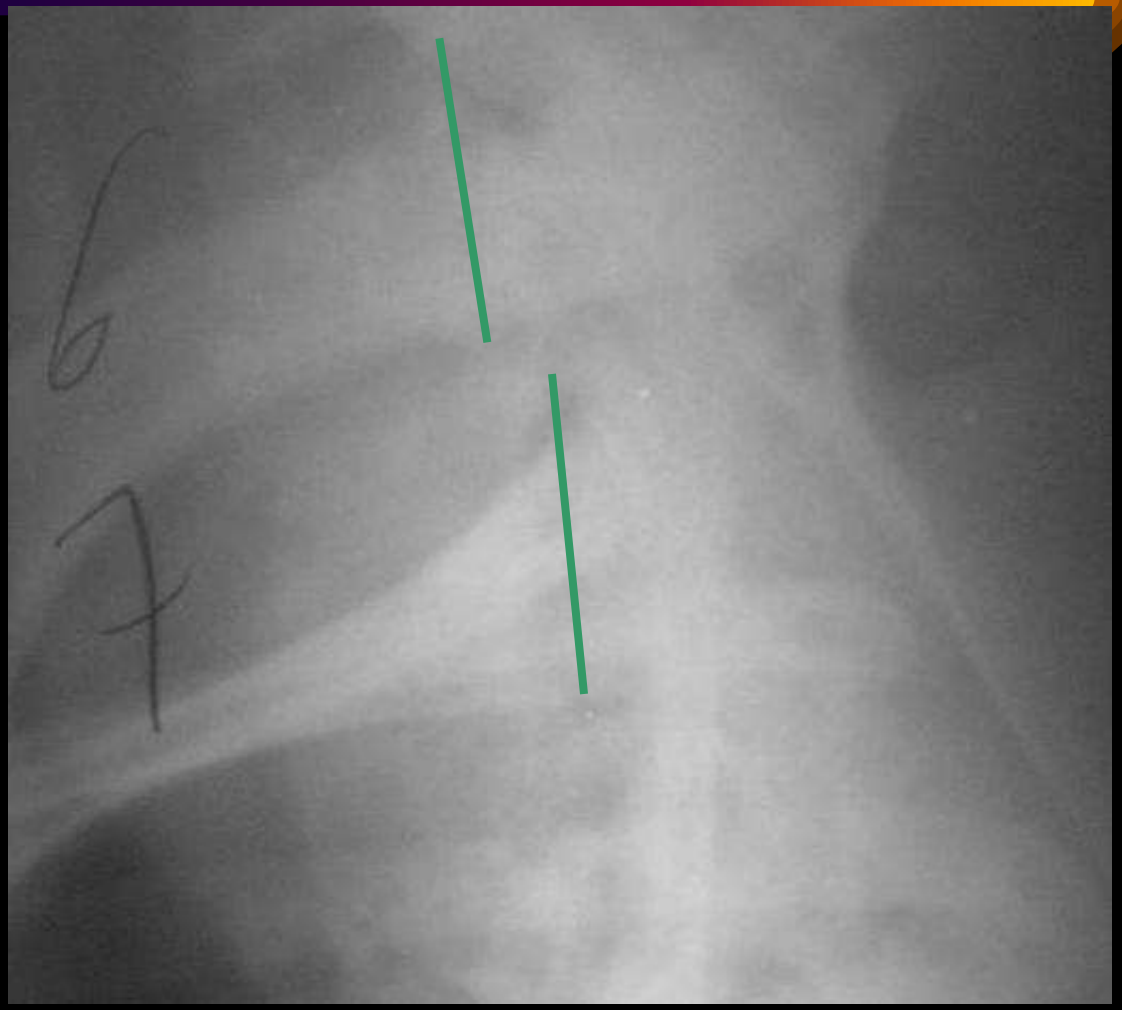
C4-5 Fracture Dislocation

Sag T1

Sag T2

C6-7 Fx subluxation





1+11+18

25M MVA

C5-6 Uni Fx dis with post op unstable C4-5

C5-6 Uni Fx dis with post op unstable C4-5

- Bifacet Fracture Dislocation

Bifacet Fracture Dislocation

- Higher energy than bifacet dislocation
- MVA

- Facet Fracture

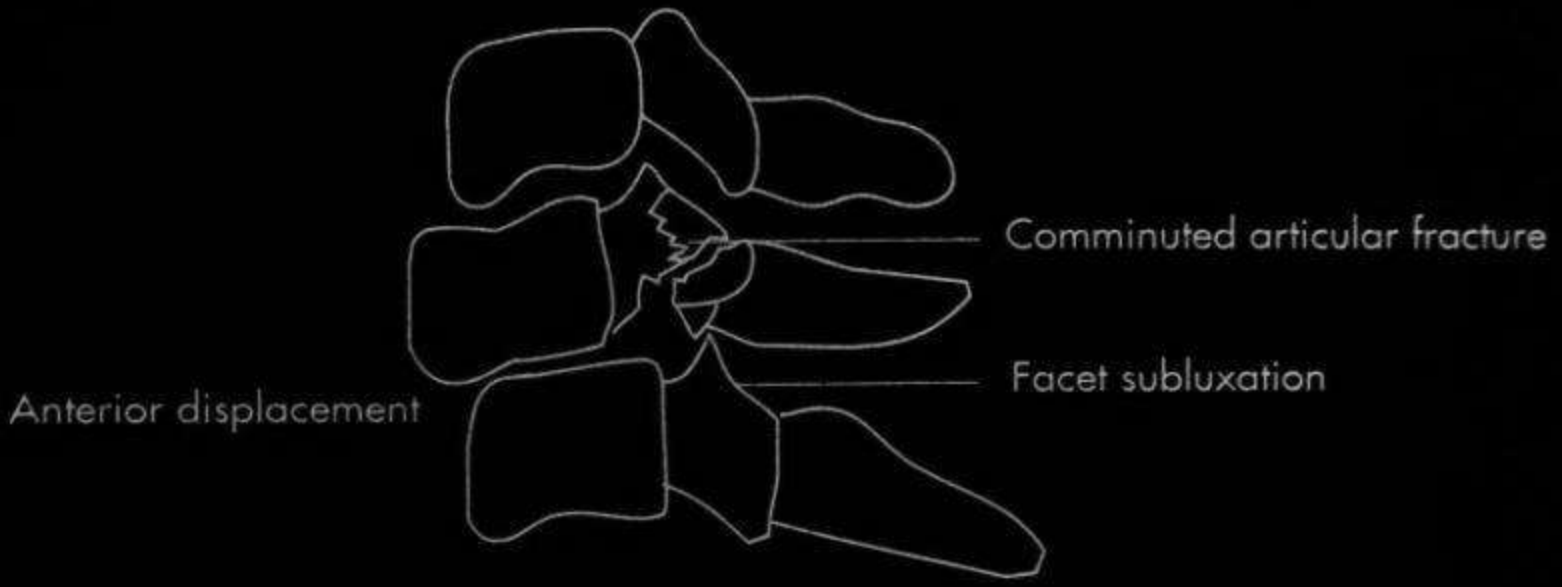
Hyperextension fracture dislocation

- Severe circular hyperextension force
  - Impact on forehead
- Anterior vertebral displacement
- Unstable

Hyperextension fracture dislocation

- Radiographic findings
  - Mild anterior subluxation
  - Comminuted articular mass fracture
  - Contralateral facet subluxation
  - Disrupted ALL, PLL

Hyperextension fracture dislocation



Clay Shovlers

- The shoveler: Special power shoveling.
- Weakness: Spinous process fractures.

•http://www.imdb.com/title/tt0132347/

The Mystery Men

C3-7

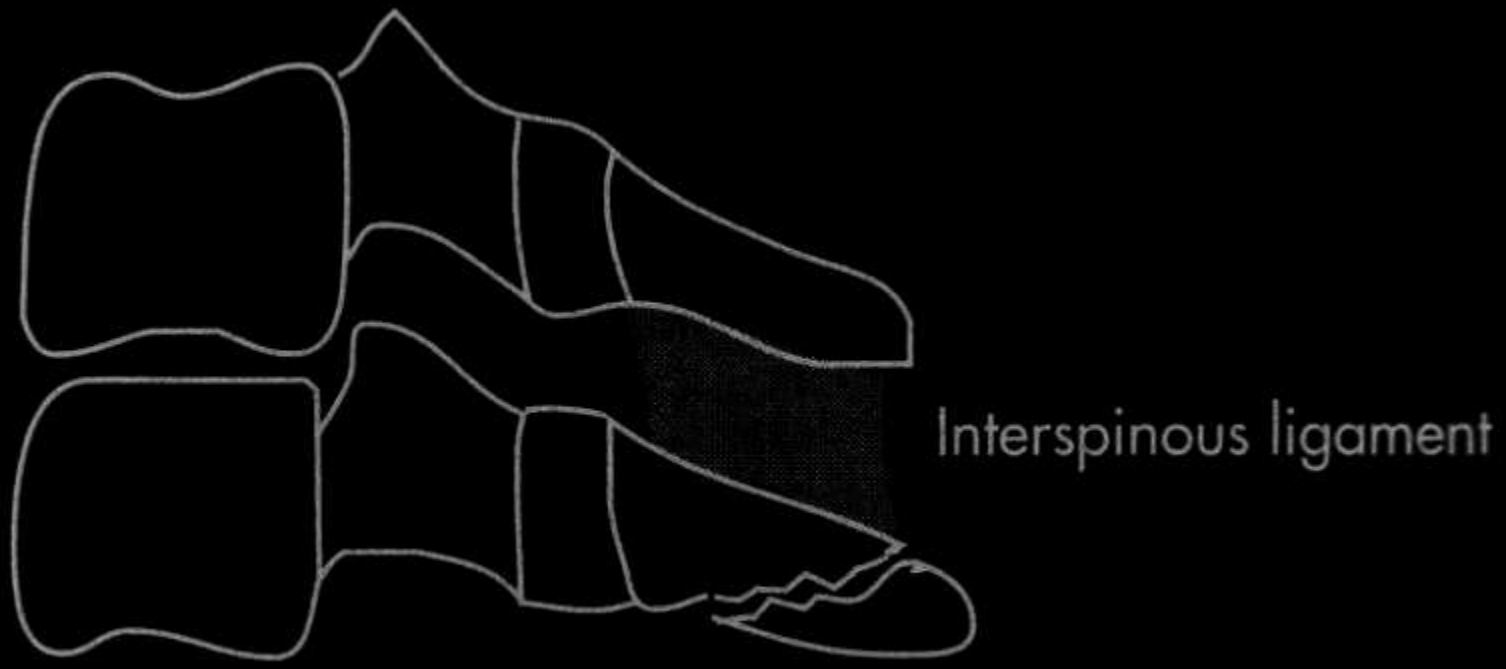
- Clay Shoveler's Fracture

Clay Shoveler's Fracture

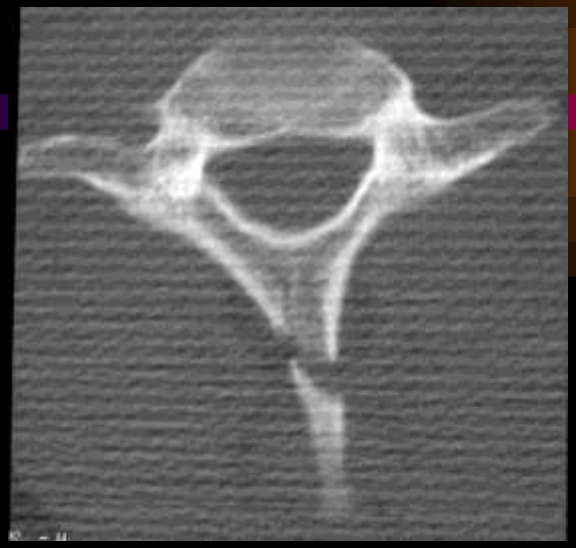
- Oblique avulsion fx of spinous process
- C7 > C6 > T1 levels
- Due to powerful hyperflexion

Clay Shoveler's Fracture

- Best seen on lateral view



Clay Shoveler's Fx



1. Oblique avulsion fx of the spinous process (C7 > C6 > T1)
2. Mechanism: Hyperflexion
3. Stable

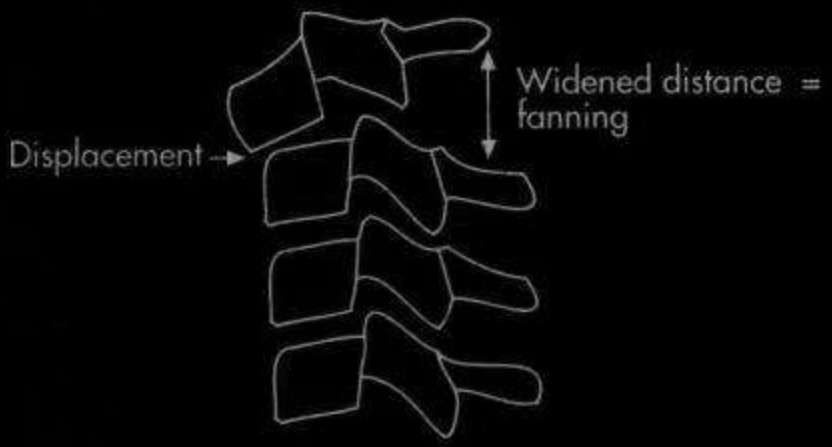
28 y.o construction worker

Old C6 clay shoveler's

- Flexion Subluxation

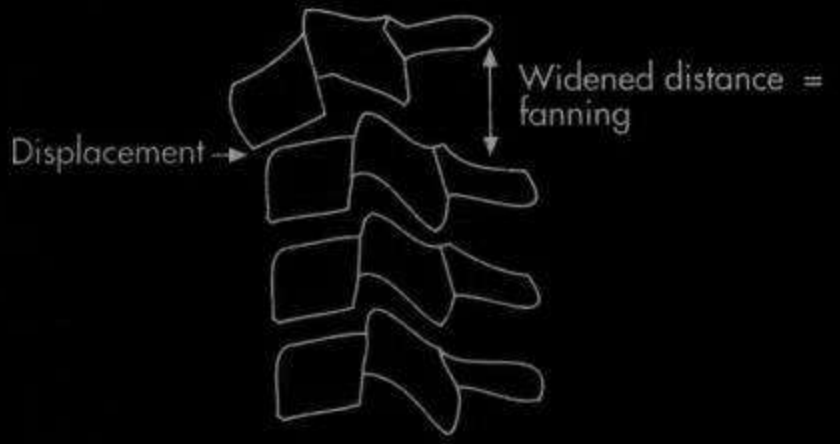
Anterior Subluxation

- Hyperflexion sprain
- Posterior ligament complex disrupted
- 20-50% s



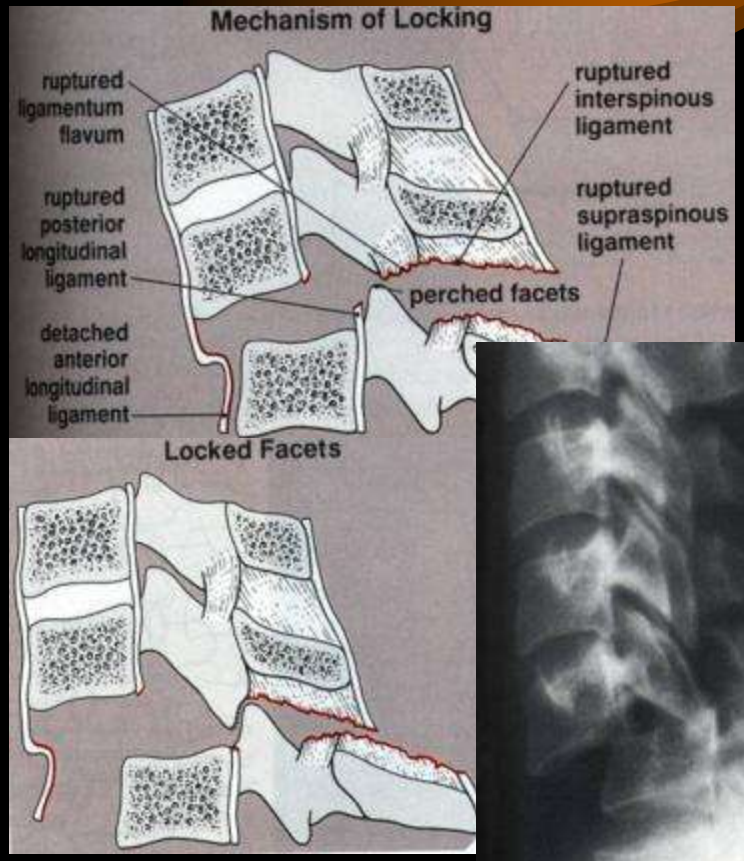
Anterior Subluxation

- Radiographic findings
  - Localized kyphotic angle
  - Fanning
    - Widened interspinous/interlaminar distance
  - Posterior widening of disc space
  - Subluxation of facet joints
  - Anterior subluxation



Facet Dislocation - Subluxations

- Anterior subluxation (hyperflexion strain)
  - The Posterior Ligament complex is disrupted. (30-50% can show delayed instability)
- Unilateral facet dislocation (stable)
  - Results from simultaneous flexion and rotation
- Bilateral Facet Dislocation (unstable)
  - Results from extreme flexion of head and neck without axial compression



Greenspan

C3-4 Flexion subluxation injury

Unstable Posterior Ligamentous Injury at C5-C6

27 y.o. female 3 mo s/p trauma with more recent “neck crackings” by chiropractor.

Unstable Posterior Ligamentous Injury at C5-C6

27 y.o. female 3 mo s/p trauma with more recent “neck crackings” by chiropractor.

Stability

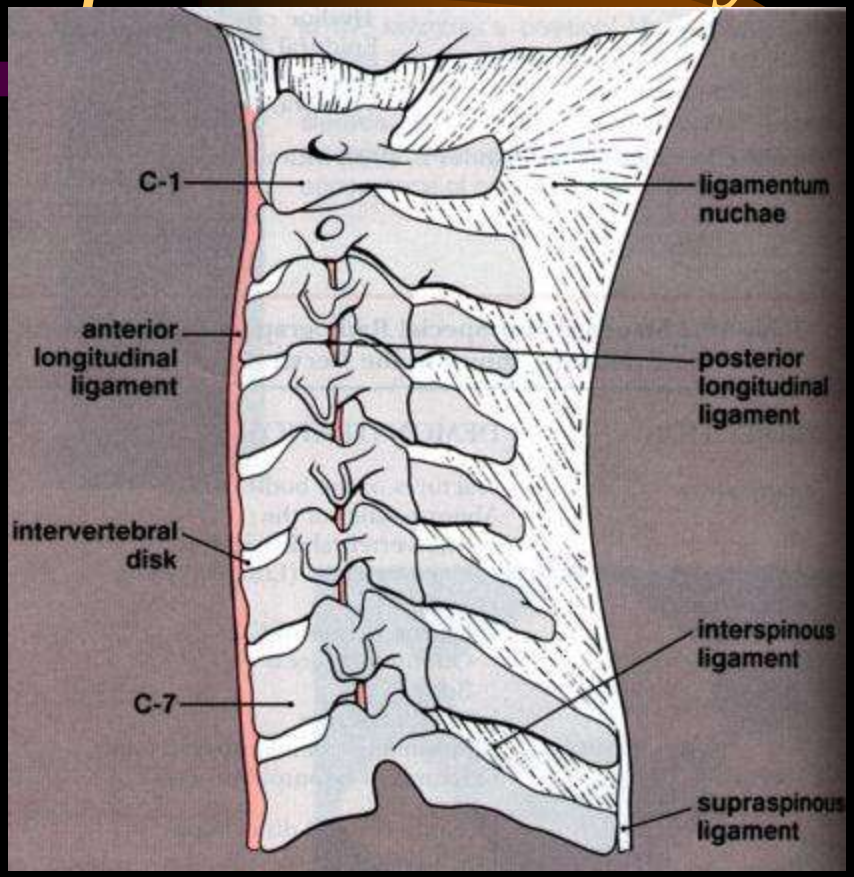
Cx-Spine - Stability

- Stability is a function of ligamentous injury
- Can be inferred from radiographs for certain fracture patterns
- Not 100% accurate
  - Eg. Flexion subluxation

Cx-Spine - Stability

FIG. 8.13 CLASSIFICATION OF INJURIES TO THE CERVICAL SPINE BY MECHANISM OF INJURY AND STABILITY

Condition	Stability
FLEXION INJURIES	
Subluxation	Stable
Dislocation in facet joints (locked facets)	
Unilateral	Stable
Bilateral	Unstable
Odontoid fractures	
Type I	Stable
Type II	Unstable
Type III	Stable
Wedge fracture	Stable
Clay-shoveler's fracture	Stable
Teardrop fracture	Unstable
EXTENSION INJURIES	
Fracture of posterior arch of C-1	Stable
Hangman's fracture	Unstable
"Extension teardrop" fracture	Stable
COMPRESSION INJURIES	
Jefferson's fracture	Unstable
Burst fracture	Stable



An unstable injury, is one which can progress and cause cord injury.

Greenspan

Stability

Flexion	Anterior Subluxation	Stable
	Unilateral facet dislocation	Stable
	Bilateral facet dislocation	Unstable
	Wedge compression fracture	Stable
	Flexion teardrop fracture	Unstable
	Clay-shoveler's fracture	Stable
Extension	Posterior arch C1 fracture	Stable
	Hangman's fracture	Unstable
	Laminar fracture	Stable
	Pillar fracture	Stable
	Extension teardrop fracture	Stable
	Hyperextension dislocation fracture	Unstable
Compression	Jefferson fracture	Unstable
	Burst fracture	Stable
Complex	Odontoid fractures	Unstable
	Atlantooccipital disassociation	Unstable

Cervical Spine - Stability

- MRI
  - Shows
    - Edema of soft tissues
    - Paravertebral hematoma
    - Ligamentous disruption
  - Still does not indicate instability
  - Negative study does not indicate stability

Cx-Spine - Stability

- Flexion Extension views
  - Patient should be erect
  - Should wait 2w for spasm to resolve
  - Must see to T1
  - Must move > 30 degrees

Cx-Spine signs of instability on Flex/Ex.

- Subluxation greater than 3.5mm
- Angular deformity of more than 11 deg.
- Compression fx more than 25% loss of height
- Narrowing of the disk space.
- Widening of the interspinous distance 1.5X
- Facet joint widening

PEARLS

- One view is no view.
- 20% of spinal fractures are multiple
- 5% of spinal fractures are at discontinuous levels
- Most spinal fractures occur in upper (C1-C2) or lower (C5-C7) regions

PEARLS (Cont)

- Spinal cord injury occurs
  - –At time of trauma 84%
  - –As a late complication 15%
- Any signs/symptoms of cord injury require MRI.
- Get CT in patients with unexplained prevertebral soft tissue swelling.

Online credits:

- www.crayola.com
- www.rad.washington.edu
- www.ispub.com
- www.radiographicceu.com
- http://www.imdb.com/title/tt0132347/

If your head comes away from your neck, it's over!

The Highlander http://www.imdb.com