Cervical Spine Trauma

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May 20th, 2010

Objectives

- Discuss relevant anatomy
- Discuss methods for clinical triage
- Discuss imaging
- Discuss fracture types in the cervical spine
- Discuss classification systems

Injuries

- ~150,000 injuries to the spinal column per year in North America.
- A majority of these are cervical
- Most are related to motorized accidents or falls resulting in bony or soft tissue injuries
- A relatively broad range of injury patterns can be seen because of the complex anatomy that allows for a wide range of motion in the cervical spine

Injuries

- Bimodal age distribution
- 15-24 y.o. usually secondary to high energy trauma such as MVC, ATV, PED vs AUTO (trolley, scooter, etc.)
- > 55 (Older folks!) – usually secondary to low energy trauma such a fall
- Cord involvement is related to the mechanism and possibly underlying pathology such as central spinal canal stenosis

Location

- The subaxial spine accounts for a majority of fractures and dislocations
- Craniocervical injury are less common but are more frequently associated with fatal motor vehicle accidents
- Reportedly cervical spine injuries can be seen in over 1/5 of fatal motor vehicle accidents with large majority being in the craniocervical junction

Clinical Assesment

- There are two major methods for clinical assessment and potential clearing of the cervical spine in the setting of trauma
- Most are based on being utilized on a patient who is not obtunded or altered

NEXUS - low risk

- No midline cervical tenderness
- No focal neurological deficit
- Normal alertness
- No intoxication
- No painful distracting injury

Canadian c-spine rules

- Is there any high risk factor that mandates imaging?
- Is there any low risk factor that allows safe evaluation of neck range of motion?
- Is the patient able to actively rotate the neck 45 degrees to the left and right?
- Can be applied to alert, stable patients

Canadian c-spine rule

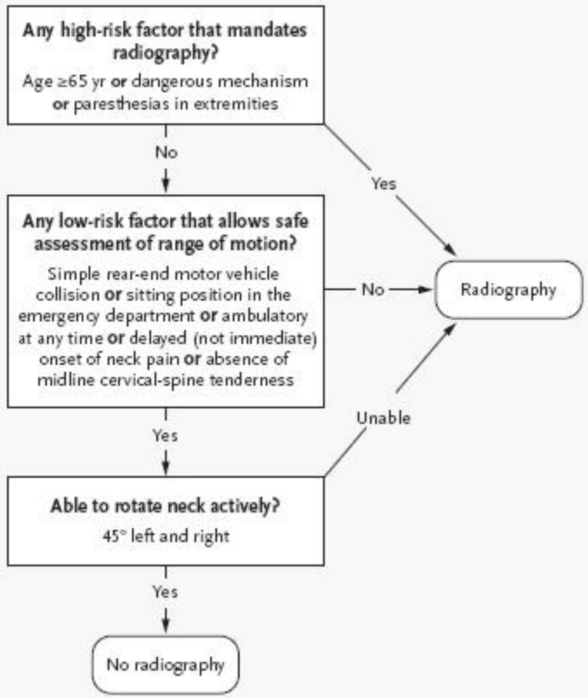


Figure 1. The Canadian C-Spine Rule.

For patients with trauma who are alert (as indicated by a score of 15 on the Glasgow Coma Scale) and in stable condition and in whom cervical-spine injury is a concern, the determination of risk factors guides the use of cervical-spine radiography. A dangerous mechanism is considered to be a fall from an elevation ≥3 ft or 5 stairs; an axial load to the head (e.g., diving); a motor vehicle collision at high speed (>100 km/hr) or with rollover or ejection; a collision involving a motorized recreational vehicle; or a bicycle collision. A simple rear-end motor vehicle collision excludes being pushed into oncoming traffic, being hit by a bus or a large truck, a rollover, and being hit by a high-speed vehicle.

Canadian c-spine rule

- High risk criteria
  - Age >65
  - Dangerous mechanism
  - Fall from 1 meter (5 stairs)
  - Axial load to the head
  - Motor vehicle collision at high speed >60mph
  - Rollover or ejection
  - Motorized recreational vehicles
  - Bicycle collision
  - Presence of paraesthesia in extremities
- Low risk criteria
  - Simple rear end collision
  - Sitting position in the emergency room
  - Ambulatory at any time
  - Delayed onset of neck pain
  - Absence of midline cervical spine tenderness
- Radiographs versus CT
  - Typically the break point is a >5% risk of CSI however there is some debate about the criteria for defining high risk
  - It is not uncommon for sites to use CT in the setting where patients cannot be clinically cleared

Other validated high risk criteria

- Focal neurological deficit
- Severe head injury
  - unconscious, skull fracture, intracranial hemorrhage
- High energy mechanism
  - MVC speed> 35mph
  - auto vs. pedestrian
  - death at scene
  - pelvic fracture

Hanson, et al, *AJR 2000:174:713-718*

Imaging

- Many still won't clear without any imaging
- Studies have shown the higher sensitivity of CCR (100%) and NEXUS
- Radiography sensitivity <95% - on the high end
- CT has been shown to be cost effective and the modality of choice in moderate and high-risk patients with a >5% risk of CSI or for evaluating suspicious or poorly evaluated areas
- The definition of high-risk is variable
- Some suggest CT replace radiography entirely

Blackmore et al

- High (fracture risk of 11.2%) = severe head injury, focal neuro deficits, >50 yrs w/ high-energy mechanism of injury.
- Moderate (4.2%)= >50 yrs w/ a moderate-energy mechanism or <50 w/high energy.
- Low (2.1%)= <50 w/ moderate energy mechanism of injury
- Blackmore et al found c- spine screening with CT is cost effective for High and Moderate risk patients
- Low risk pts should undergo radiography or no imaging

Imaging

- Flexion and extension views can be utilized to evaluate for instability
- Should be considered in those with persistent symptoms and normal radiographs or CT
- 10-14 day delay is suggested but not universal
- MRI can be used in the more acute setting to detect ligament or cord injury especially in the setting of a neurologic deficit

Anatomy

- The cervical spine consists of two distinct regions
  - Craniocervical junction – occitput, C1 and C2
  - Lower cervical spine – C3-C7
- C2-3 is a considered a transitional region
- Injury patterns in the lower cervical spine are characterized into groups
- This same approach is considered to have limited application in the craniocervical junction

Three Column Theory of Denis

- Spinal column divided into an ANTERIOR, MIDDLE and POSTERIOR column.

- Injury to one column is stable, two or three are unstable.

ANTERIOR COLUMN

- The anterior longitudinal ligament, anterior 2/3 of the vertebral body and disc

MIDDLE COLUMN

- Posterior longitudinal ligament and posterior 1/3 of the vertebral body and disc

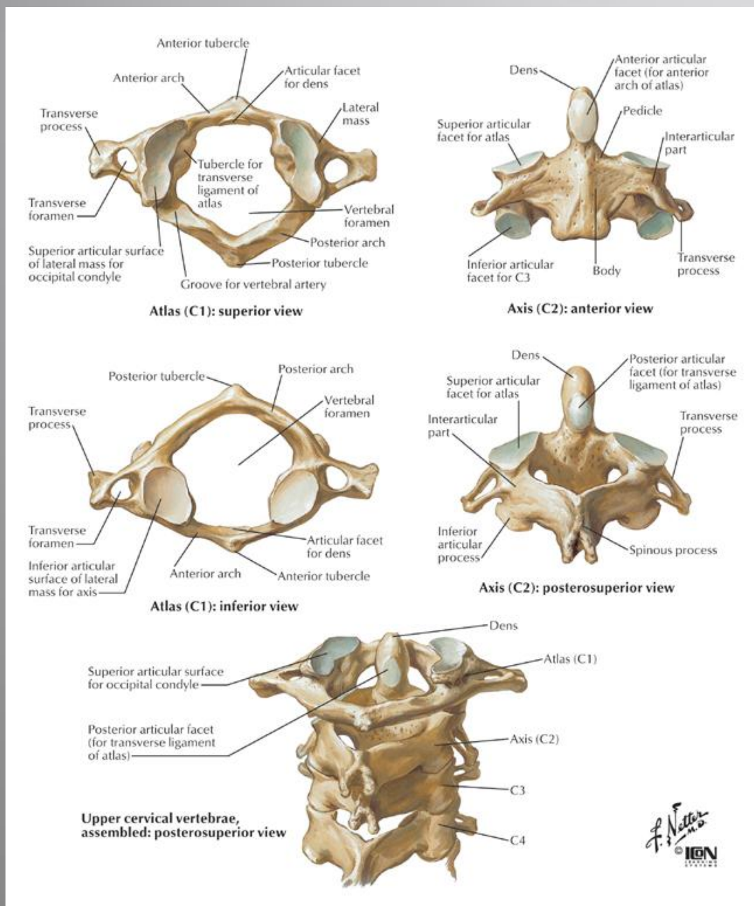
POSTERIOR COLUMN

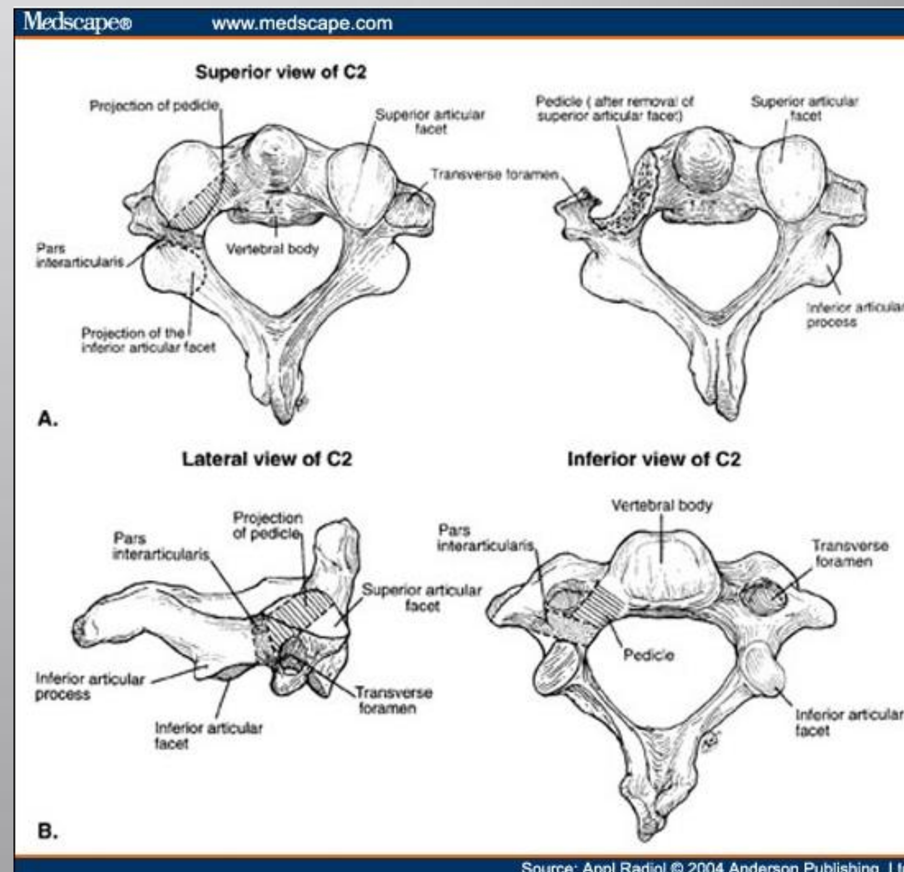
- The posterior osseous arch and ligaments

DOES IT WORK?

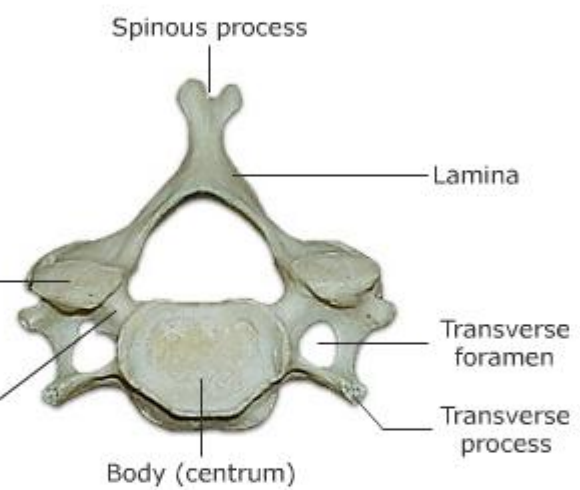
- If two or three columns injured, lesion is unstable
- Works well for C3 to T1
- Does not work so well for C1-2, so consider most or all injuries here unstable

Craniocervical junction





Typical cervical vertebral body



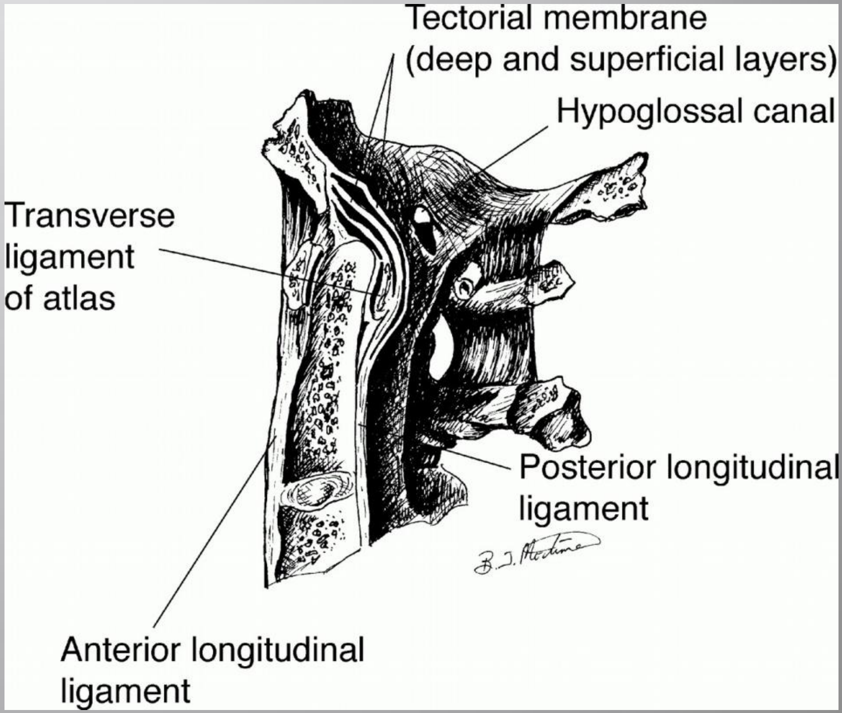
Superior view of a typcial 3rd - 7th cervical vertebra

Craniocervical Articulations

- Middle or median (posterior and anterior) atlantoaxial joints which consists of two synovial compartments
- Atlantooccipital joints-paired
- Lateral atlantoaxial joints-paired
- All are true synovial joints with hyaline cartilage and prominent lax capsules
- These allow rotation of C1 around C2

Articulations

- These articulations are held together and supported by an array of ligamentous structures considered internal and external craniocervical ligaments
- These ligaments provide a large portion of the stability in the craniocervical junction
- Probably more so than the combined ligamentous and osseous stabilizers found in the lower cervical spine



Deliganis A V et al. Radiographics 2000;20:S237-S250

Critical structures

- Tectorial Membrane – a continuation of the posterior longitudinal ligament
- Alar ligaments – extend from the superior lateratal dens to the medial aspect of the occipital condyle
- Transverse ligament – transverse portion of the cruciate ligament
- Others – anterior longitudinal ligament, anterior atlantoaxial and atlantooccipital ligaments, superior and inferior fasciculi of the cruciform
- ?Lateral atlantooccipitial ligament –of interest as it suspected to provide stability but not well studied

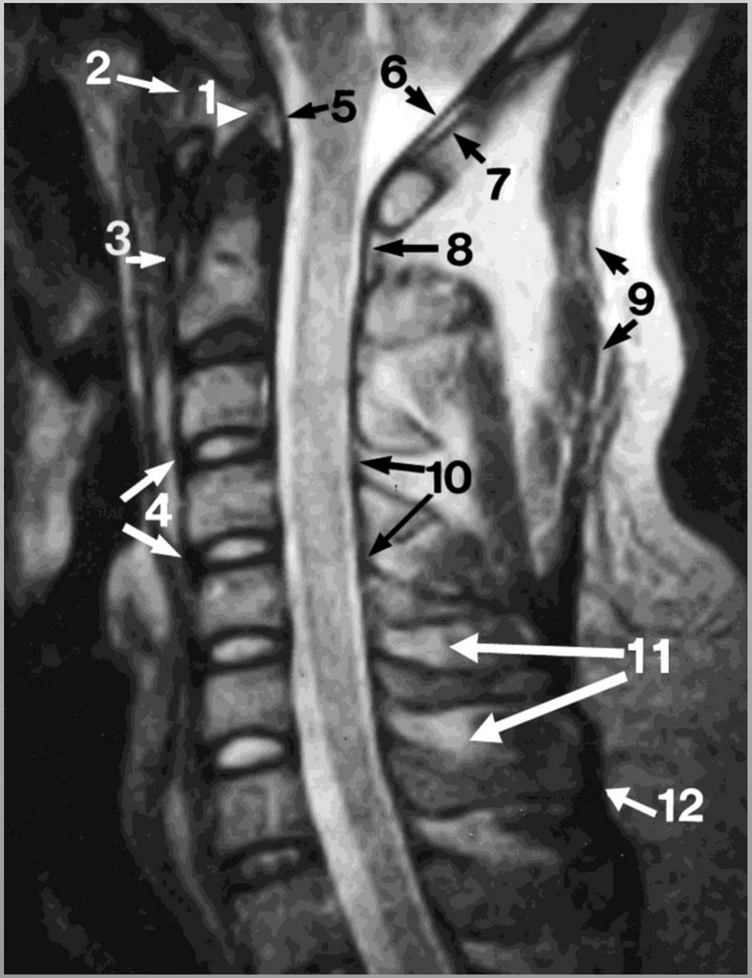
Complex craniovertebral anatomy

Schweitzer, M E et al AJR 158:1087-1090

Key to Abbreviations Used in Figures

a	alar ligaments
b	anterior atlantoaxial ligament (deep portion)
b′	anterior atlantoaxial ligament (superficial portion)
c	anterior atlantooccipital membrane
C	clivus
d	anterior longitudinal ligament
D	dens (odontoid process)
e	apical ligament (in fat)
f	articular cartilage
g	atlantooccipital ligaments
h	transverse ligament of atlas
hi	inferior longitudinal fasciculus of cruciform ligament
hs	superior longitudinal fasciculus of cruciform ligament
i	capsule of anterior median atlantoaxial joint
k	capsule of atlantooccipital joint
l	capsule of lateral atlantoaxial joint
m	capsule of posterior median atlantoaxial joint
n	interspinous ligament
O	occiput
p	ligamenta flava
r	posterior atlantooccipital membrane
s	posterior longitudinal ligament
t	tectorial membrane
V	vertebral artery
1	atlas (C1)
2	axis (C2)

Anatomy



Benedetti, P. F. et al. Am. J. Roentgenol. 2000;175:661-665

Anatomy

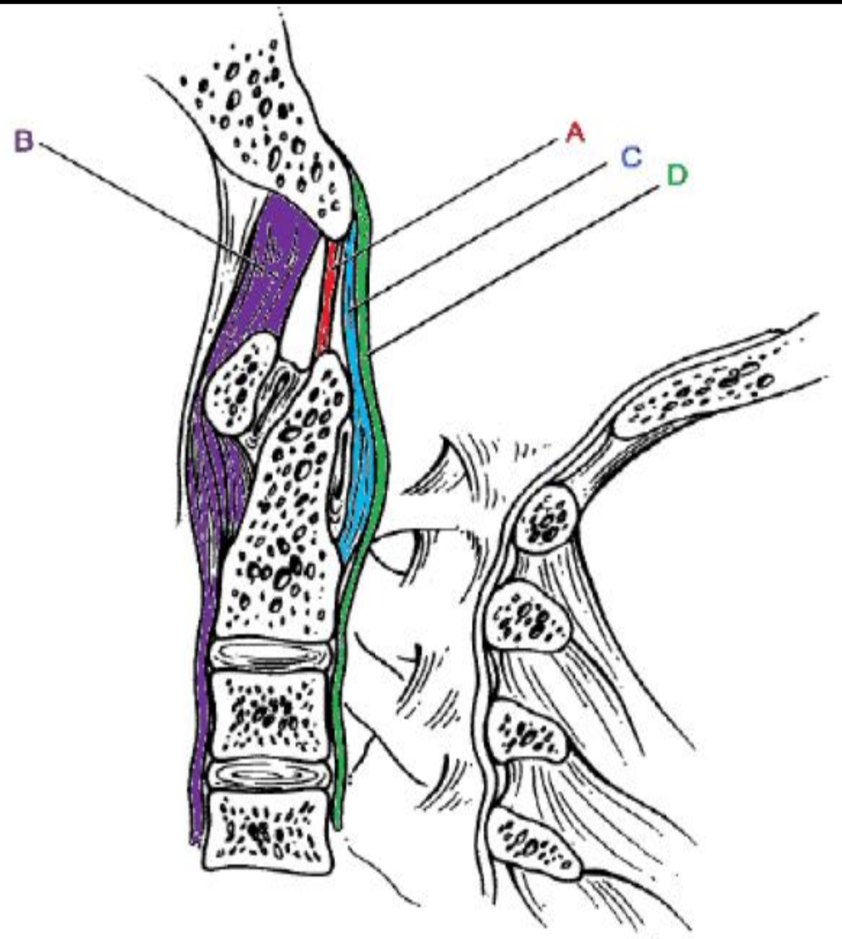
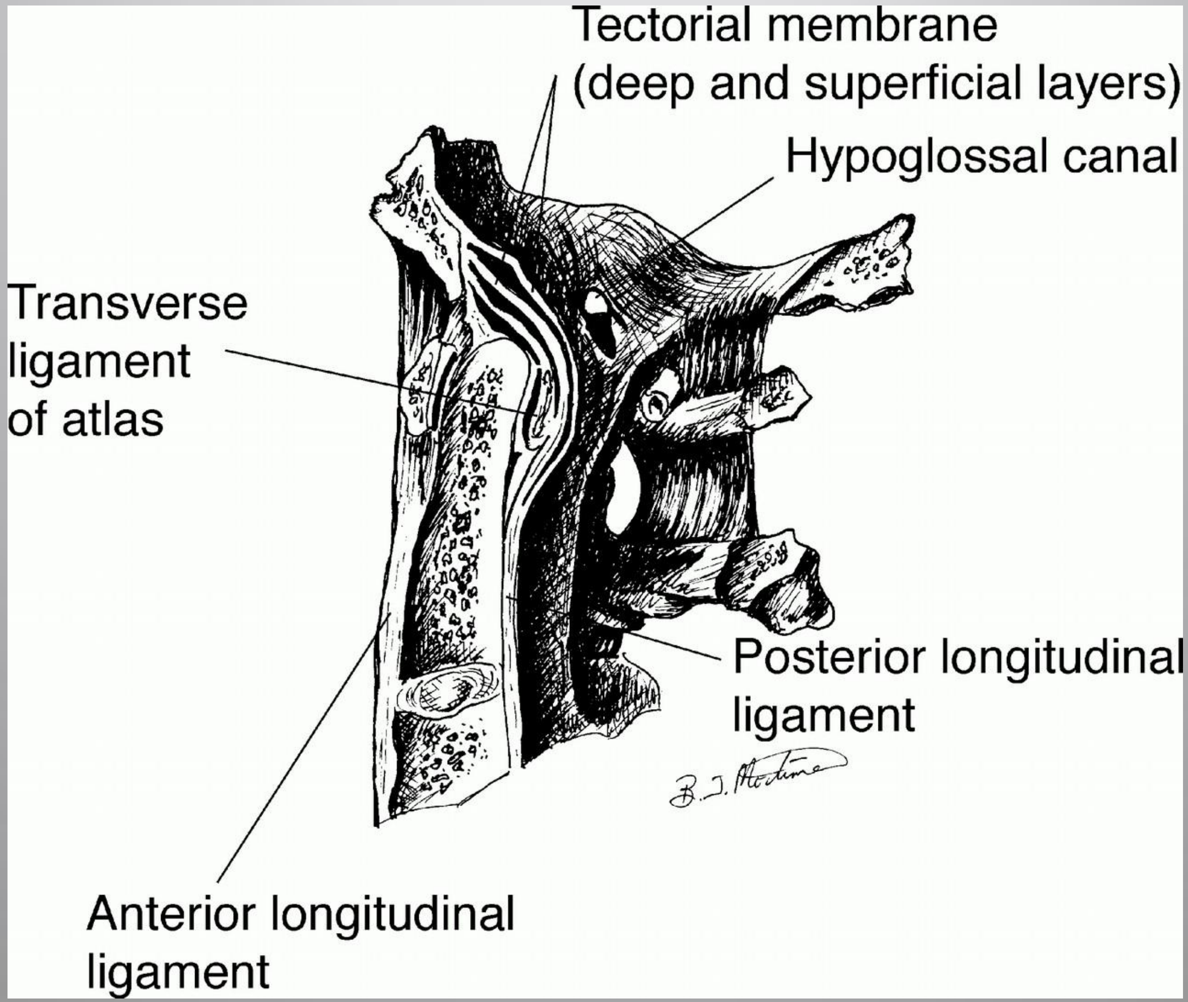


FIG. 2. Drawing depicting the midsagittal view of the craniocervical junction. A: Apical ligament. B: Anterior atlantooccipital membrane. C: Superior crus of the cruciform ligament. D: Tectorial membrane.



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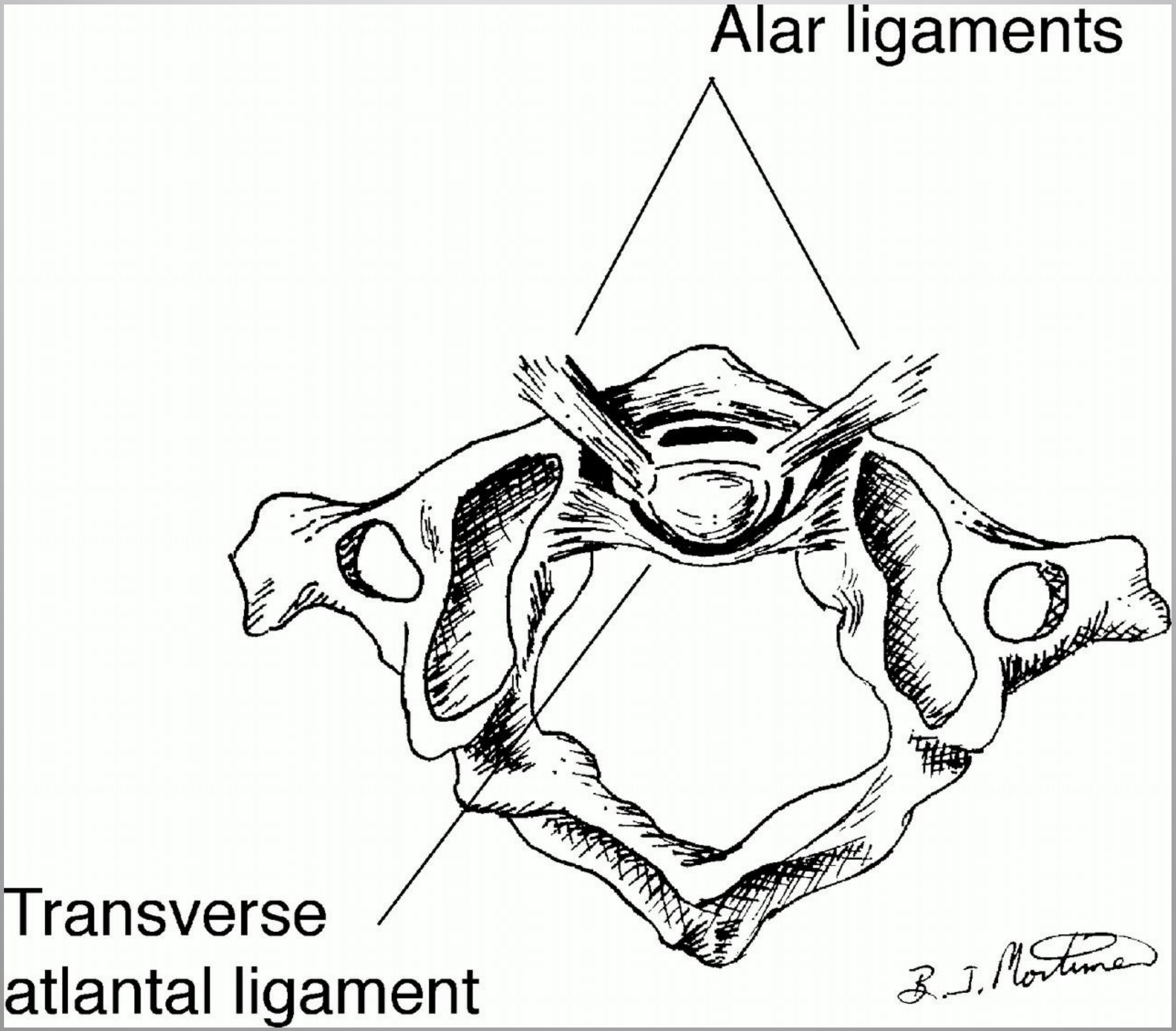
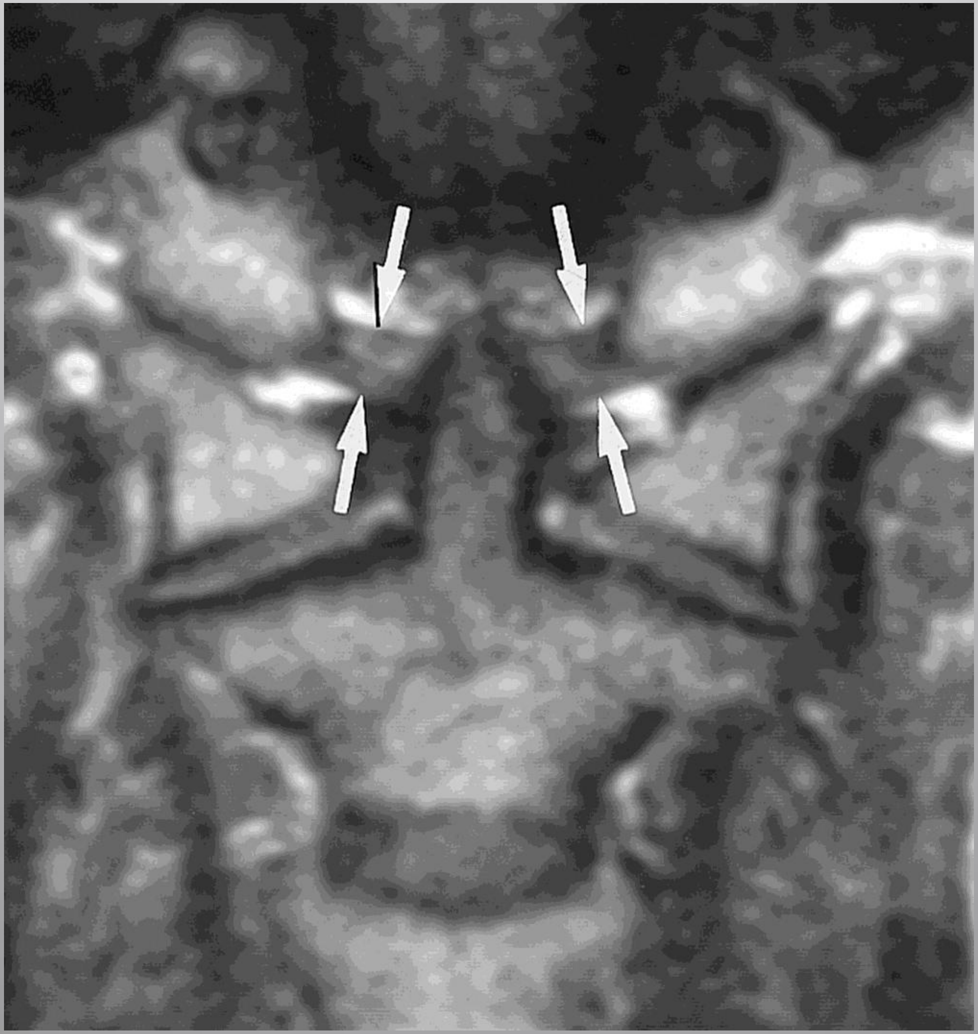
RadioGraphics



Deliganis A V et al. Radiographics 2000;20:S237-S250

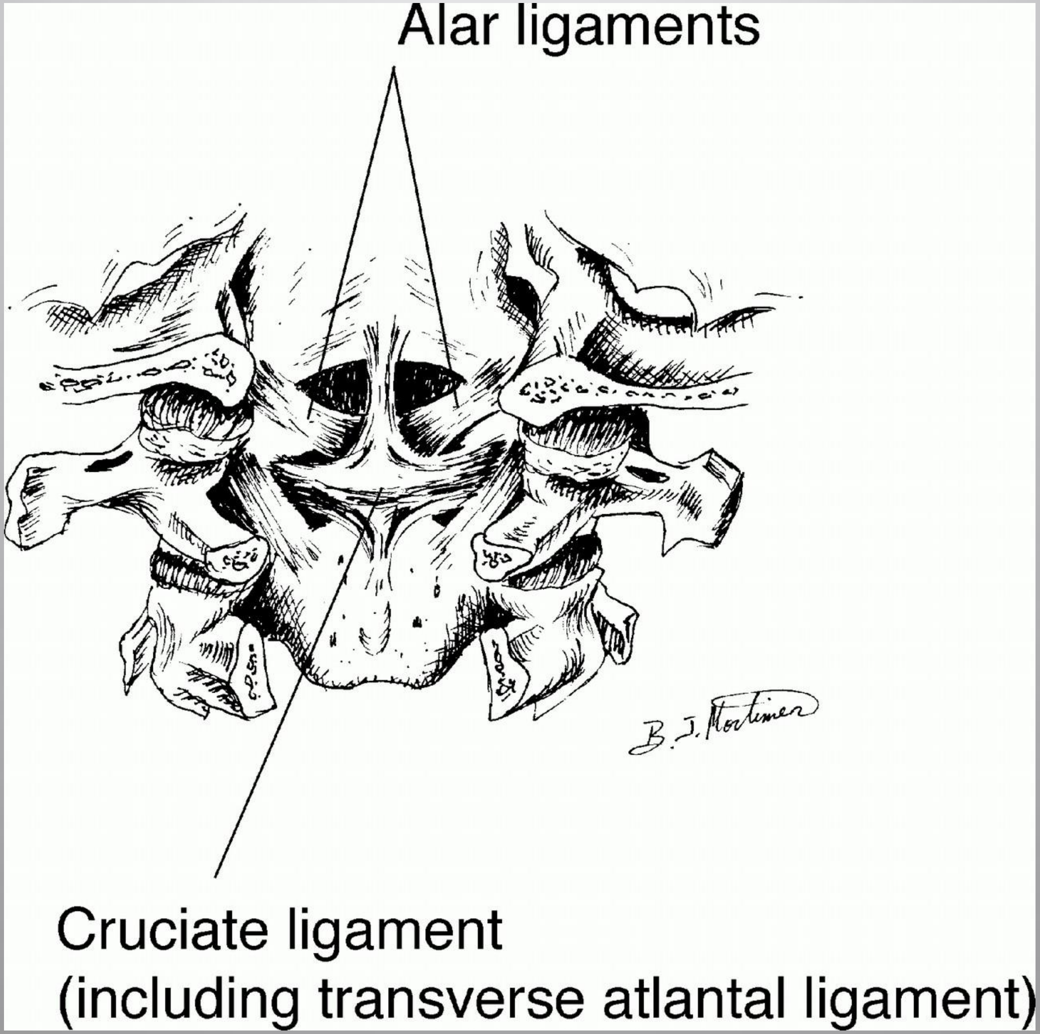
RadioGraphics

Coronal T1-weighted spin-echo MR image (350/15) in a 29-year-old asymptomatic woman.



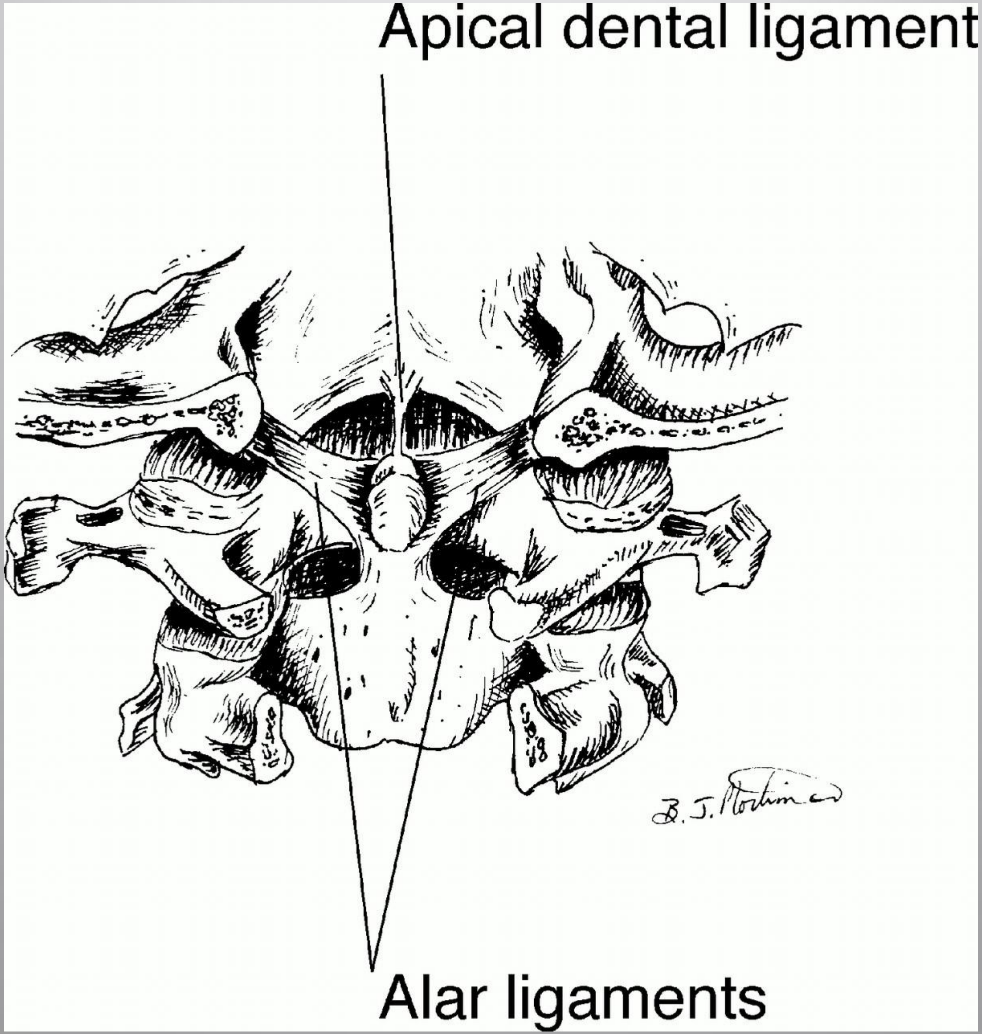
Pfirrmann C W A et al. Radiology 2001;218:133-137

Radiology



Deliganis A V et al. Radiographics 2000;20:S237-S250

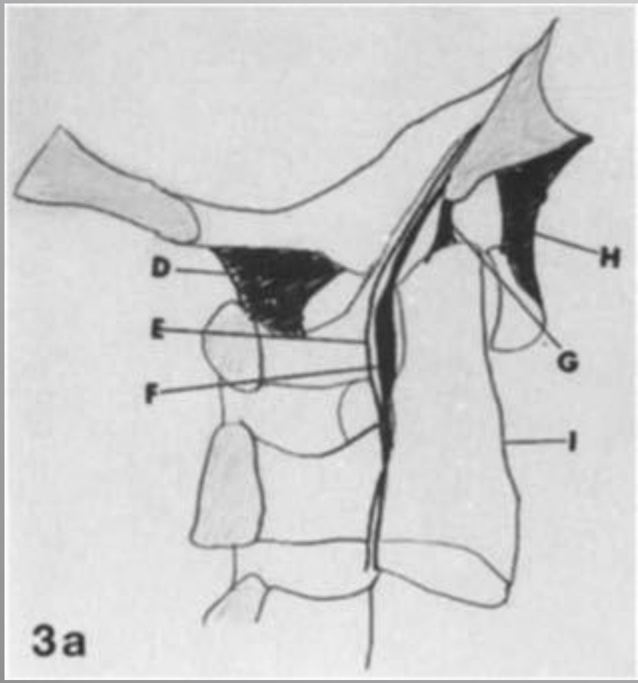
RadioGraphics

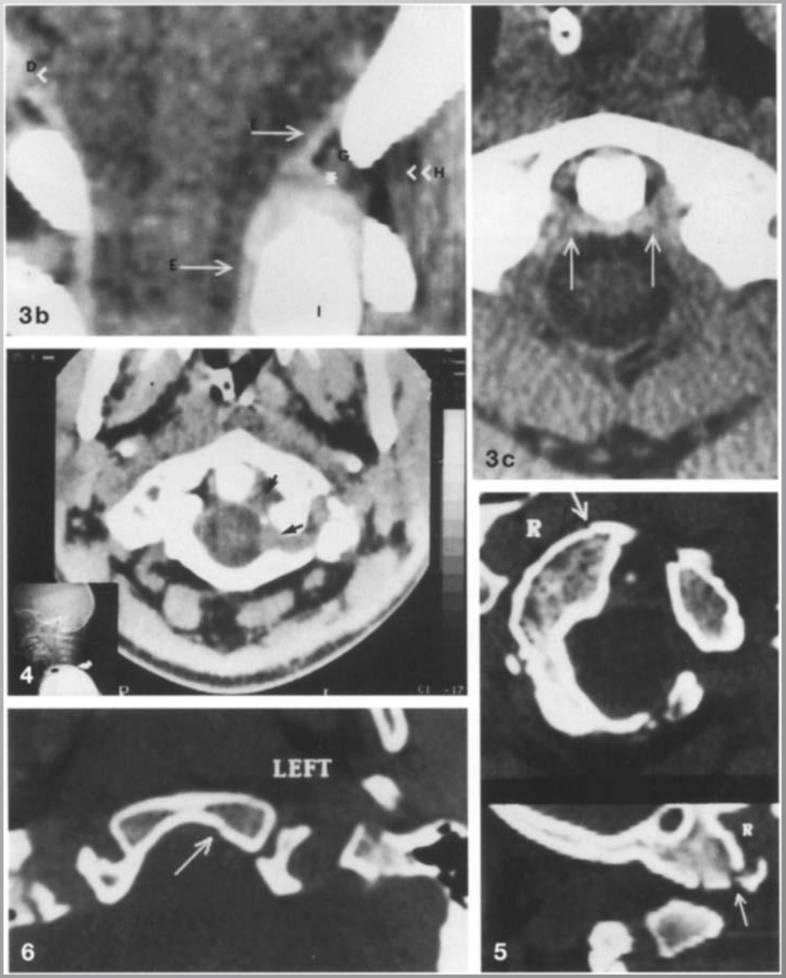


Deliganis A V et al. Radiographics 2000;20:S237-S250

RadioGraphics

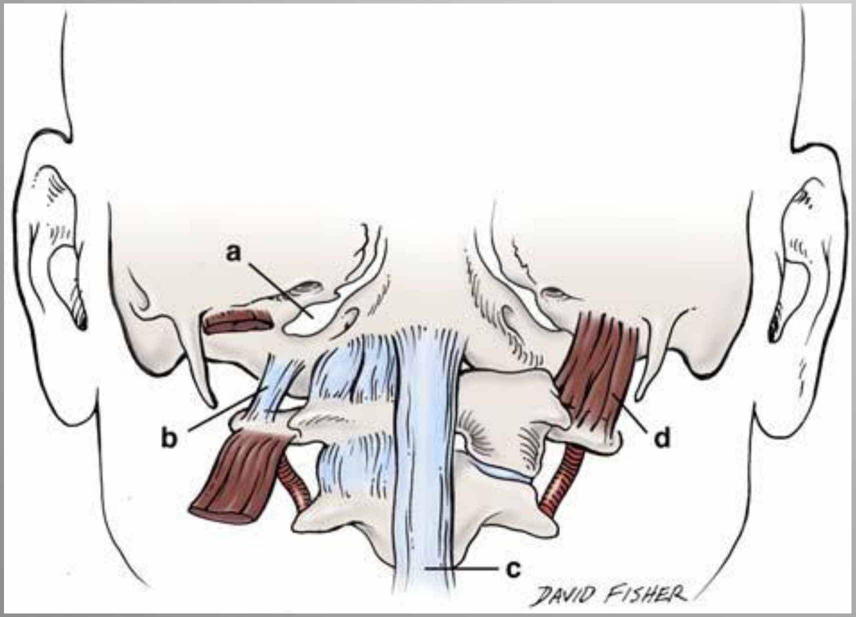
More anatomy





Bloom A I, et al Pediatric Radiology 26: 786-790

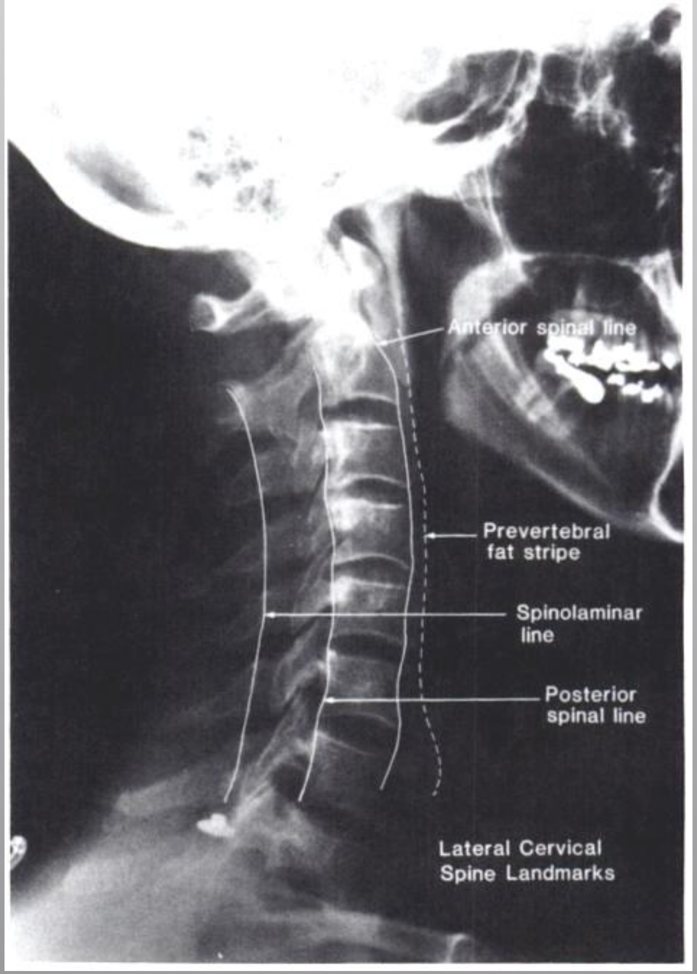
Lateral Atlantooccipital Ligament



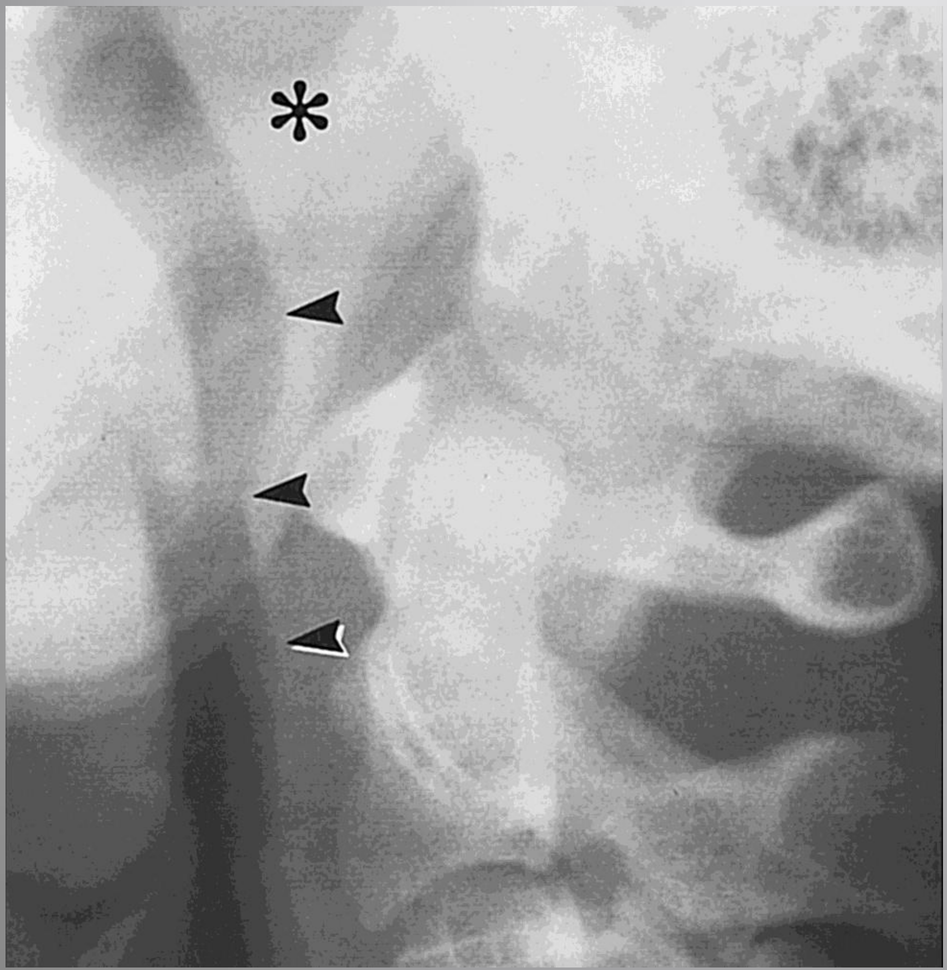
- LAO –may be important in craniocervical stability, primarily in the inhibition of the lateral flexion of the head
- Not well studied
- Situated lateral to the anterior atlantooccipital and atlantoaxial ligaments

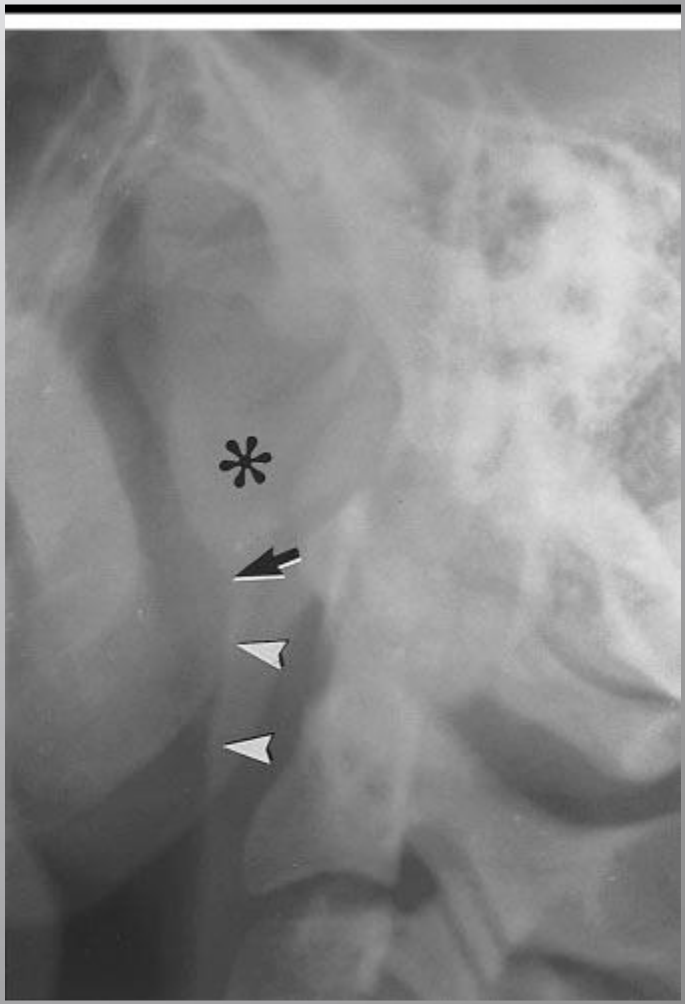
Tubbs SR, et al Surg Radiol Anat (2007) 29:219–223

Alignment and Relationships



(a, b) Contact lateral radiographs show normal cervicocranial prevertebral soft-tissue contour (arrowheads) in two adults. On right normal contour of adenoidal soft tissues.





Harris J H Radiology 2001;218:337-351

Figure 2. Normal relationships within the craniocervical junction.

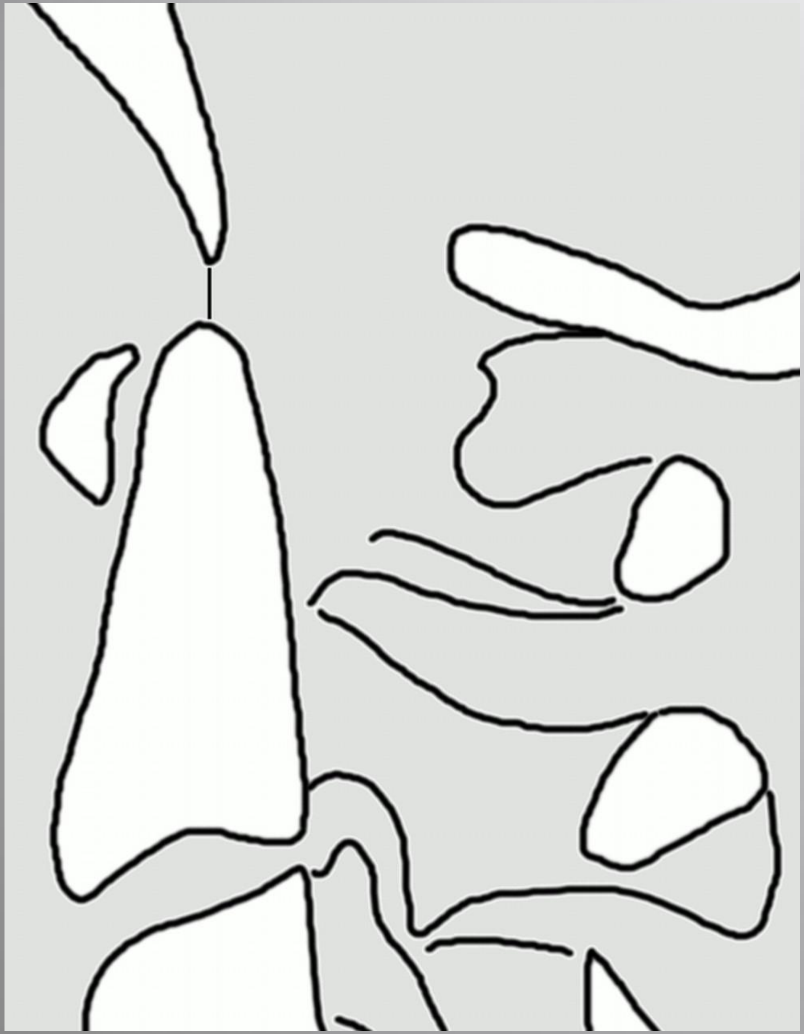


TABLE 3. Normal Dimensions of the Craniocervical Junction at Lateral Radiography

Anatomic Location	Dimensions
Basion-dens interval	<12 mm
Basion-posterior axial line interval	<12 mm posterior to dens, <4 mm anterior to dens
Prevertebral soft tissues	<6 mm at C2, flat or concave
Anterior atlanto-dens interval	<2 mm
Lateral atlanto-dens interval	<2–3-mm side-to-side difference
Atlanto-occipital articulation	1–2 mm
Atlantoaxial articulation	2–3 mm

Deliganis A V et al. Radiographics 2000;20:S237-S250

RadioGraphics

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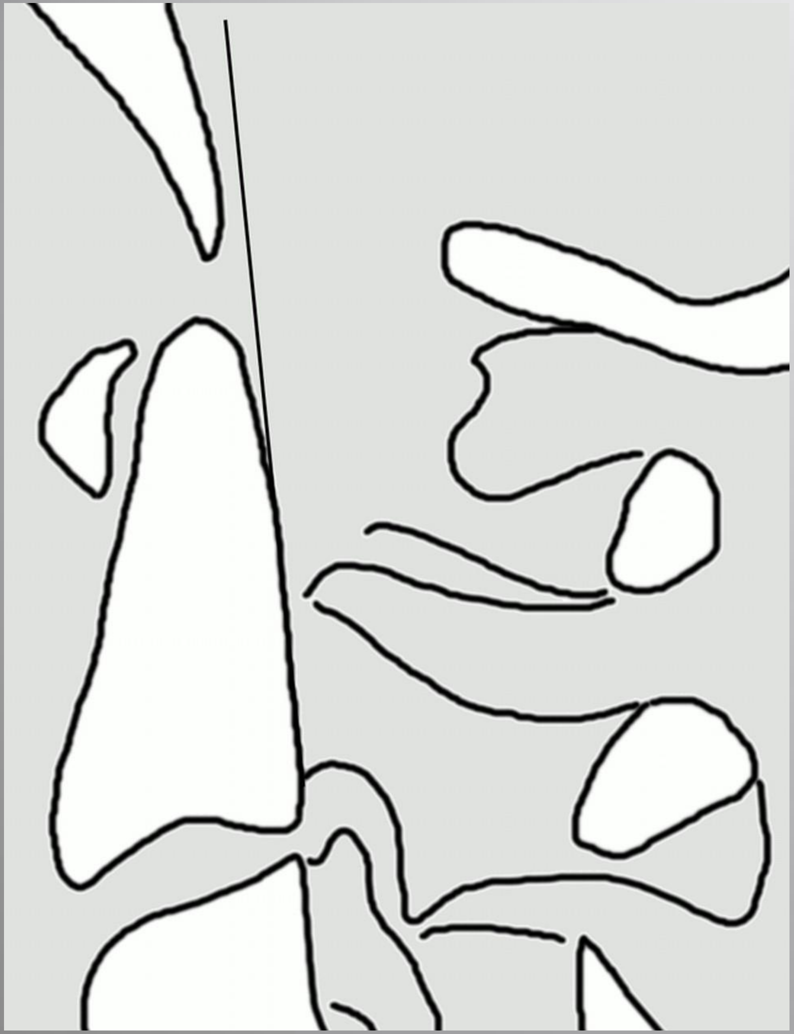

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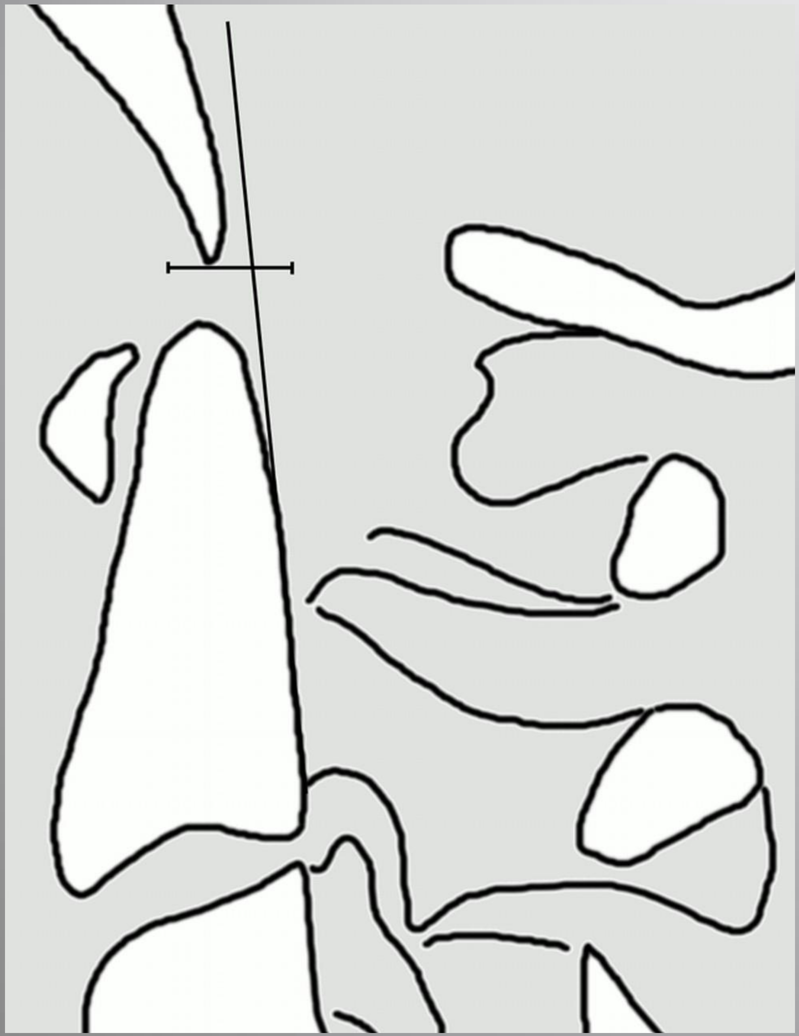

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RadioGraphics

Powers ratio

Fig 3. Midsagittal MDCT image of the craniocervical junction demonstrates the Powers ratio, which is calculated by dividing the distance between the tip of the basion to the spinolaminar ine by the distance from the tip of the opisthion to the midpoint of the posterior aspect of the anterior arch of C1.

•**Power's Ratio** (Powers etal, 1979)
•Basion-Post. C1 arch divided by Opisthion-Ant. C1 arch

<0.9 normal (1 s.d. below lowest case of AOD)
≥ 0.9 & <1 7% normal
≥ 1 All AOD

CT values versus CR values

Table 1: Normal anatomic relationships of the craniocervical junction on MDCT in 200 patients and comparison with accepted values on plain radiographs*

Method	Mean	SD	Range	MDCT Normal Value†	Plain Radiograph Normal Value[2,5,8]
BAI	3.4	4.64	−8.7–26.0	Not reliable	<12.0
BDI	5.7	1.39	1.4–9.1	<8.5	<12.0
Powers ratio	0.8	0.08	0.6–1.2	<0.9	<1.0
ADI	1.3	0.37	0.5–2.4	<2.0 in both sexes	<3.0 men
					<2.5 women
AOI	1.0	0.23	0.5–1.8	<1.4	No data in adults

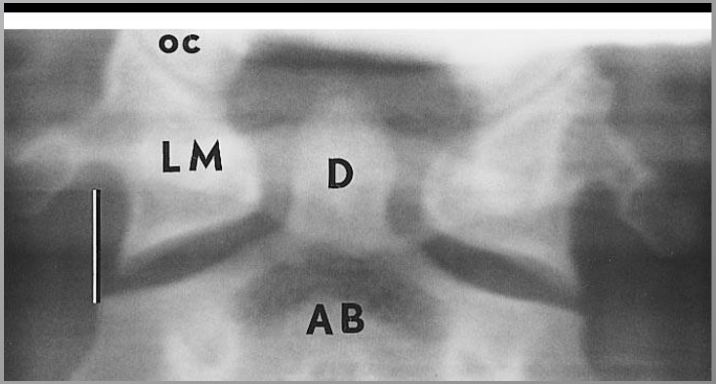
Note:—MDCT indicates multidetector row CT; BAI, basion-axis interval; BDI, basion-dens interval; ADI, atlantodental interval; AOI, atlanto-occipital interval.

*Results are given in millimeters with the exception of the Powers ratio.

Rojas et al. Reassment of the Craniocervical Junction. American Journal of Neuororadiology 28:1819-1823. 2007.

Lateral masses

- Must align exactly
- If there is 1-2mm of lateral displacement on one side there must be equal medial displacement on the contralateral side to call it rotational
- There can be significant variability in the appearance here depending on head position and rotation
- With extreme rotation there can be narrowing or vertical approximation of the interspace between the lateral masses



Harris J H Radiology 2001;218:337-351

Craniocervical Injuries

- Atlanto-occipital Injuries
- C1 fractures- anterior arch, posterior arch, Jefferson
- C2 fractures – dens fractures, traumatic spondylolisthesis, and C-2 body fractures

Atlantooccipital dislocation

- Werne demonstrated that isolated atlanto-occipital dislocation required complete disruption of the tectorial membrane and alar ligaments

Deliganis A V et al. Radiographics 2000;20:S237-S250

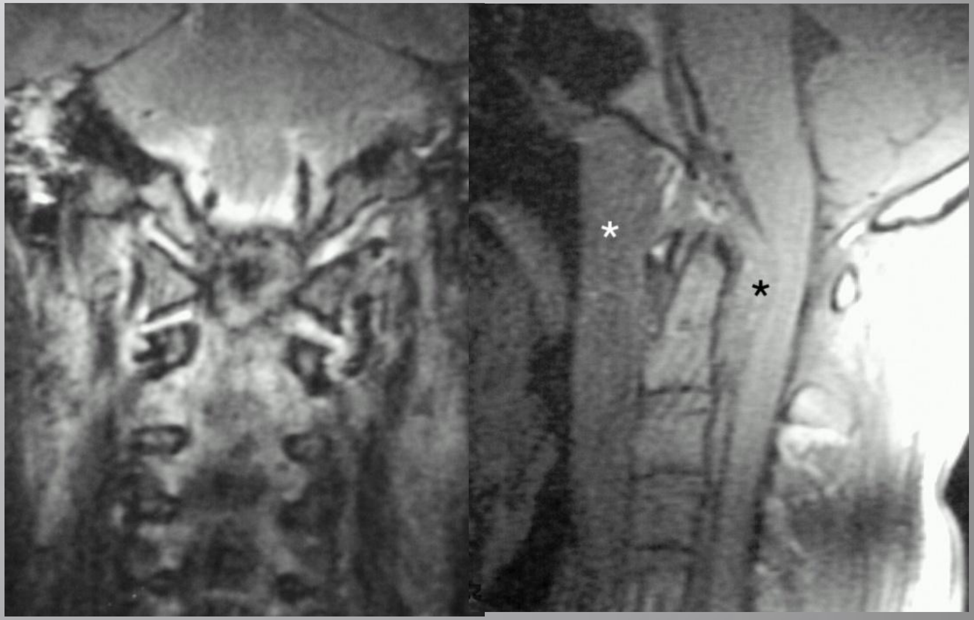
Radiographic signs of Atlantooccipital injuries

- Prevertebral soft tissue thickening
- Basion-dens interval
  - >12mm
- Basion-posterior axial line
  - >12mm anterior and 4mm posterior
- CT helps identify fractures that are frequently occult on radiographs including fractures of the basion
- CT can show subtle widening of the atlantooccipital and atlanto-axial articulations
- MR can depict ligamentous injury, cord injury or compression from developing hematoma

Deliganis A V et al. Radiographics 2000;20:S237-S250

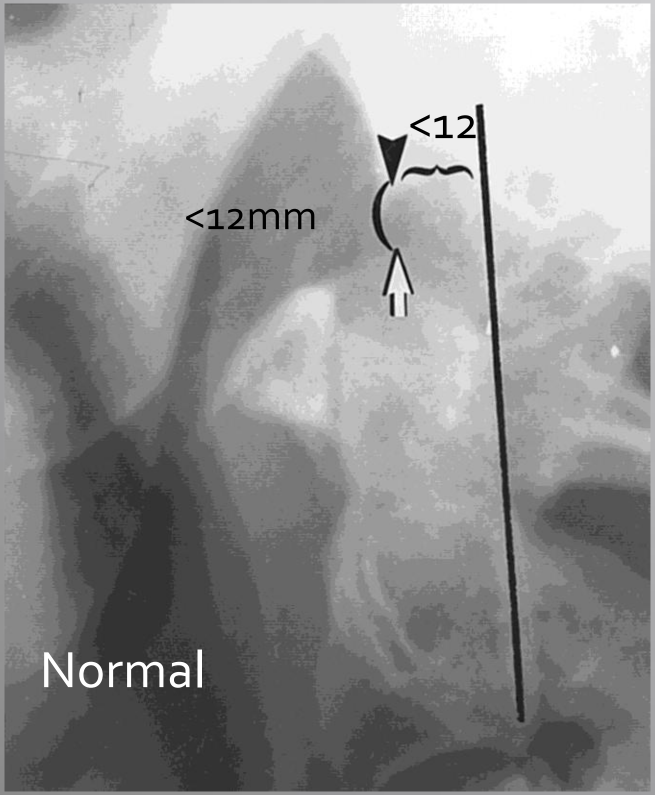
Atlantooccipital

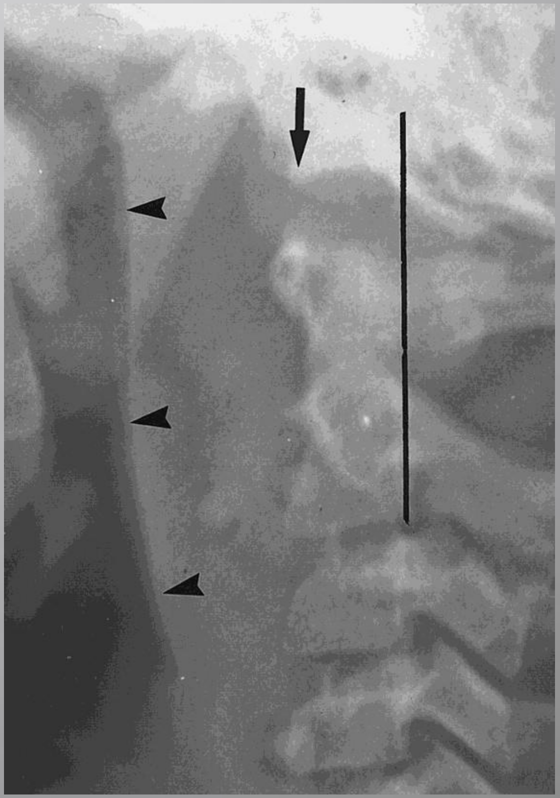
- Findings can be occult on radiography
- MRI can help depict soft tissue injury
- This case shows subtle increased fluid in atlanto-occipital and atlantoaxial articulations
- Developing prevertebral thickening and hematoma impinging the cord
- It has been recognized that prevertebral soft tissue thickening may be absent on initial imaging if performed very early



Occipitoatlantal subluxation

- Subluxation can be subtle and patients can survive so it must be recognized
- Abnormal basion-axial interval and/or basion-dental interval, both >12mm





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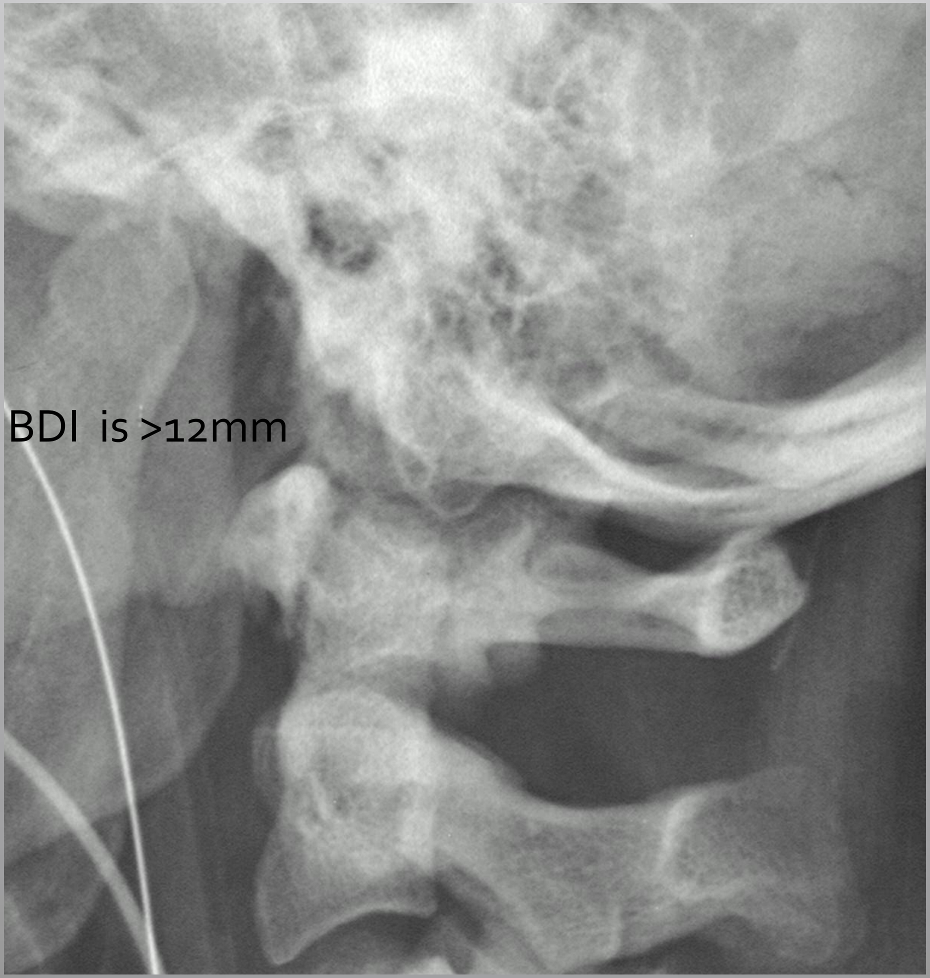
Atlantooccipital subluxation



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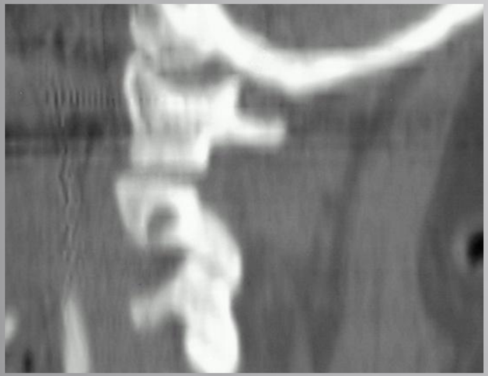
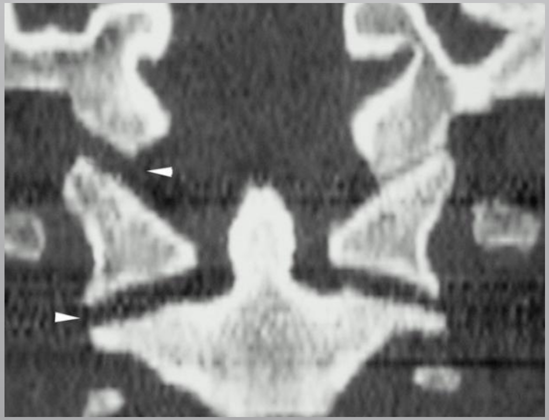
Atlantooccipital subluxation





Deliganis A V et al. Radiographics 2000;20:S237-S250

Occipital Condyle fractures

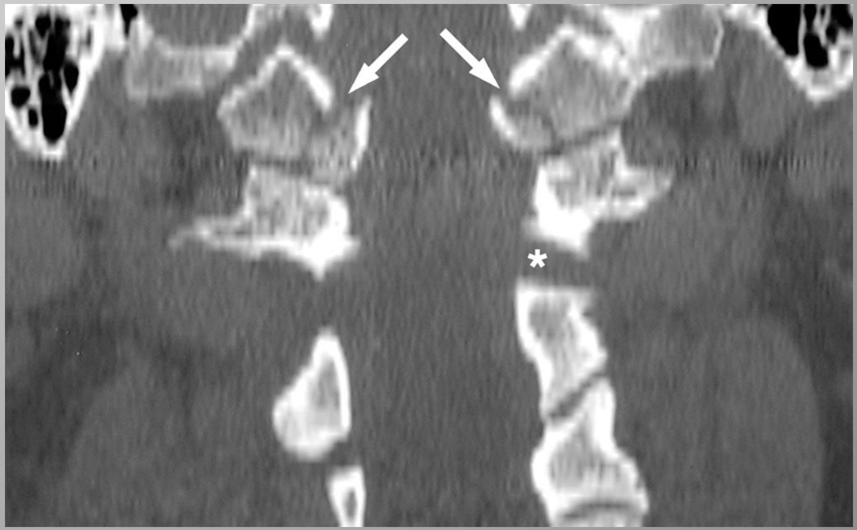
- Three types classified by Anderson and Montesano
- Type I
  - split or comminution secondary to axial forces
- Type II
  - extension of an occipital bone fracture into the condyle
- Type III
  - avulsion fracture at the medial surface of the condyle where the alar ligament attaches

Occipital Condyle fractures

- Can be associated with instability of the occipitoatlantolaxial joint complex
- Tectorial membrane and alar ligaments are critical components
- Tectorial membrane limits extension at the occipitoatlantal joints
- Alar ligaments limit lateral tilt and rotation
- Can be associated with lower cranial nerve palsies, in particular CNXII due to fracture extension into the hypoglossal canal

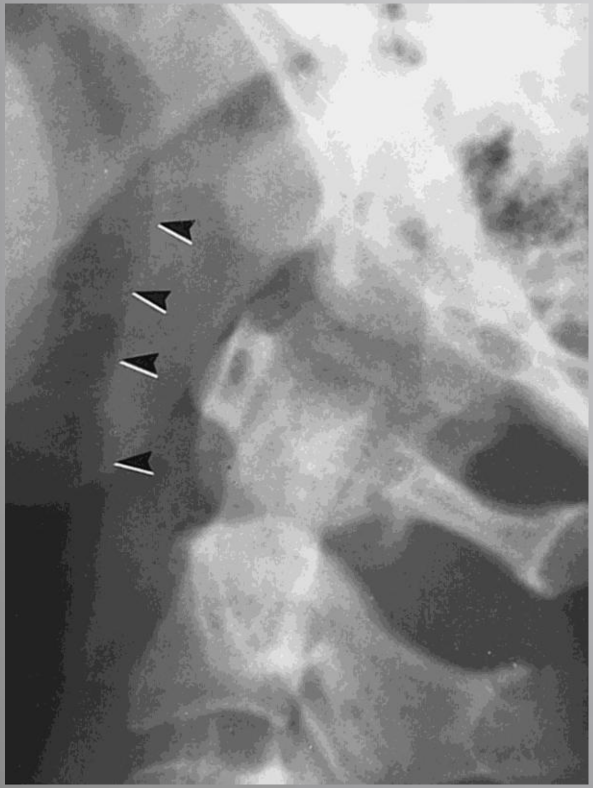
Occipital Condyle Fractures-Type III

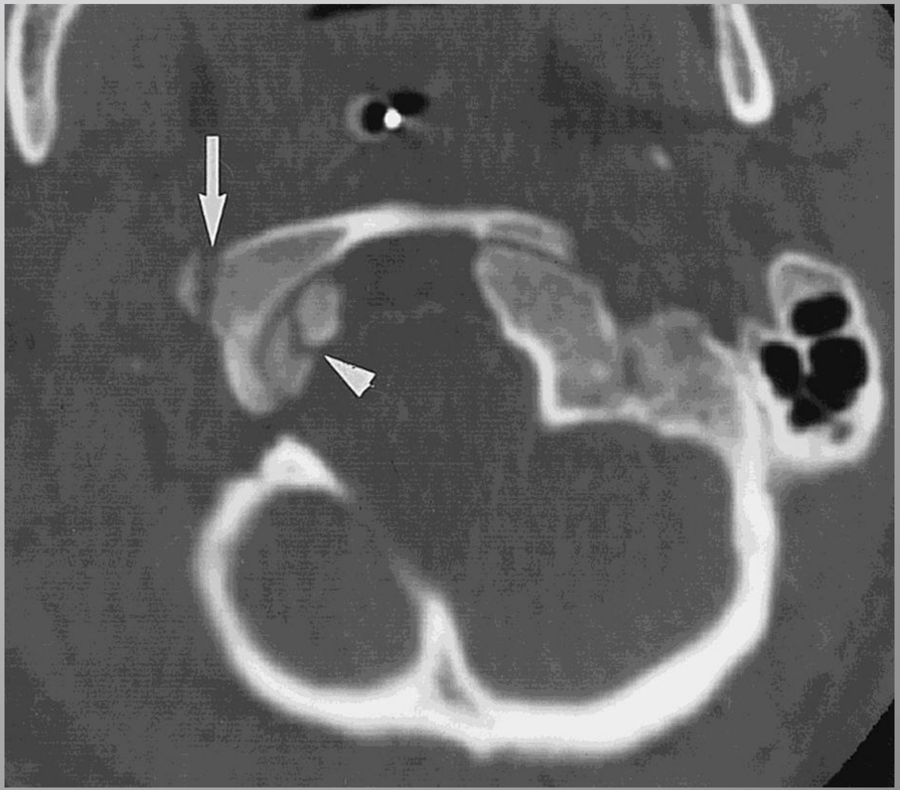
- Hansen et al suggested subdividing Type III fractures into stable and unstable
- Bilateral occipitoatlantoaxial joint complex injury –
  - bilateral occipital condyle fractures or unilateral occipital condyle fracture with contralateral widening of the occipitoatlantal [>2 mm]
  - Atlantoaxial joint widening of >3mm
- Either criteria can be used as a marker for instability



Hanson, J. A. et al. Am. J. Roentgenol. 2002;178:1261-1268

Type I Occipital condylar fracture with ipsilateral fracture of the mass of C1





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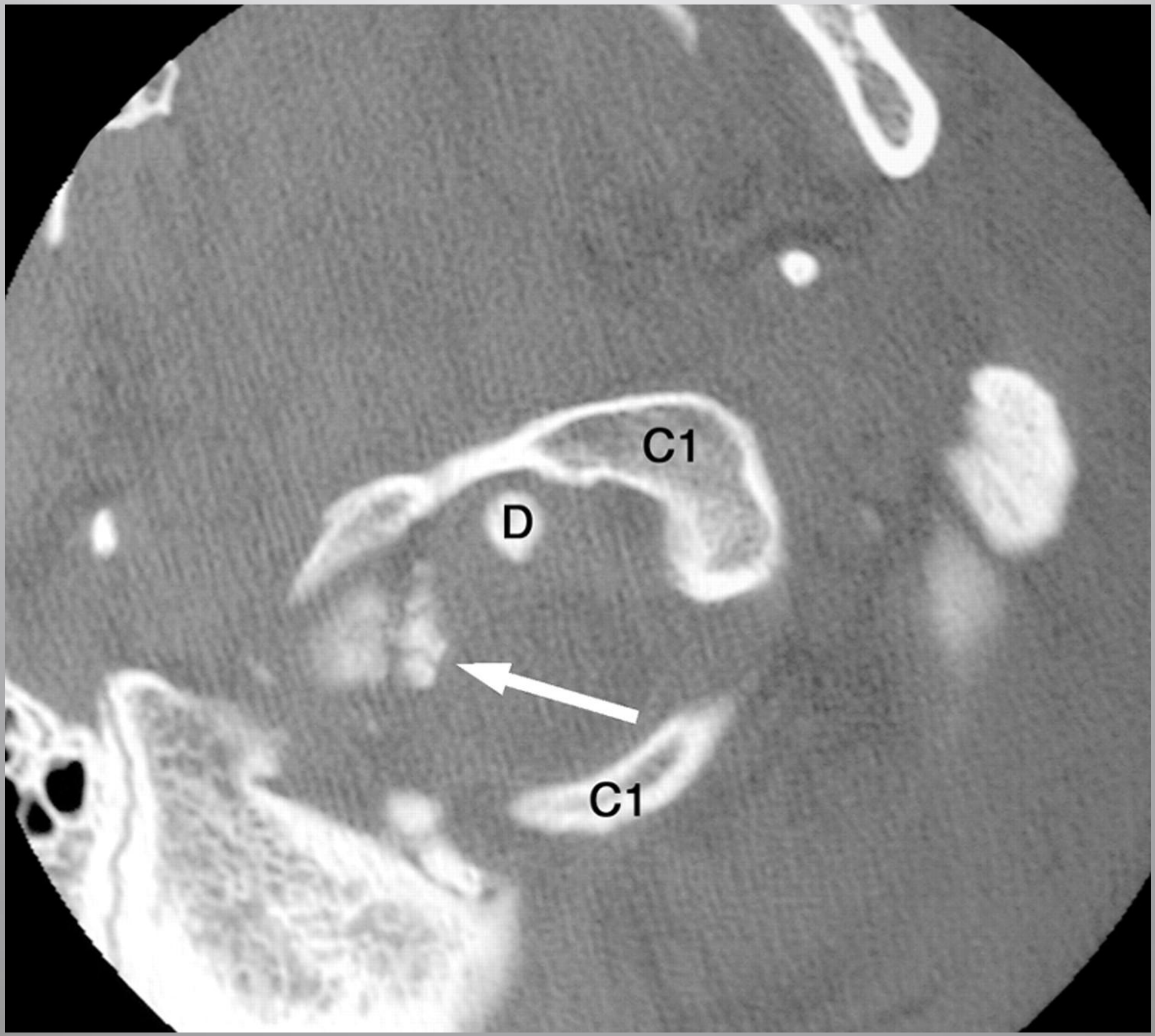

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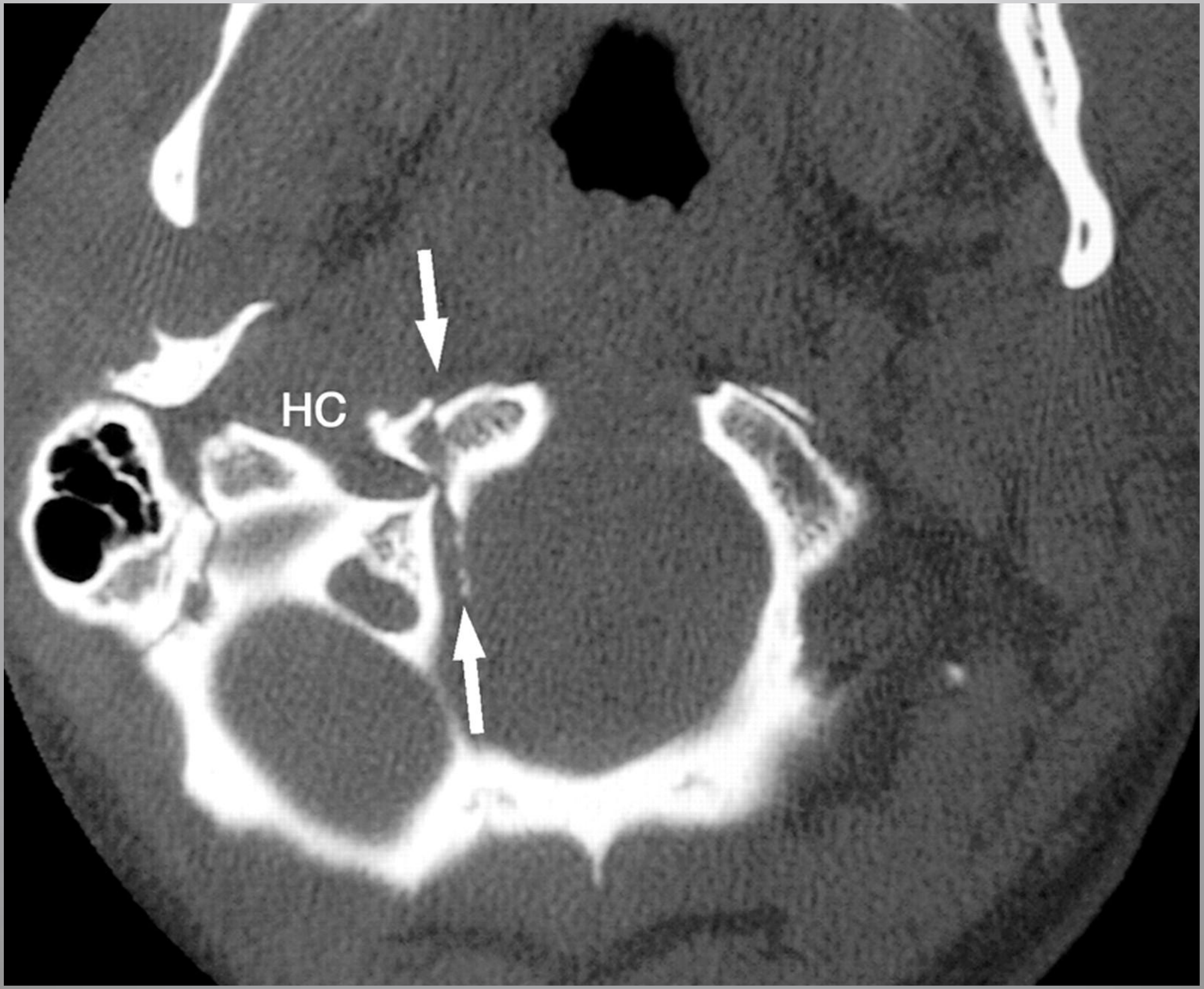
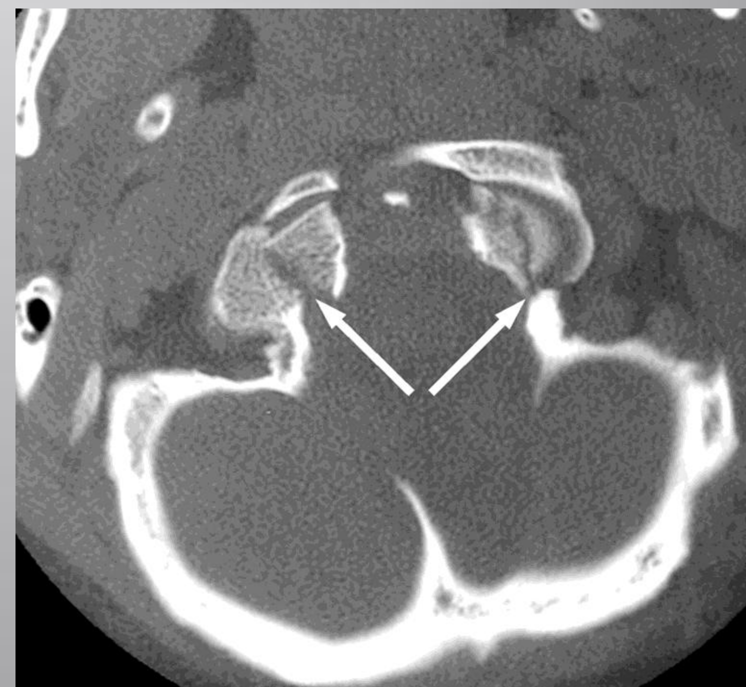
19-year-old man injured in motor vehicle crash



Hanson, J. A. et al. Am. J. Roentgenol. 2002;178:1261-1268

44-year-old man injured in motorcycle crash who sustained bilateral type III Anderson and Montesano [13] avulsion occipital condyle fractures

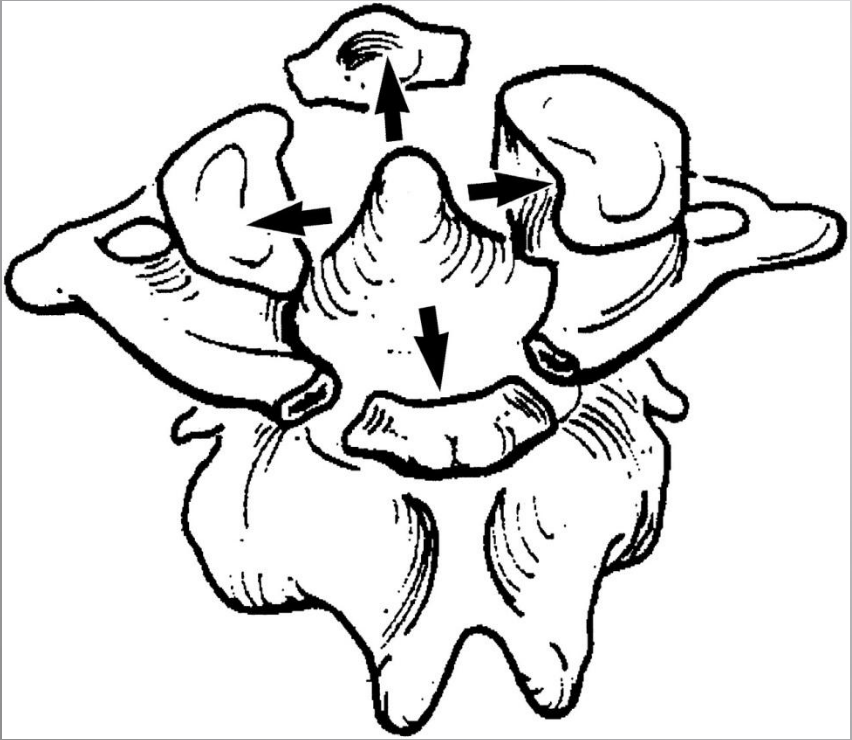


Hanson, J. A. et al. Am. J. Roentgenol. 2002;178:1261-1268

Types of Atlas fractures

- Isolated fracture of the posterior arch
  - resulting from hyperextension and axial loading
- Lateral mass fracture
  - resulting from axial loading and lateral bending
- Jefferson's fracture
  - resulting from axial loading
- Fractures of the anterior arch
  - resulting from hyperextension
- Transverse process fractures

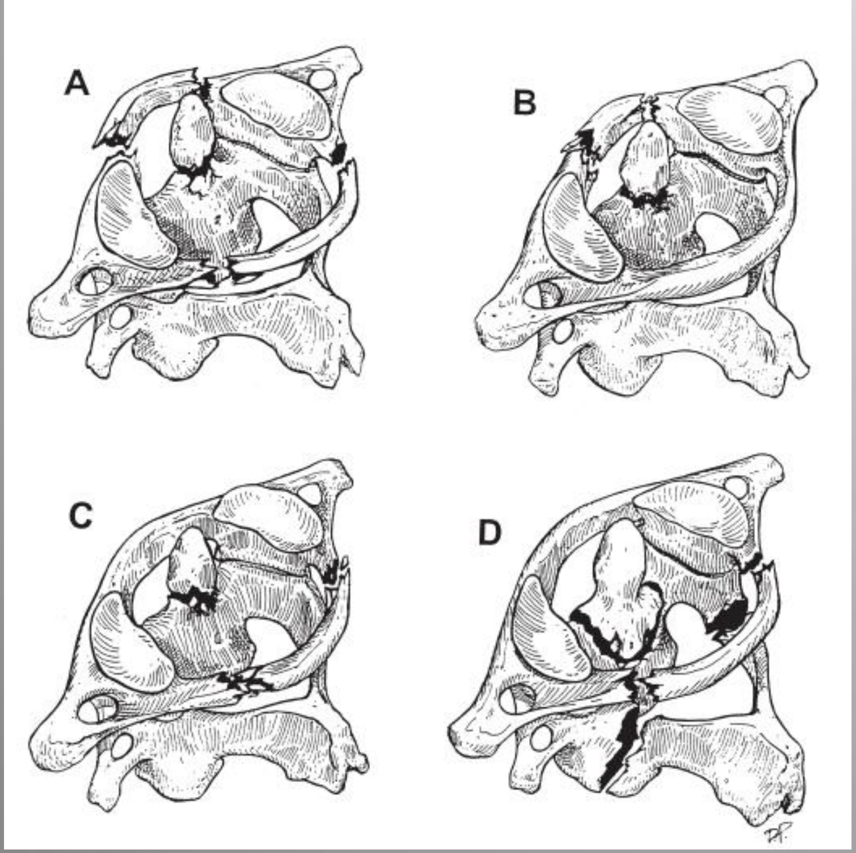
Jefferson Fracture



Hunter T B et al. Radiographics 2000;20:819-736

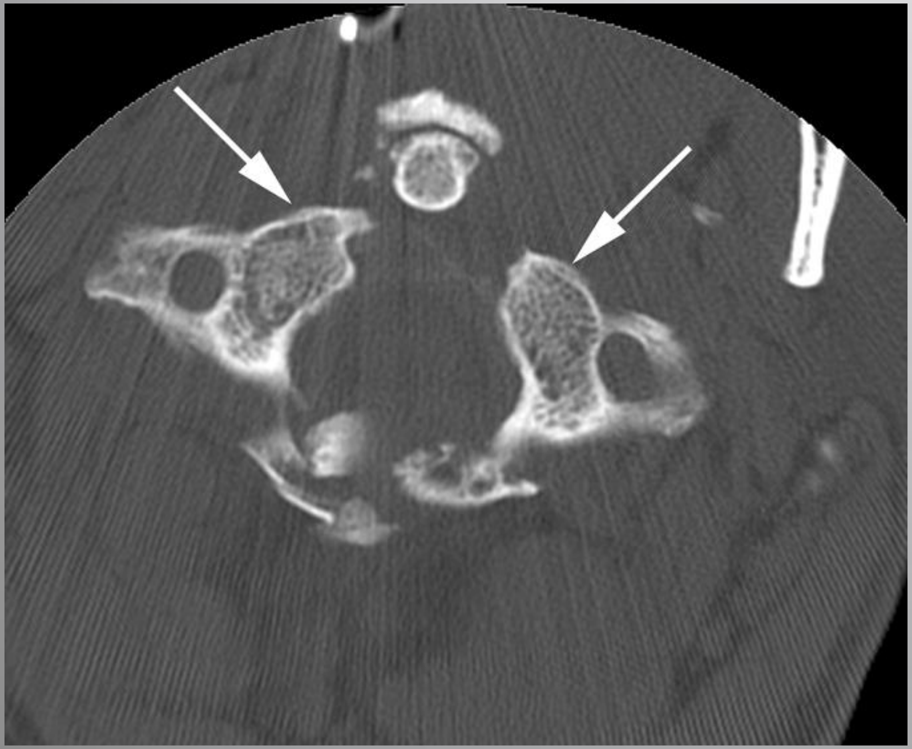
- Axial loading
- Comminuted
- Classic is a four part fracture
  - two anterior and two posterior
- Variant
  - involves one fracture through each arch but more central
  - Results is the same symmetric displacement of the lateral masses
- About 15% are associated with cord injury

Combined fracture



- Approximately 1/3 of Jefferson fractures are associated with a C-2 fracture
- If the sum of lateral mass displacement over articular surfaces of axis is > 7 mm the transverse ligament is likely to be torn
- If the atlantodental interval is >4mm there may be a rupture of the transverse ligament
- If the atantal dens interval is > 6 mm the transverse ligament is likely disrupted and the injury is unstable

Anterior arch fracture



Mohit A A , etl al AJR 2003;181:770

- Can be divided into two catagories
  - Horizontal – which are proposed to be avulsions
  - Vertical – most commonly seen as a component of the Jefferson fracture
- Plough variant
  - displaced fracture of the anterior arch resulting from hyperextension
  - The bony equivalent of a transverse ligament rupture

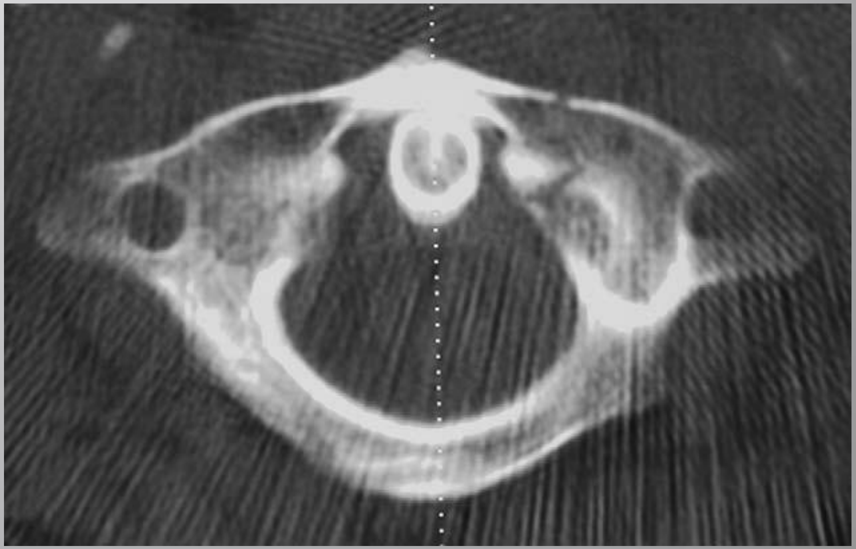
Anterior arch fracture

Rao S K et al. Radiographics 2005;25:1239-1254

- Avulsion
  - related to the attachement of the longus colli or anterior longitudinal ligament
- Hyperextension
- Usually stable
- Can have an united ossification center that may be confused with an acute fracture

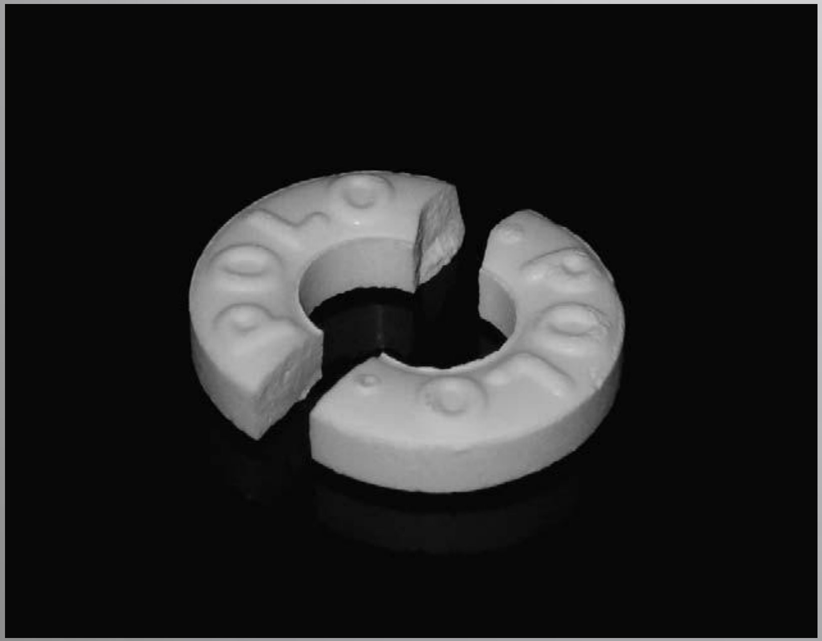
Lateral Mass fracture

- Case report which did not follow the typical rules as the ring only broke in one place
- Usually stable
- Axial compression or lateral hyperflexion
- Typical teaching is that the ring breaks in two places
- The "polo mint"



Patton M S, et al Injury, Int. J. Care Injured (2006) 37, 663—664

Broken polo mint



Patton M S, et al Injury, Int. J. Care Injured (2006) 37, 663—664

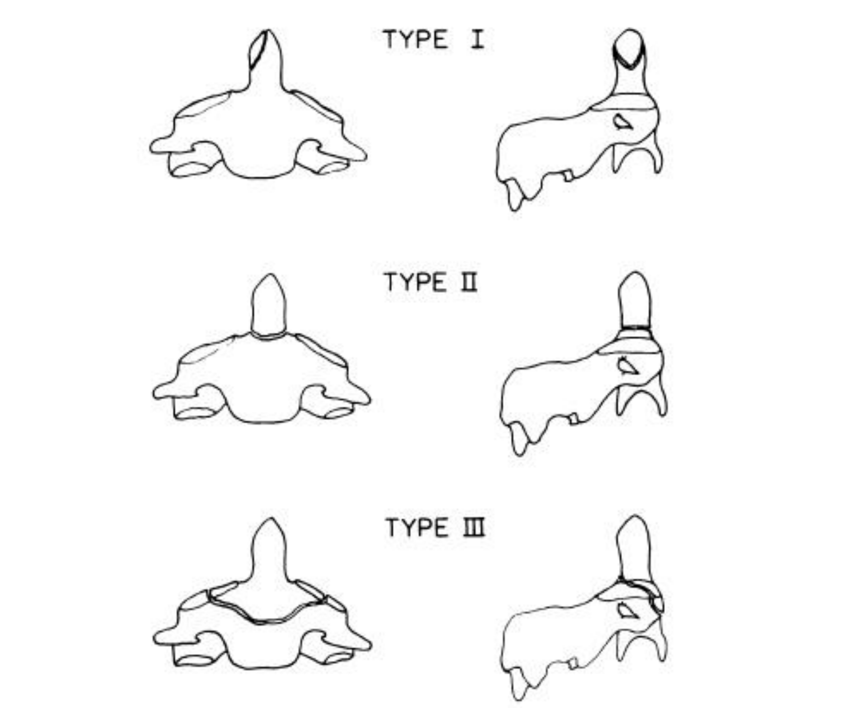
Posterior arch fracture

Rao S K et al. Radiographics 2005;25:1239-1254

- Compression of the posterior arch of C1 and the spinous process of C2 during hyperextension
- Can be isolated but up to ½ have been shown to be associated with fractures of C2 and C3

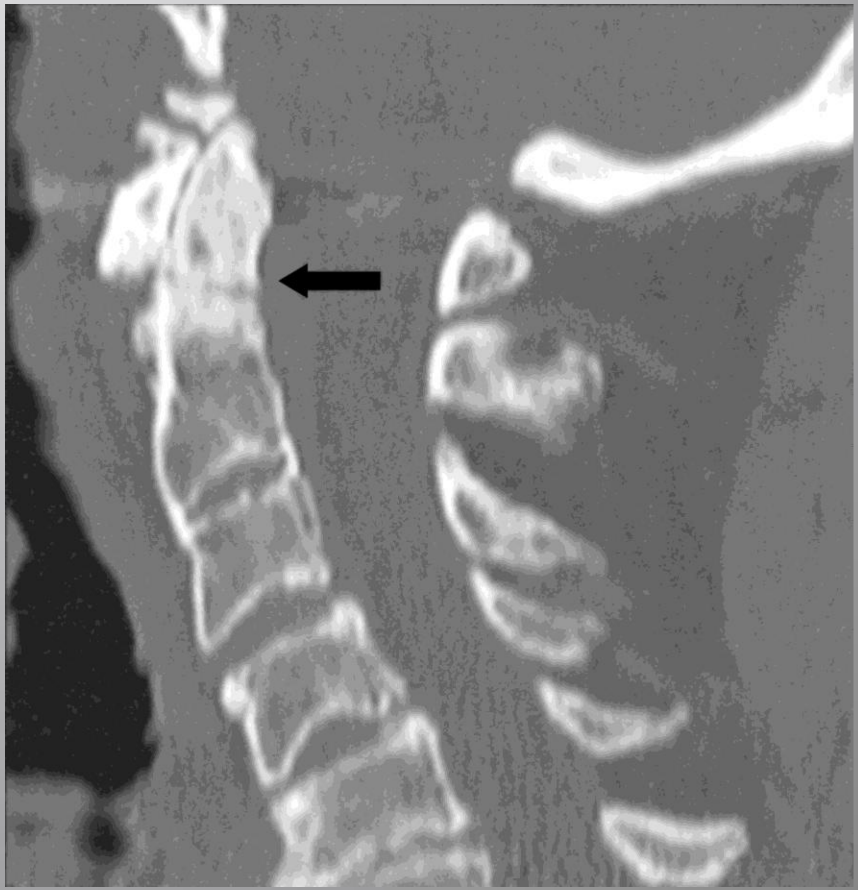
Dens fracture

- The most common fracture of the axis
- Accounts for > 50%
- Type I
  - rare, thought to be from avulsion of alar ligaments
- Type II –
  - most common variant
- Type III
- Described variant
  - verticle fracture typically associated with more complex fractures
- Mechanism
  - mostly felt to be multifactorial, including axial compression, hyperextension, hyperflexion and rotation



Type II

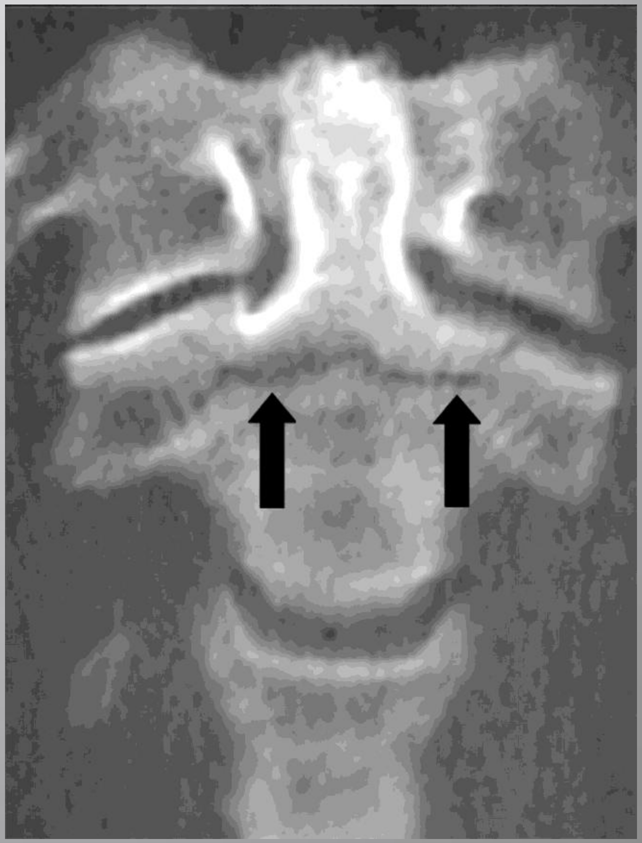
- Most common variant
- Transverse fracture throught the base of the dens
- Unstable
- Amount of angulation or displacement correlate with the likelihood of nonunion
- Nonunion reported in up to 50%



Rao S K et al. Radiographics 2005;25:1239-1254

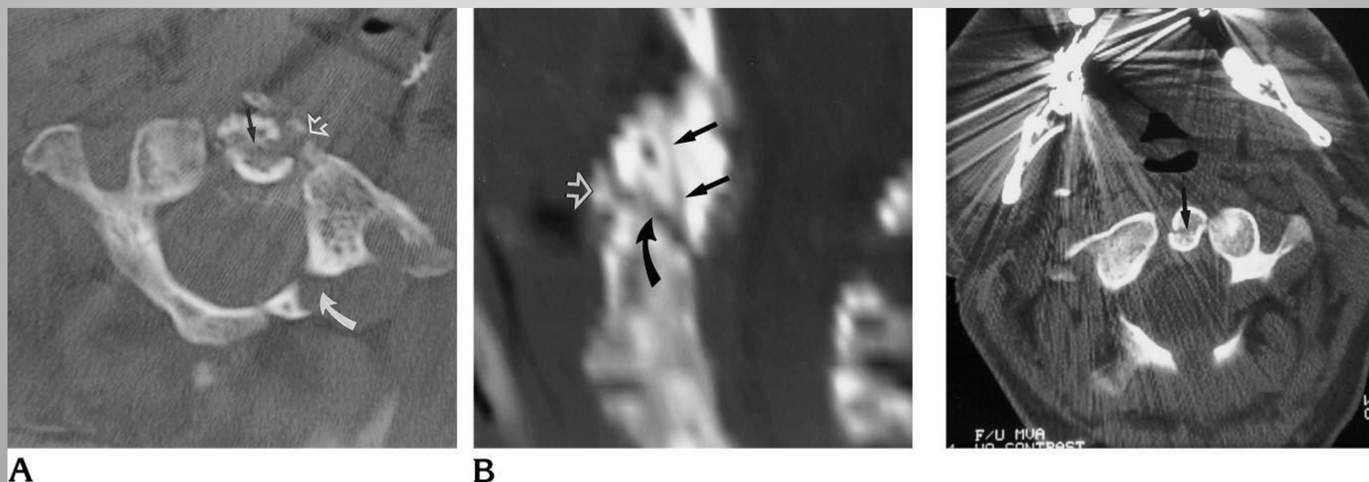
Type III

- Horizontal fracture throught the superior body of C-2
- Stable
- Less commonly have issue with nonunion
- Suggested this is related to the larger area of cancellous bone involved



Rao S K et al. Radiographics 2005;25:1239-1254

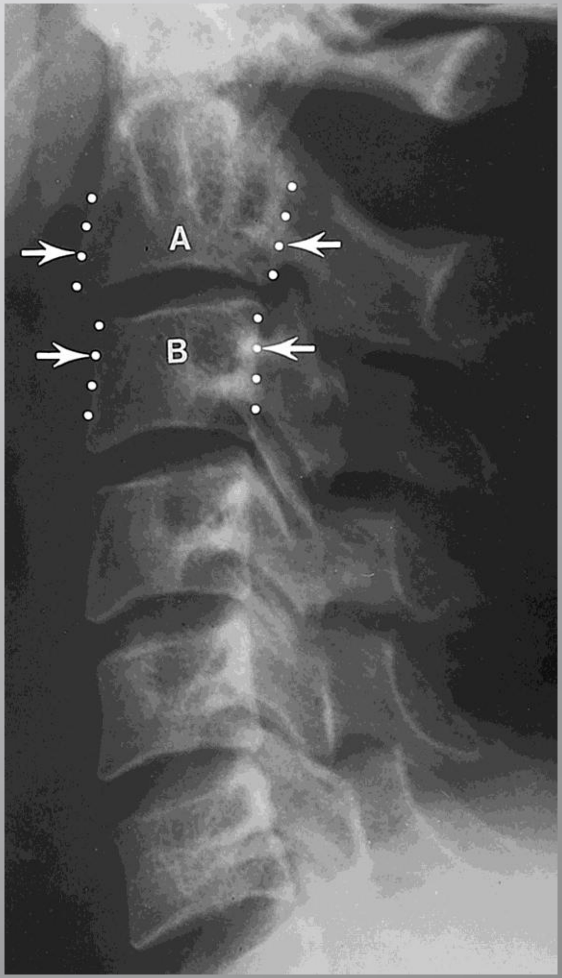
Verticle dens fracture



- Uncommon variant
- Most case are seen in associated with other craniocervical fractures

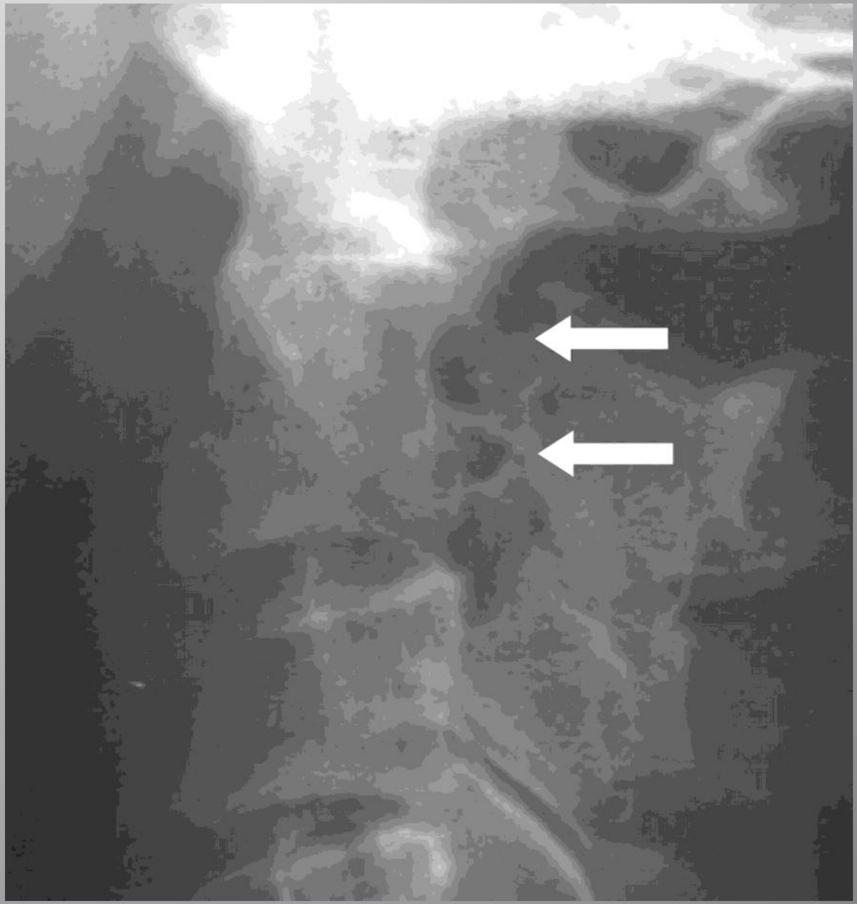
Fat C-2 sign

- Secondary to oblique fracture through C-2 body
- May be from a complex fracture of the C-2 body, a low (type III) dens fracture, or atypical traumatic spondylolithesis
- Multidirectional mechanism of injury
- Often associated with ligmentous injury and may be unstable



C-2 hyperextension injuries

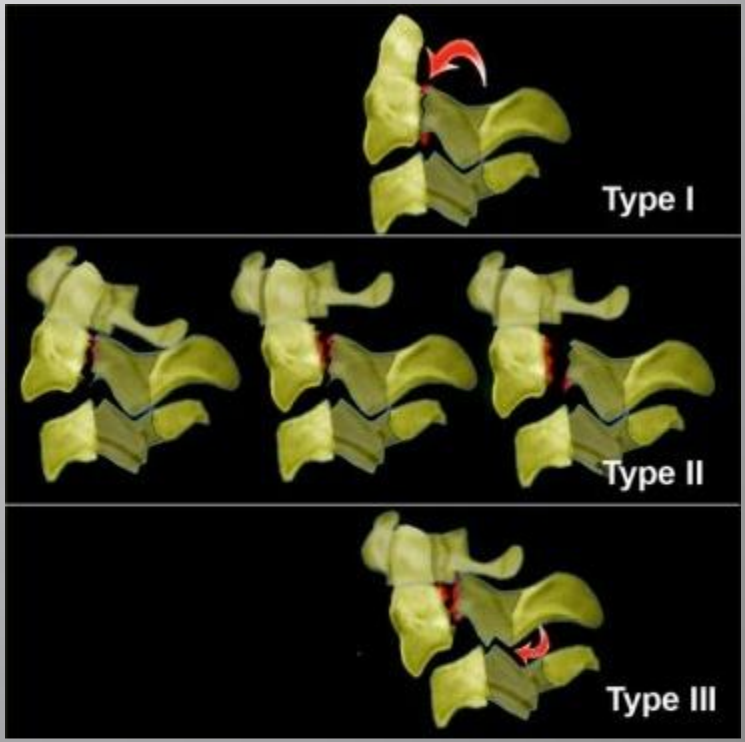
- Represent about 5% of cervical spine fractures
- Bilateral pedicle or par interarticularis fractures
- High association with vertebral artery injury which may lead to neurologic compromise
- About 33% associated with fractures elsewhere in the cervicothoracic spine
- Classification is based on Effendi artcle JBJS 1981



Rao S K et al. Radiographics 2005;25:1239-1254

Traumatic spondylolithesis (Hangman's)

- Type I (65%) – fracture at the base of the pedicle
  - Less than 3mm of translation, no angulation
  - C2-3 disc normal
  - Results from hyperextension with axial load
  - Identification of pattern is based on use of flexion and extension images as Type II can appear as a type I on a supine radiograph



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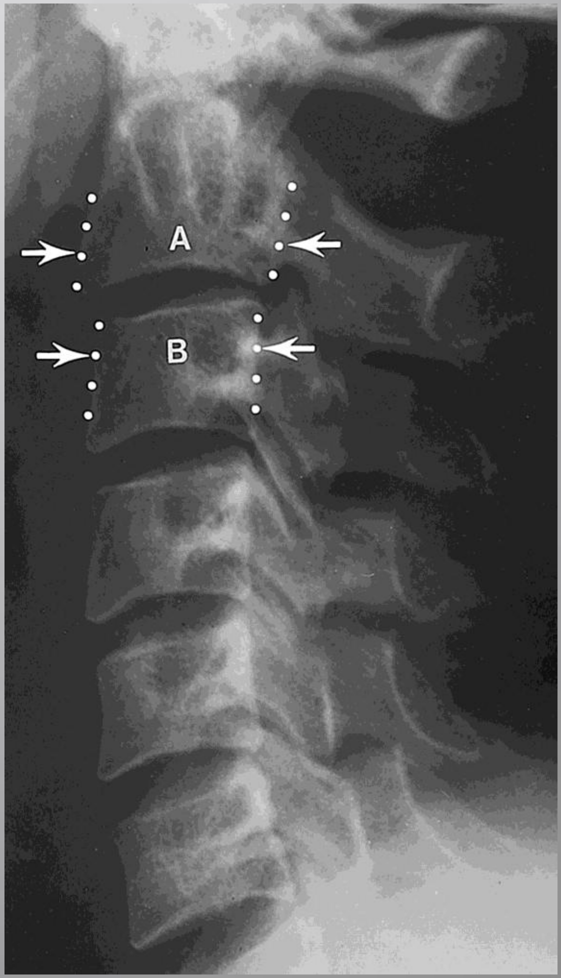
Hangman’s

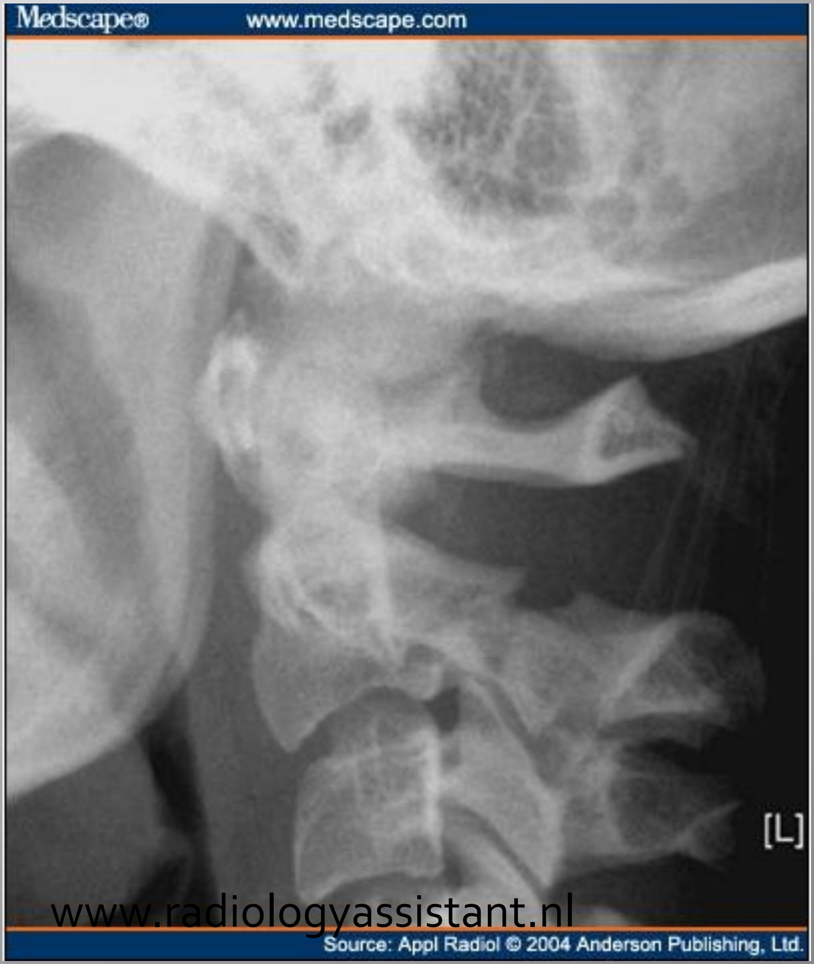
- Type IA
- Atypical, remember the fat C-2 sign
- Hyperextension with axial loading or flexion with axial loading are the mechanisms seen in most of the Hangman type fractures



Pellei DD. The fat C2 sign. Radiology.2000;217:359-360

Hangman's

- Type II (28%)
- Displaced C2
  - >3mm with angular deformity
- Disrupted C2-3 disc
- Ligamentous rupture with instability
- Frequently seen with compression of the anterosuperior C3 body
- Type IIA
  - like type II but without the anterior translation and fracture line tends to be more oblique



Hangman’s

- Type III (7%)
  - displaced C2
  - C2-3 bilateral facet dislocation
  - severe instability

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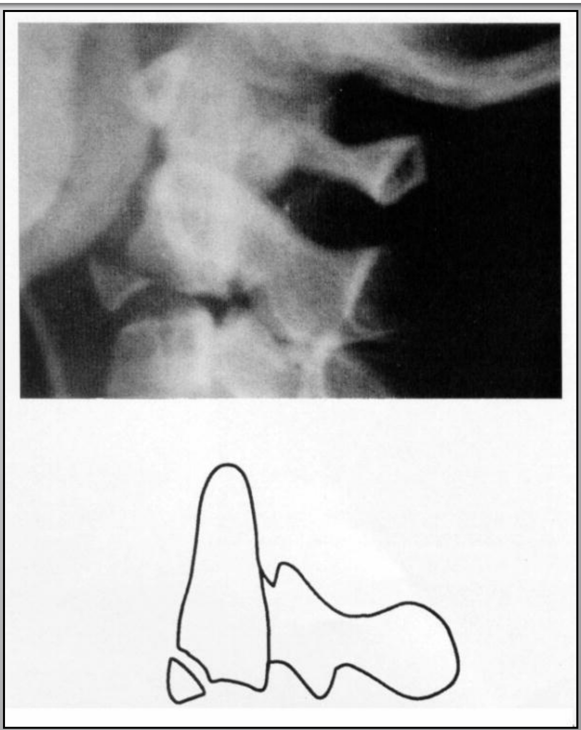
C-2 body fractures

- Type I
  - avulsion fracture is localized at the anteroinferior margin of the axis body, and the fragment dislocates anteroinferiorly
- Mild posterior displacement of C2 on C3
- Hyperextension

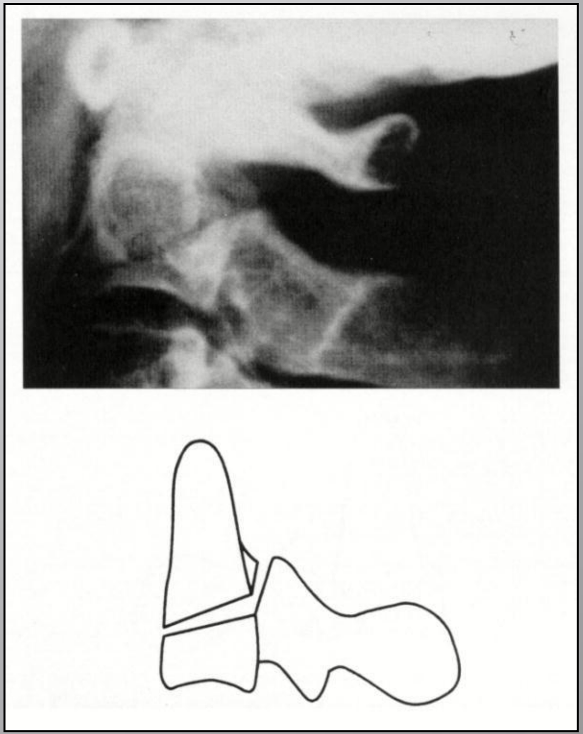


Classification and Treatment of Axis Body Fractures.
Fujimura, Yoshikazu; Nishi, Yukimi; Kobayashi, Keiji

Journal of Orthopaedic Trauma. 10(8):536-540, November 1996.

C-2 body fracture

- Type II
  - transverse fracture of the c-2 body
- Differs from type III dens
  - fracture is distal to the atlantoaxial joint
- Flexion-distraction or traction in extension

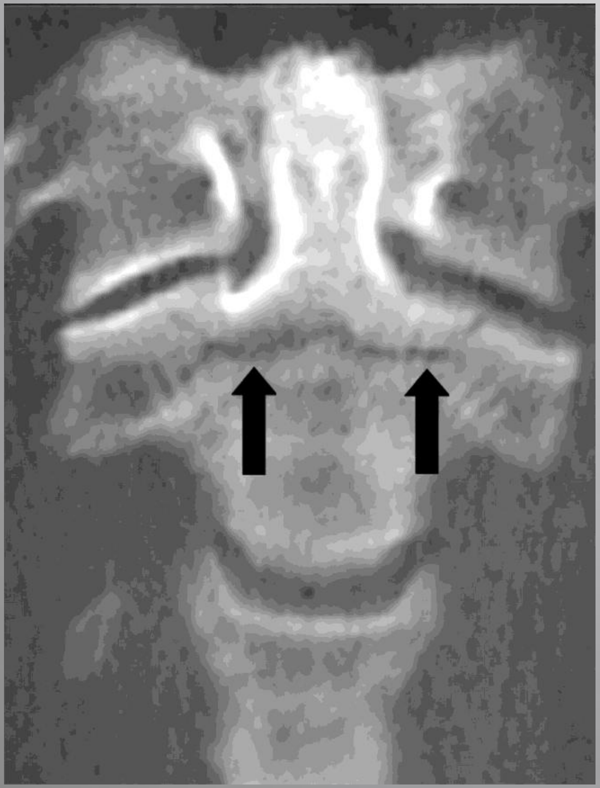


Classification and Treatment of Axis Body Fractures.
Fujimura, Yoshikazu; Nishi, Yukimi; Kobayashi, Keiji

Journal of Orthopaedic Trauma. 10(8):536-540, November 1996.

C-2 body fractures

TYPE III DENS FRACTURE



Rao S K et al. Radiographics 2005;25:1239-1254

TYPE II C-2 BODY FRACTURE

C-2 body fractures

- Type III – burst fracture with displaced fragments
- Posterior fragments are commonly retropulsed
- Associated with traumatic spondylolisthesis
- Axial loading

Classification and Treatment of Axis Body Fractures.
Fujimura, Yoshikazu; Nishi, Yukimi; Kobayashi, Keiji

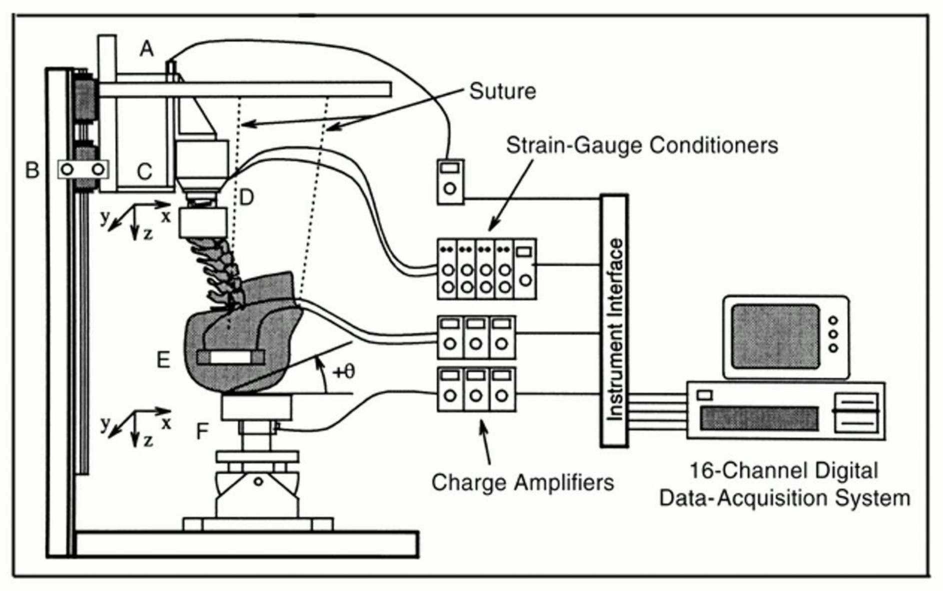
Journal of Orthopaedic Trauma. 10(8):536-540, November 1996.

C-2 body fractures

- Type IV-
  - sagittal or parasagittal fracture extending from a point lateral to the dens vertically or diagonally to the inferior surface of C2

Lower cervical spine

- Three column Theory of Denis for predicting stability
- Soft tissue structures are critical in evaluation of stability in the presence or absence of bone pathology
- Numerous variations of classification systems for categorizing injuries
- Based on mechanism of injury



NIGHTINGALE R. W. et.al. J Bone Joint Surg 1996:78:412-21

Allen and Ferguson

- Widely accetped but more commonly utilized in the research setting
- Components:
  - Flexion-compression
  - Vertical compression
  - Flexion-distraction
  - Extension-compression
  - Extension-distraction
  - Lateral flexion

- Each has various stages that are based on severity

Harris classification for lower cervical spine

MECHANSIM

- Flexion
  - Anterior subluxation (hyperflexion sprain)
  - Bilateral interfacetal dislocation
  - Simple compression fracture (wedge)
  - Clay-shoveler's fracture
  - Flexion teardrop fracture
- Flexion-rotation
  - Unilateral interfacetal dislocation
- Extension-rotation
  - Pillar fracture
- Vertical compression
  - Burst fracture
- Hyperextension
  - Hyperextension dislocation
  - Laminar fracture
  - Hyperextension fracture-dislocation
- Lateral flexion
  - Uncinate process fracture

LOCATION –LOWER CERVICAL

- Compression
- Burst
- Teardrop
- Facet fractures and dislocations
- Extension injuries
- Minor avulsions (transverse process, clay shoveler's)

Proposed classification

Table 3 "Minor" cervical injuries

Mechanism
1. *Hyperflexion*
a. Spinous process fracture
b. Wedge-like compression of body
c. Transverse process fracture (isolated)
d. Uncinate process fracture (isolated)
e. Articular pillar fracture (isolated)
f. Laminar fracture
g. Lateral wedge fracture body
2. *Hyperextension*
a. Horizontal fracture of anterior arch of atlas
b. Anterior inferior margin of C2 ("teardrop")
c. Spinous process fracture
d. Posterior arch of atlas fracture (isolated)
3. *Rotary*
None
4. *Axial compression*
a. Lateral mass of atlas (isolated)
b. Occipital condyle type I and type II fractures

Table 2 "Major" cervical injuries

Mechanism
1. *Hyperflexion*
a. Hyperflexion sprain
b. Hyperflexion dislocation
(1) Without facet lock
(2) With unilateral or bilateral facet lock
c. Comminuted ("teardrop") body fracture
d. Burst fracture
e. Hyperflexion fracture-dislocation
f. Occipito-atlantal dislocation/subluxation
g. Atlantoaxial dislocation
h. Anterior fracture-dislocation of dens
i. Lateral fracture-dislocation of dens
2. *Hyperextension*
a. Hanged man fracture
b. Hyperextension sprain
c. Posterior fracture-dislocation of dens
d. Posterior atlantoaxial dislocation
3. *Rotary*
a. Rotary atlantoaxial dislocation (fixation)
b. Rotary atlantoaxial subluxation
4. *Axial compression*
a. Bursting fracture of Jefferson
b. Vertical and oblique fractures of axis body
c. Occipital condyle type III fracture

Daffner RH et al Skeletal Radiology (2000) 29:125-132

Major if….

- >2mm of displacement in any plane
- Wide vertebral body in any plane
- Wide interspinous or interlaminar distance
- Wide facet joint
- Disrupted posterior vertebral body line
- Wide disc space
- Burst fracture of the vertebral body
- Locked or perched facets (uni or bilateral)
- Hangman's fracture
- Dens fracture
- Type III occipital condyle fracture

Daffner RH et al Skeletal Radiology (2000) 29:125-132

Hughes categorization

- Entity
- Stability
- Mechanism
- Characteristics

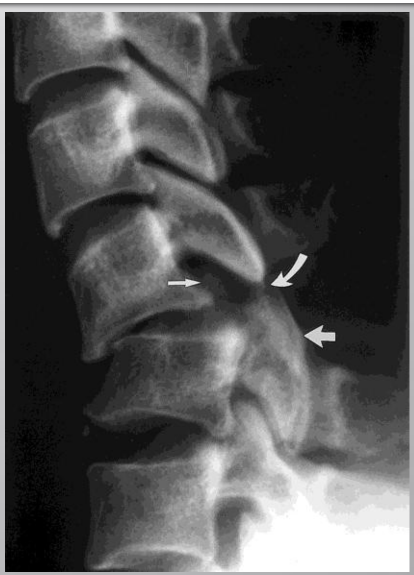
Hyperflexion sprain

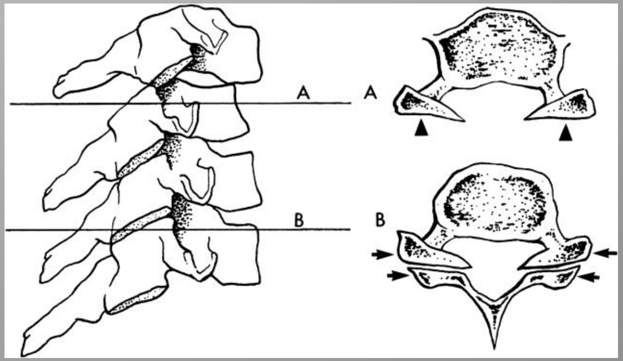
- Disruption of ligaments
  - Supraspinous, interspinous, ligamentum flavum, facet joint capsule, possibly PLL and posterior aspect of annulus fibrosus
- Frequently have normal radiographs with clinical evidence for cord injury
- Unstable

Wilmink European Radiology 9,1259-1266

Bilateral apophyseal joint dislocation

- Hyperflexion
- Significant ligamentous injury
- High association with neurologic deficit
- High association with traumatic disc herniation
- Unstable

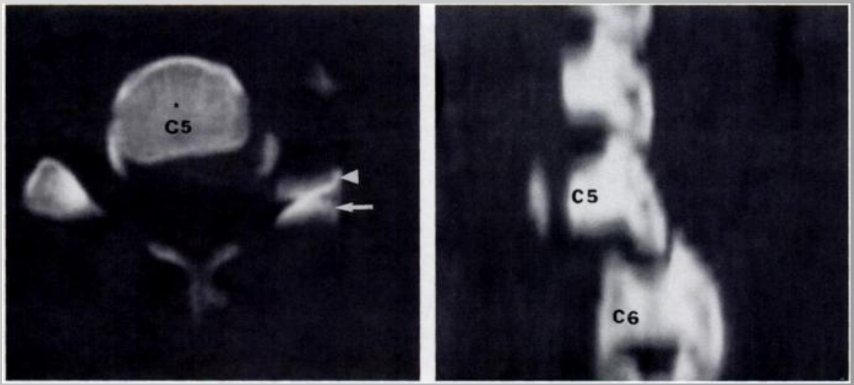


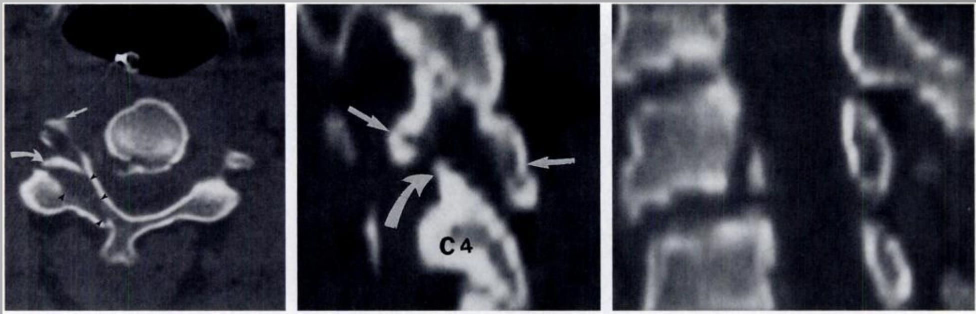


Lingawi S S Radiology 2001;219:366-367

Unilateral apophyseal joint dislocation

- Hyperflexion with rotation
- Ligamentous injury
- Associated with fractures of the articular process and vertebral bodies
- Stability is variable

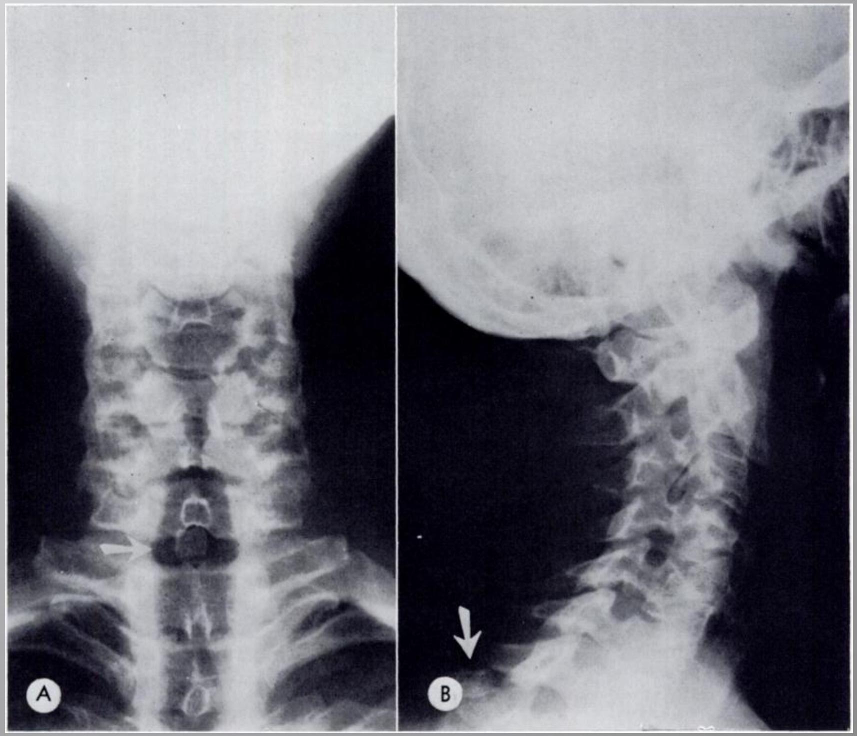




Shanmuganathan et al AJR 163 (5): 1165-1169 (1994)

Spinous process fractures

- Generally stable
- Careful to look for associated injuries
- Clay-shoveler's
  - Most common type
  - Inferior displacement
  - hyperflexion
- Hyperextension type
  - Impaction injury with contact of adjacent processes
- Double spinous process sign
- Stable



Cancelmo JJ AJR 115: 540-543

Vertebral body compression

- Wedge-like compression
- Typically spares posterior ligaments
- Usually stable
- Compressive hyperflexion

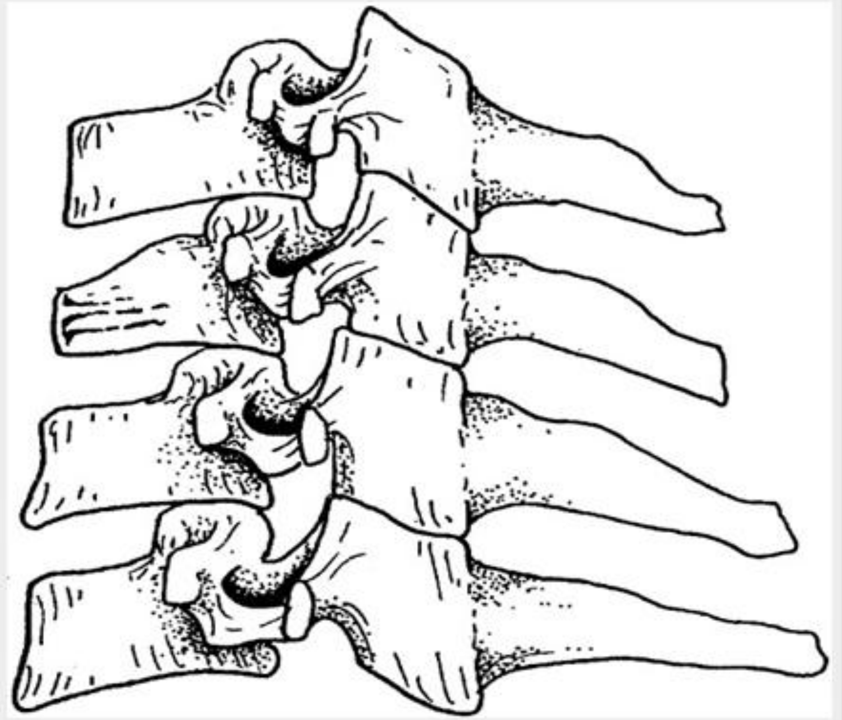
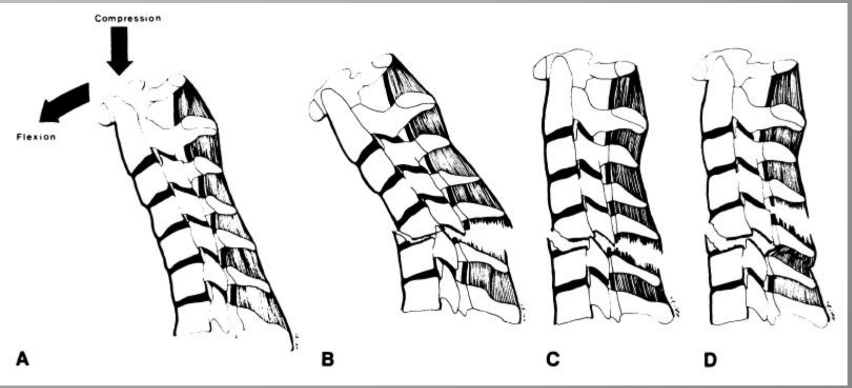


Image Credit:
http://faculty.washington.edu/alexbert/MEDEX/Winter/EM1DisordersSpine.htm

Flexion teardrop

- Unstable
- Compressive hyperflexion
- Results in a characteristic finding of displacement of a majority of the body posteriorly into the canal
- Can be confused with other injuries producing teardrop fragments
- Disc disruption and ligamentous injury contribute to this being highly unstable
- Can see widening of facets and interspinous spaces but these findings are less specific for this type of injury



Kim KS et al AJR 152:319-326

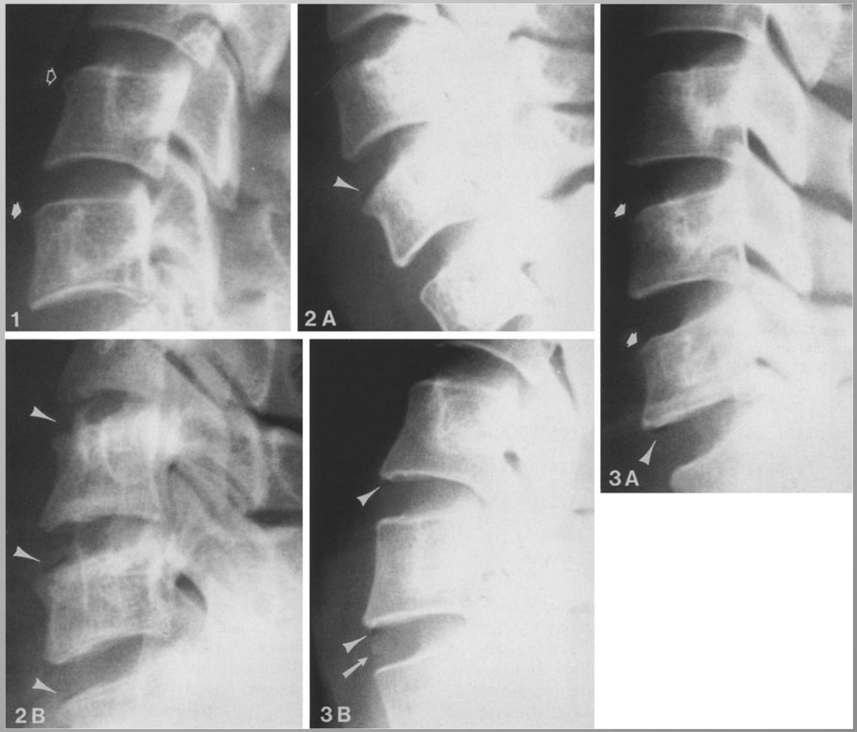
Extension tear drop

- Variable stability
- Hyperextension
- Tear drop fracture most commonly seen at C2
- More common in older people who are demineralized

Rao S K et al. Radiographics 2005;25:1239-1254

Lucent annular cleft sign

- Can be seen in the setting of trauma and can persist for years
- Can be seen in the setting of degenerative changes
- Stable vs unstable



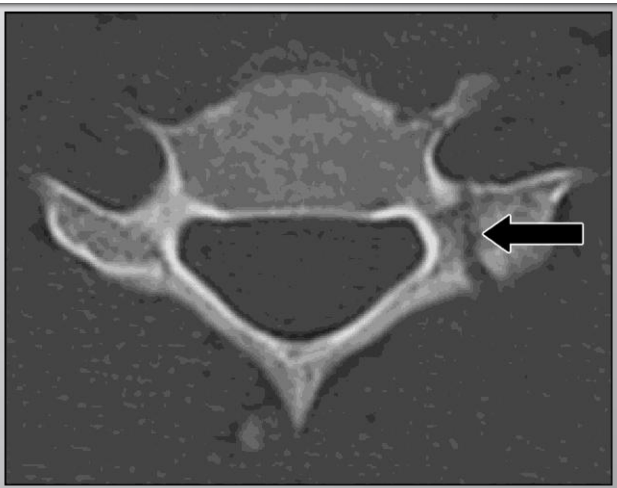
Hyperextension

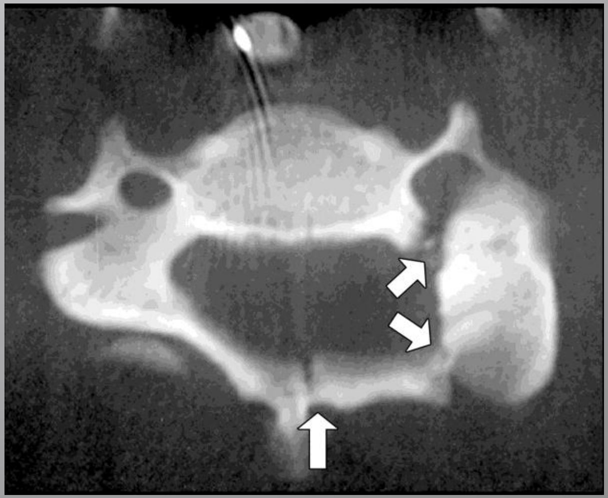
- Radiographs can be very unrevealing with a 1/3 showing only prevertebral soft tissue thickening
- Ruptures of ALL, annulus, disc
- PLL, ligamentum flavum and paraspinous muscles can be injured
- Majority have a small osseous component
- Cord injury almost always present

Rao S K et al. Radiographics 2005;25:1239-1254

Pillar fractures

- Commonly stable
- Hyperflexion and rotation
- Unilateral vertical or obliquely oriented fracture
- Can be comminuted
- May extend into adjacent osseous structures
- Variant is pedicolaminar fracture which is considered unstable and has a higher association with neurologic compromise

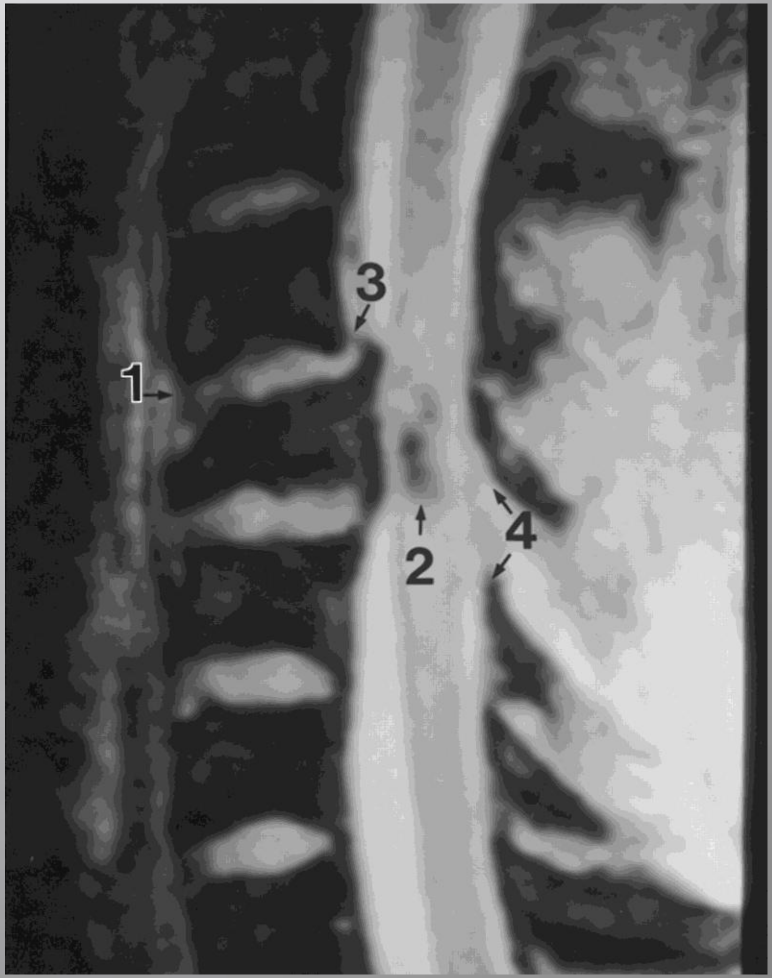




Rao S K et al. Radiographics 2005;25:1239-1254

Burst fractures

- Variable stability
- Axial compression with flexion
- High level of neurologic deficit
- Depending of severity of fracture the lucency may not be well seen at radiography



Benedetti, P. F. et al. Am. J. Roentgenol. 2000;175:661-665

Lateral hyperflexion injuries

- Transverse process fracture
  - Stable
  - Uncommon
- Uncinate process fracture
  - Stable, uncommon
- Nerve root or brachial plexus avulsion
  - Variable stability
- Lateral wedge compression of vertebral body
  - Stable, uncommon

Newer classfication system

- SLIC- sub-axial injury classification
- Developed in response to a perceived lack of a "gold standard" system for classifying subaxial c-spine injuries and the resulting treatments
- Treatment is based on several variables
  - Fracture pattern
  - Suspected mechanism of injury
  - Spinal alignment
  - Neurologic injury
  - Expected long-term stability

Vaccaro et al Spine Volume 32, Number 21, pp 2365–2374

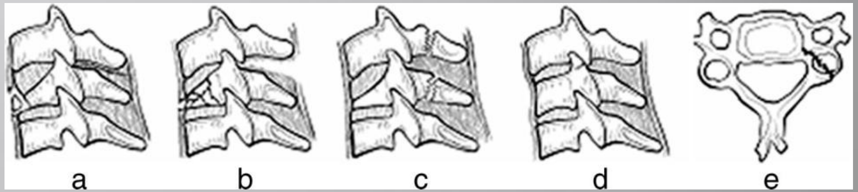
SLIC

- Trended away from classic classification base on mechanism and anatomy
- Focuses on injury morphology and clinical status
- Goals were to morphologically categorize injuries and to predict treatment
- 3 injury axes were utilized
  - Morphology
  - DLC
  - Neurologic status

Vaccaro et al Spine Volume 32, Number 21, pp 2365–2374

Compression

- Defined as the visible loss of height
  - Part or entire body
  - Disruption through an endplate
- Includes:
  - Compression fractures
  - Burst fractures
  - Sagittal and coronal plane fractures
  - Flexion compression fracture primarily involving the vertebral body
  - Can have fractures of the posterior elements when axial loading is more even throughout
  - D – felt to likely be related to lateral compression
    - Compression category unless visible translation is present



A - compression fracture
B - compression fracture with DLC
C - compression with laminar fx
D - ND lateral mass and/or facet
E – axial view of lateral mass fx

Vaccaro et al Spine Volume 32, Number 21, pp 2365–2374

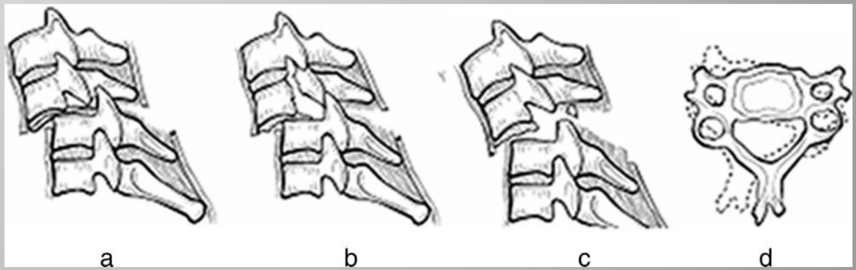
Distraction

- Evidence of dissociation in the vertical axis
- This pattern involves DLC injury
- Includes:
  - Pure distraction injuries
  - Hyperextension injuries
  - Hyperflexion injuries
  - Bilateral facet dislocations- these may be in translation category as well

A - circumferential distraction
B - bilateral facet dislocations
C - hyperextension with distraction
D – flexion with distraction

Translation/Rotation

- Evidence of horizontal displacement
- Authors consider "any visible translation unrelated to degenerative changes" to be abnormal
- Unilateral or bilateral facet fracture-dislocations, floating lateral mass, bilateral pedicle fractures



A - translation with DLC injury
B - translation with pedicle fx
C - translation with facet fx
D - rotation seen best on axial

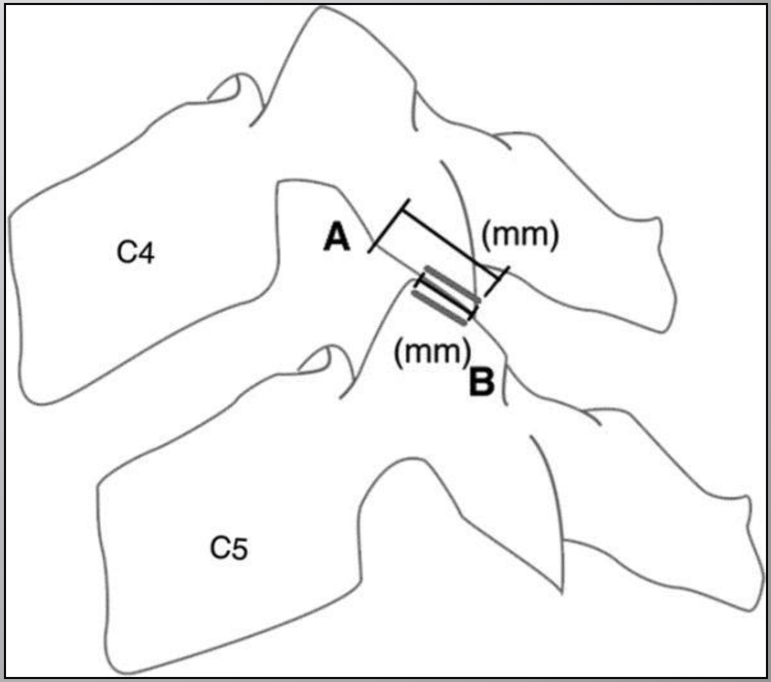
DLC

- Includes:
  - Disc
  - ALL
  - PLL
  - Interspinous ligaments
  - Facet capsules
  - Ligamentum flavum
- Injury is often inferred from visible abnormal bone relationships

Vaccaro et al Spine Volume 32, Number 21, pp 2365–2374

DLC

- Evidence of instability
- Absolute
  - <50% articular apposition of facets
  - >2mm of diastasis
  - Widening of the disc space
  - Increased signal in the disc space is considered highly suggestive
- Interspinous widening may be indicative of DLC injury (instability) if flex/ext radiographs are abnormal



Measurement Techniques for Lower Cervical Spine Injuries: Consensus Statement of the Spine Trauma Study Group.
Bono, Christopher; Vaccaro, Alexander; Fehlings, Michael; Fisher, Charles; Dvorak, Marcel; Ludwig, Steven; Harrop, James

Spine. 31(5):603-609, March 1, 2006.
DOI: 10.1097/01.brs.0000201273.39058.dd

Neurologic status

- Historically not included in classification systems
- Important sign of the severity of spine injury
- Can be very influential in predicting the need for treatment

SLIC

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

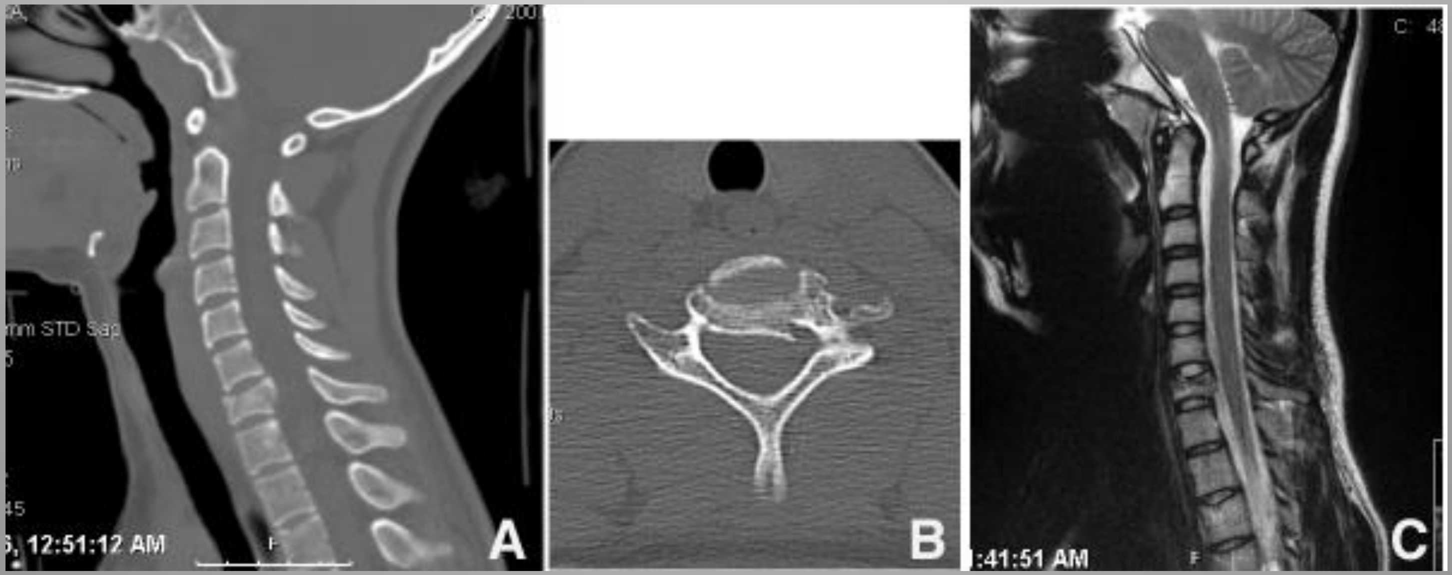
Vaccaro et al Spine Volume 32, Number 21, pp 2365–2374

SLIC

- The descriptive identification of the injury pattern includes:
  - Spine level
  - Morphology
  - Bone injury description
  - DLC status
  - Neurologic status
  - Confounders

Vaccaro et al Spine Volume 32, Number 21, pp 2365–2374

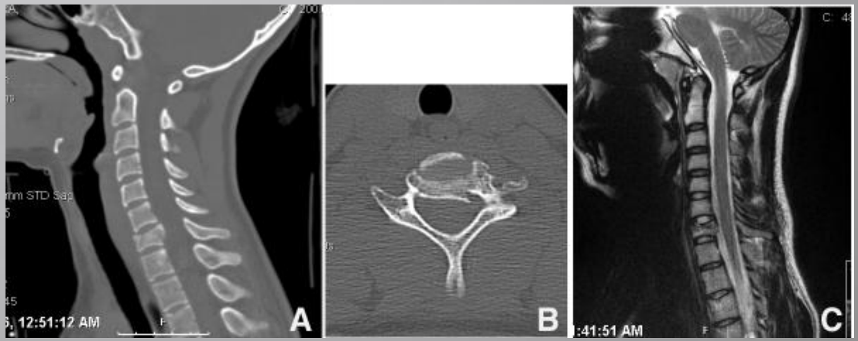
SLIC application



Patel et al Neurosurg Focus 25 (5):E8, 2008

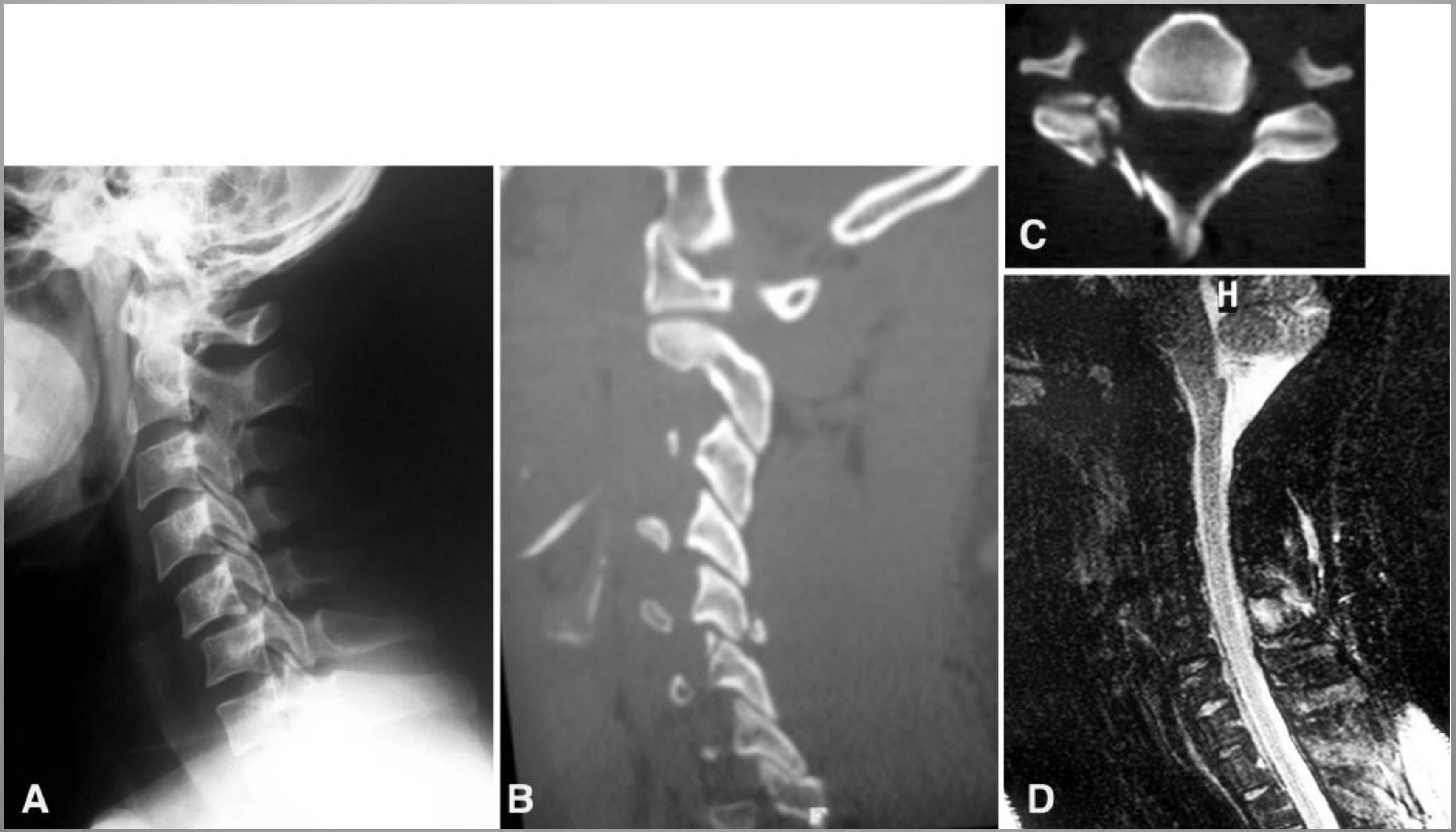
Case

- Normal neurologic exam
- C-7 burst fracture, DLC intact
- 2 points for fracture
- 0 DLC intact
- 0 nl neuro exam
- Total 2 – no surgery



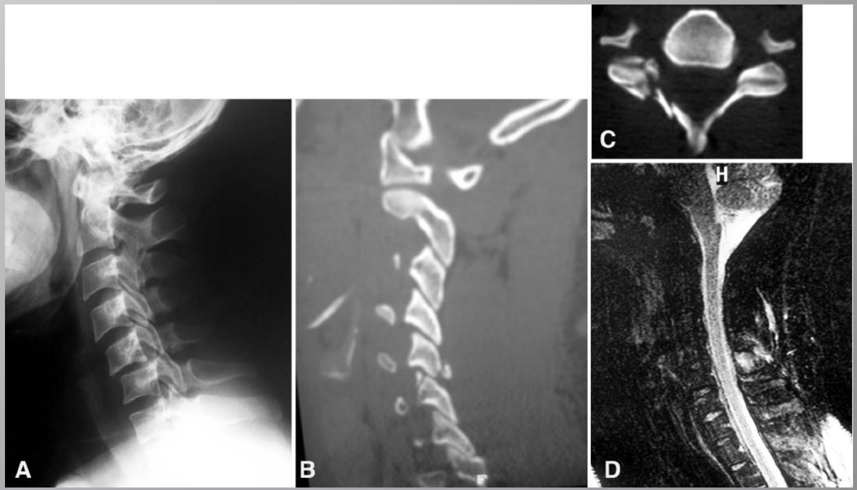
Patel et al Neurosurg Focus 25 (5):E8, 2008

Case 2



Case 2

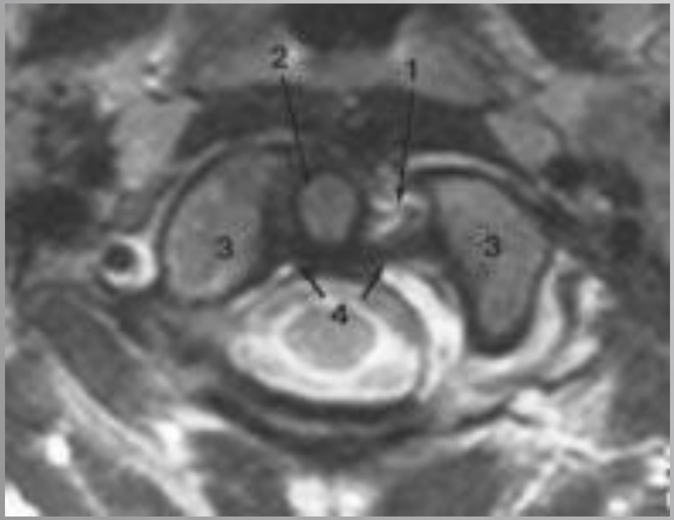
- Left arm weakness
- Translation at c5-c6 with fxs of facets and MR evidence for posterior ligamentous injury
- 4 –translational injury
- 2 – DLC disrupted (1)
- 1 – abnormal neuro exam – root injury
- 7 = surgery



MR imaging

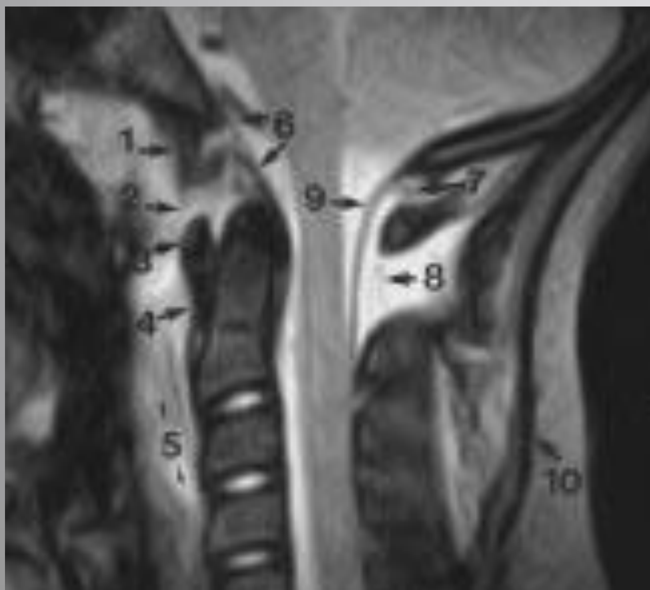
- Evaluating the obtunded patient
- Patients with negative imaging but persistent or developing neurological deficit
- Positive CT with MRI assisting in determining the extended of soft tissue injury

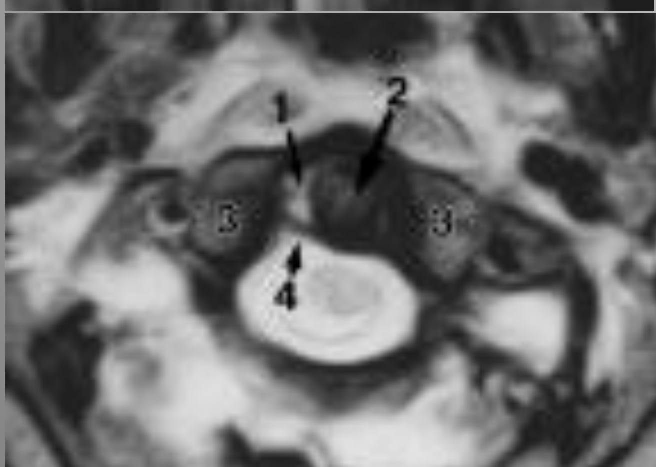
Benedetti et al



- Torn alar ligament
- Fix deviation of the dens
- CT was negative for fracture or rotary fixation

Benedetti et al





- Torn tectorial membrane
- Torn right alar ligament
- Torn anterior atlantooccipital membrane
- Prevertebral soft tissue thickening
- The extent of injury and instability was not fully appreciable on CT and CR

Benedetti et al

- Disc extrusion and stripping of the PLL
- Disc extrusion, PLL tear, disrupted annulus fibrosus
- Ligamentum flava tear
- Interspinous ligament tear
- All findings were occult on CT

Benedetti et al

- Central cord syndrome
- ALL tear
- Anterior disc disruption

Benedetti et al

- Bilateral facet dislocation
- ALL tear
- PLL tear
- Traumatic disc extrusion
- Cord contusion and compression
- Interspinous ligament injury