Cervical Spine Injuries in Children

Unni Udayasankar MD
Professor and Vice Chair
Department of Medical Imaging
University of Arizona

Banner
University Medical Center
Tucson

THE UNIVERSITY OF ARIZONA

Learning Objectives

Differentiating Pediatric C-Spine injuries from those of adults

- Incidence
- Distributions
- Physiologic features
- Normal variants
- Biomechanics
- Fracture patterns
- Mechanisms of injury

Incidence:

Younger children tend to injure the upper cervical spine:

- Craniocervical junction to C3 spinal level

Child abuse should also be considered in the young child with a suspected whiplash mechanism of cervical spine injury

Biomechanical Factors

- Children's heads are larger in proportion to their bodies
  - more cranially positioned center of mass of the head and neck,
  - a fulcrum centered at the C2-C3 spinal level
  - in adults, the fulcrum is at the C5-C6 spinal level
- Cervical muscles and ligaments are weaker and more lax
- Cervical vertebral bodies are wedge shaped anteriorly
- Intervertebral disks are more capacious
- Vertebral facets have a more horizontal orientation

RadioGraphics 2019; 39:1126–1142

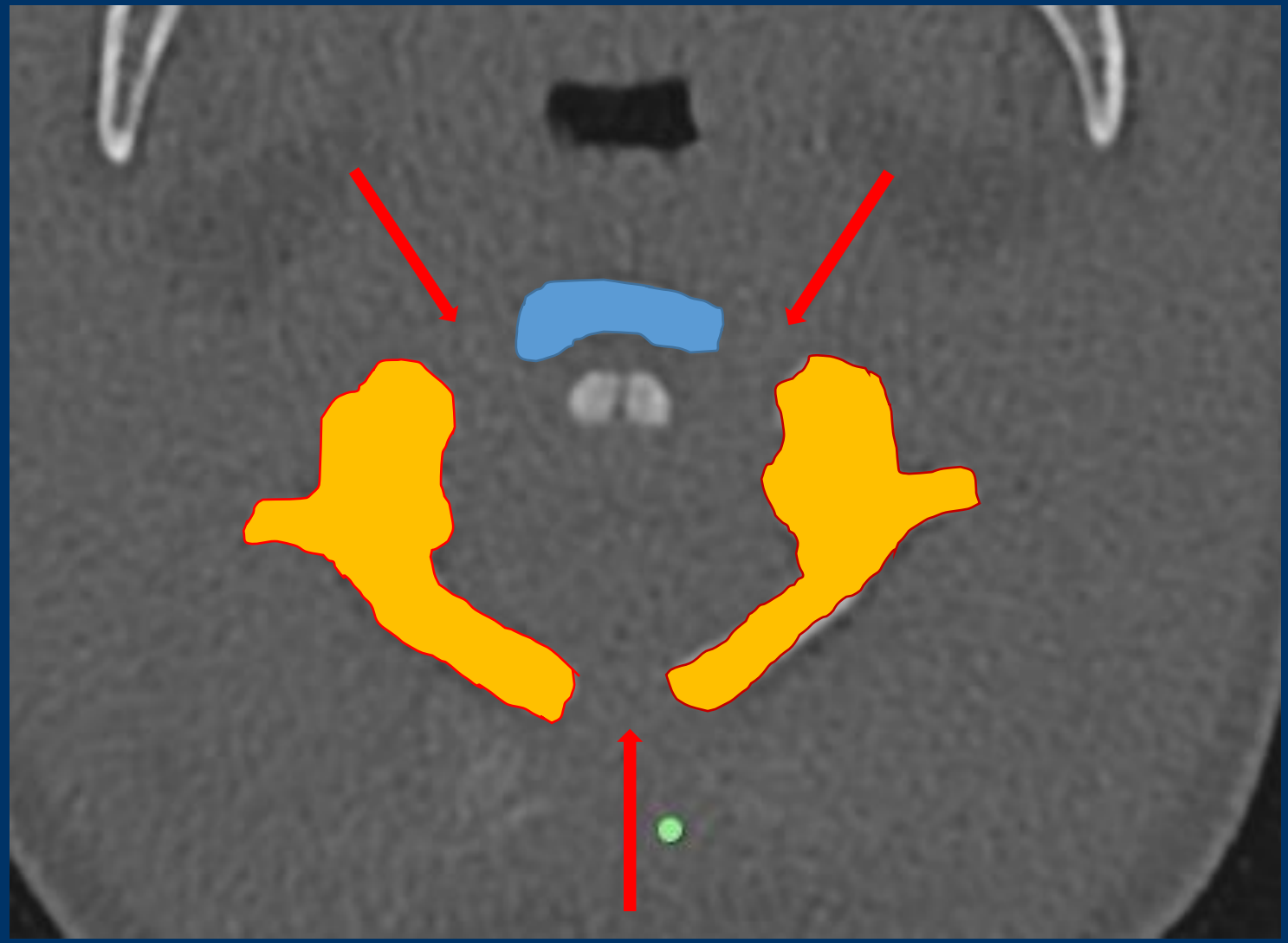
Mechanism of injury

- MVC
- Fall
- Sports
- Abusive trauma (<2 years)

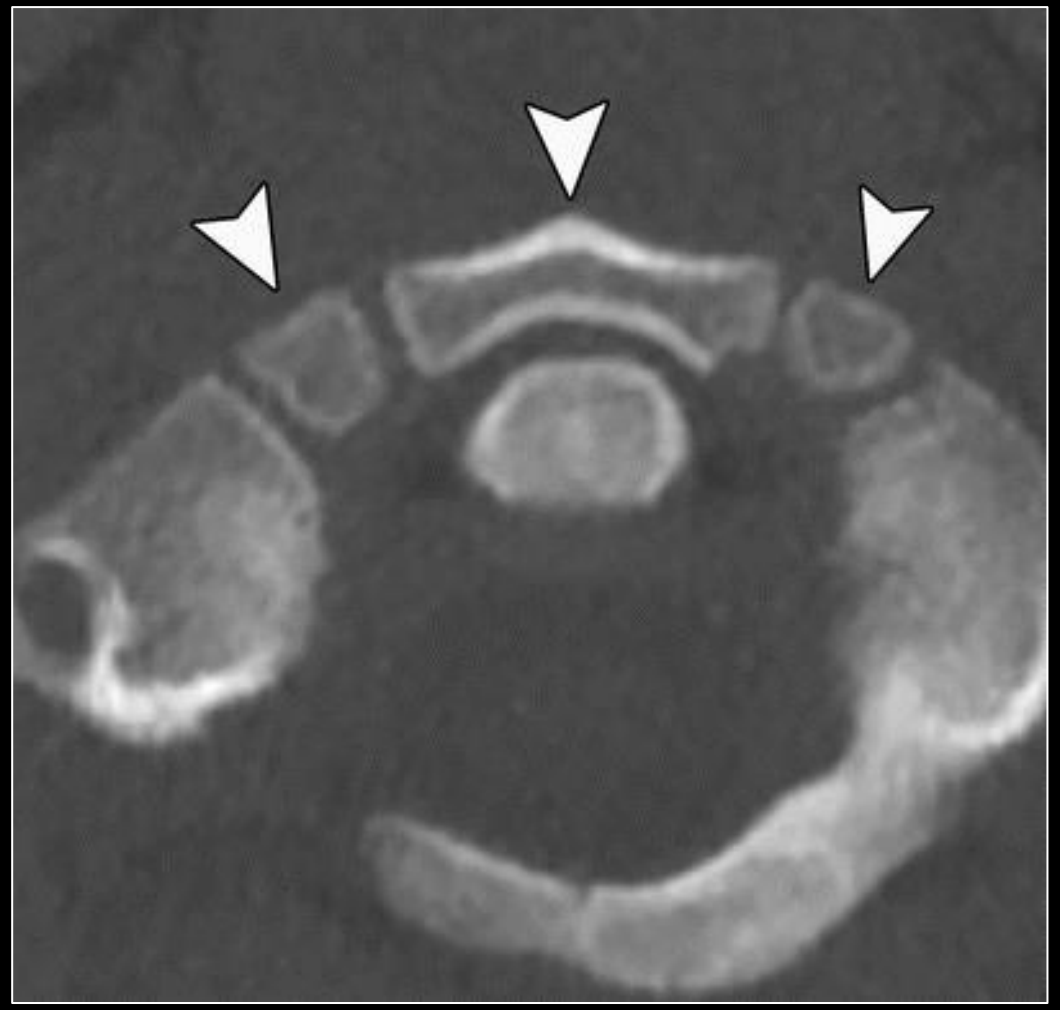
Developmental features

C1 Vertebral body

- Anterior Arch (<1 year old)
- Two neural arches (present at birth)
- Three synchondrosis (fused by 3 years)



Bipartite anterior ossification center in a 2 year old



Multiple anterior ossification center in a 2 year old

RadioGraphics 2019; 39:1126–1142

- C2 develops from 6 ossification centers

Fracture vs Synchondrosis

Synchondrosis	Fractures
located in predictable areas	less predictable areas
relatively smooth, regular, and corticated margins	Margins are irregular, without a cortical border

Rarely The synchondrosis itself also can be injured

Imaging in Pediatric C spine injuries

Who should be imaged?

Clinical predictors of cervical spine injury that were seen in children after blunt trauma by using Pediatric Emergency Care Applied Research Network (PECARN)

Predictors of C Spine Injury in Children
Altered Mental Status
Focal Neurologic Deficit
Neck Pain
Torticollis
Substantial body injury
Predisposing medical condition
Diving
High-risk motor vehicle crash

Ann Emerg Med 2011;58(2):145–155

Imaging modality of choice

- Spinal radiography is the initial imaging modality of choice

- CT is the initial imaging modality of choice
  - Children who are obtunded,
  - have experienced polytrauma, or
  - are otherwise at high risk owing to their mechanism of injury.

- CT and/or MRI
  - problem solving,
  - for further evaluation of radiographic abnormalities,
  - to investigate symptoms that cannot be explained at radiography alone

Table 4: Factors Influencing the Selection of Modality for Pediatric Cervical Spine Imaging

Selected Modality	Reason for Selection
No imaging examination	Normal clinical examination results Absence of risk factors Low clinical suspicion
Radiography	Initial imaging modality of choice for most children who require imaging
CT	Initial imaging modality for children who are obtunded, have experienced polytrauma, and/or have a high-risk mechanism of injury C1-C3 vertebral bodies depicted on pediatric brain trauma CT images, if obtained Further evaluation owing to cervical spine radiographs that are inadequate or have suspicious or abnormal findings Normal radiographs with high clinical suspicion for injury A radiation dose higher than that with radiography is needed
MRI	Abnormal neurologic examination results (even if symptoms have resolved) Imaging of spinal cord Imaging of soft tissues Abusive head trauma is suspected

RadioGraphics 2019; 39:1126–1142

Radiography

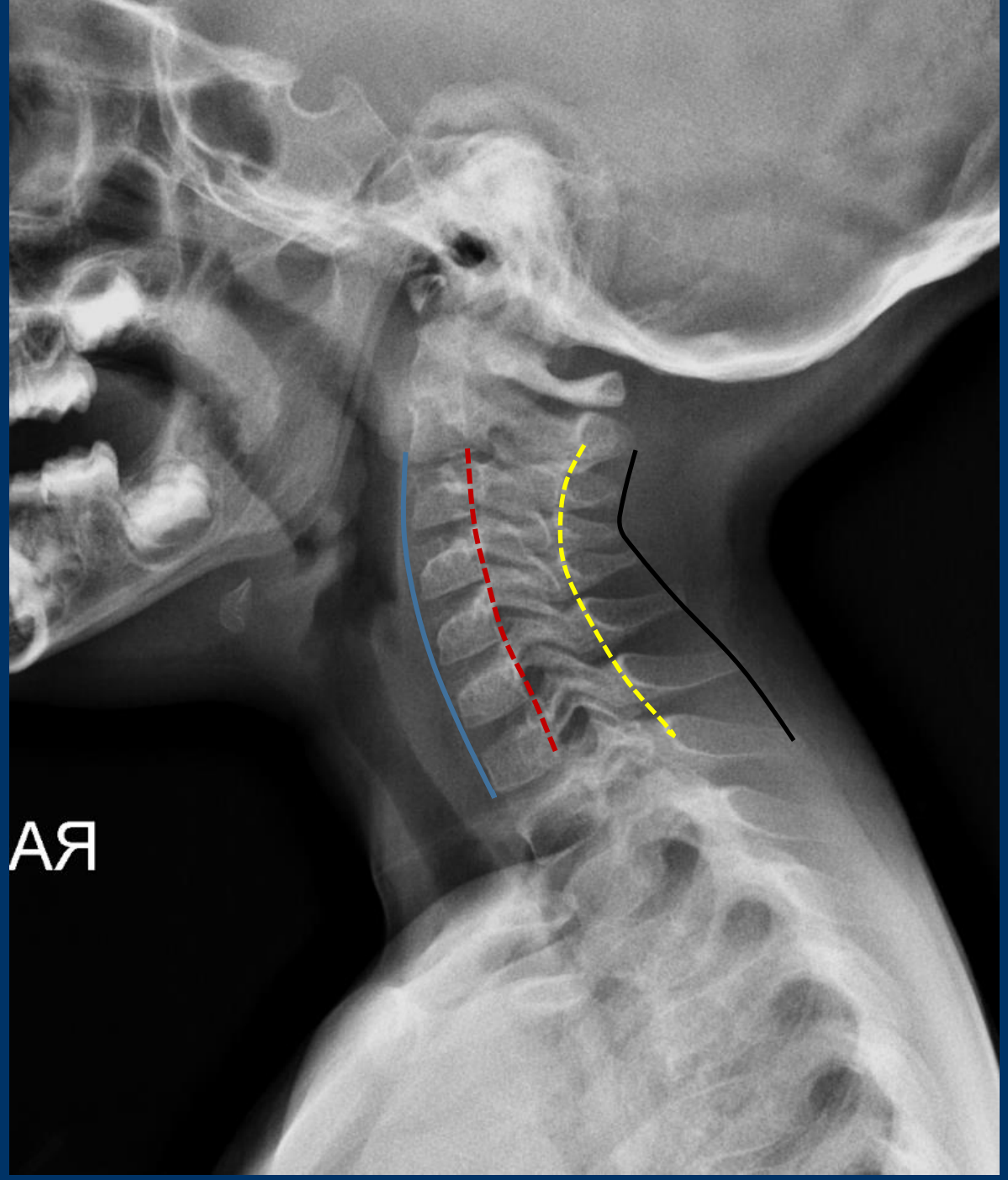
- Frontal and lateral views
- Open-mouth odontoid-view radiograph is difficult to obtain in young children and *adds little diagnostic information*
- Flexion and extension radiographs are *not recommended* in the acute setting
- The external auditory canals and the lower cervical facets should be superimposed.

Anterior vertebral line

Posterior vertebral line

Spinolaminar line

Posterior spinous line



Effect of Cervical Collars

- Cervical collars are known to change the spinal alignment, with generalized straightening and loss of lordosis
- Even in patients with a normal spine, collars may increase spinal measurements beyond the published normal ranges,
- In injured patients, overdistraction may exacerbate the injury.

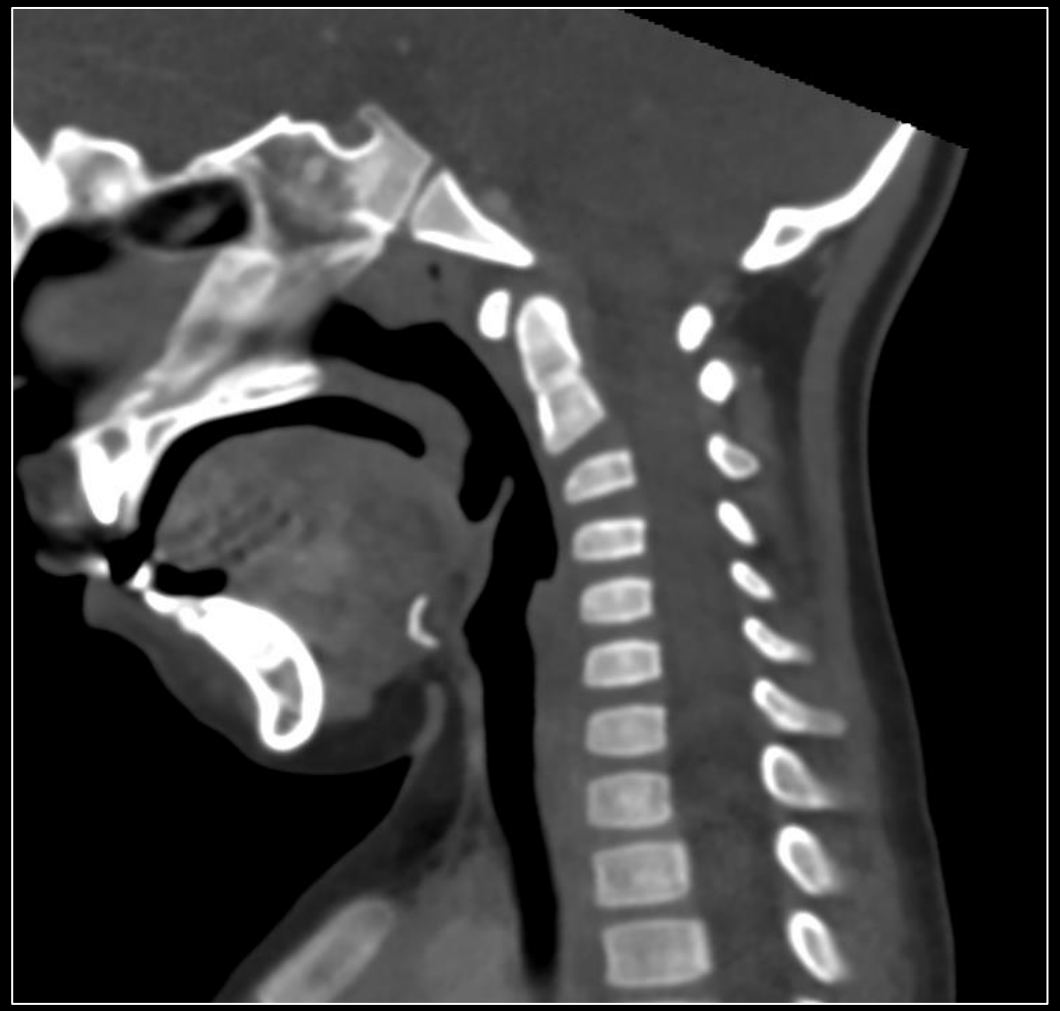
CT

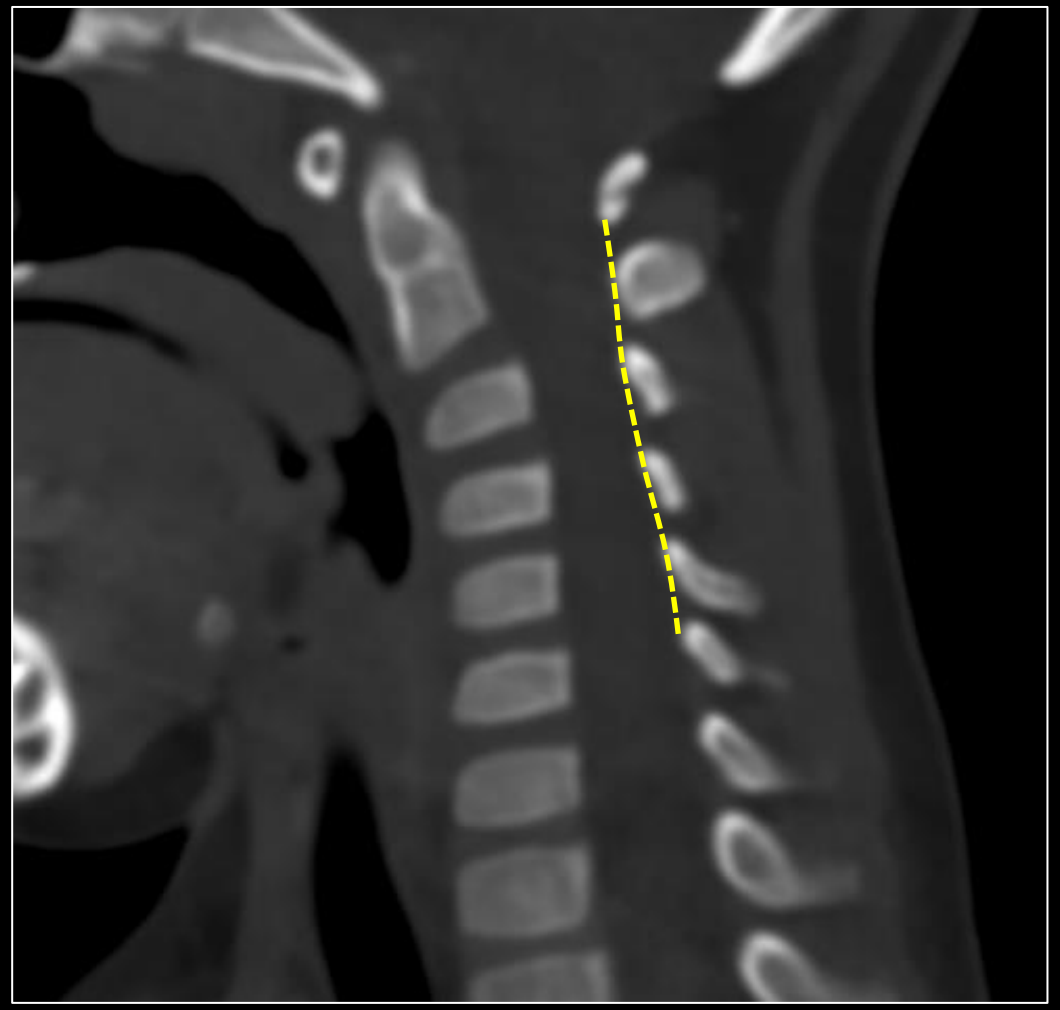
- Usefulness of cervical spine CT in children increases with their age
- The radiation dose should be sufficient to enable assessment of the soft tissues
- The higher radiation exposures used for brain CT improve soft-tissue visualization of the upper cervical spine

- MRI is the most sensitive and specific method of assessing acute pediatric spine trauma.

Pediatric Cervical Spine Variants on Imaging

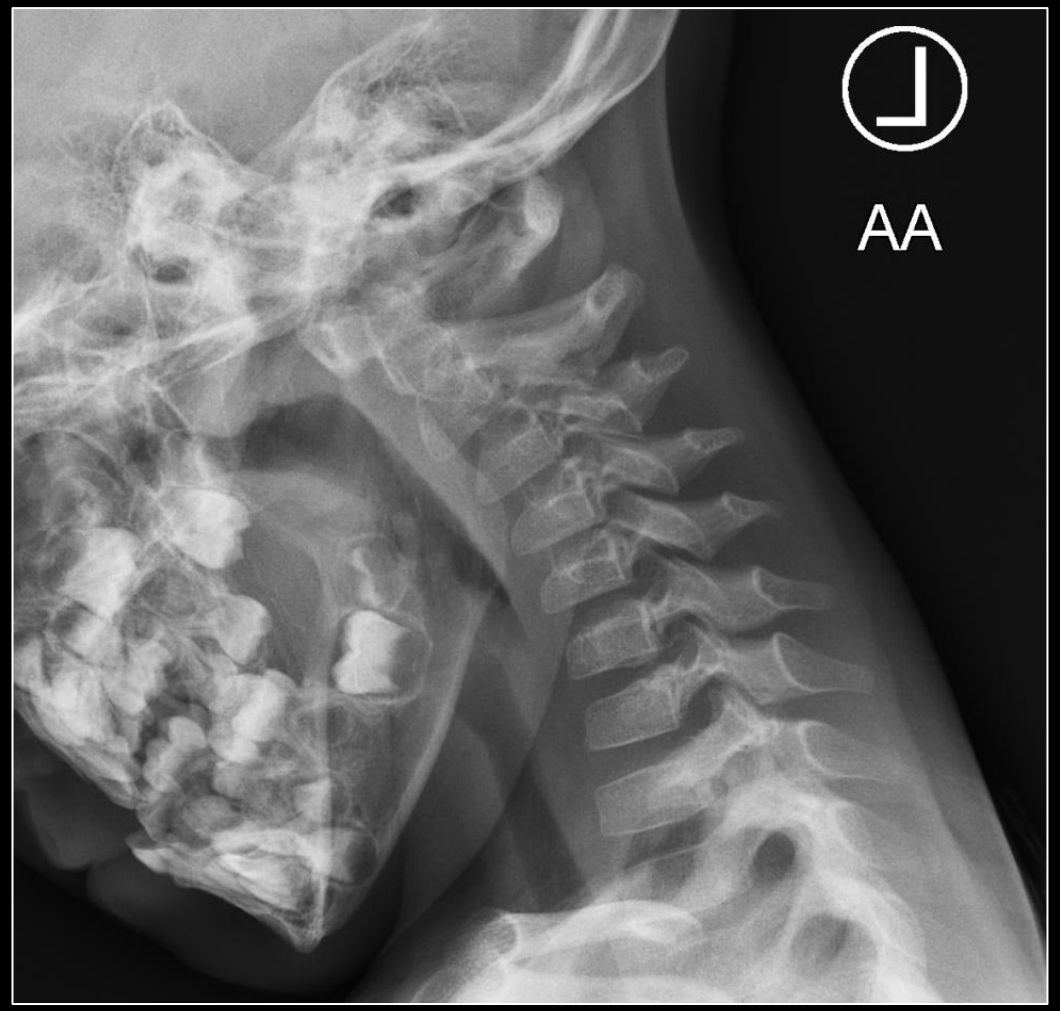
Peudo-subluxation





46% of children less than 8 years old has pseudo-subluxation of C2 on C3


AA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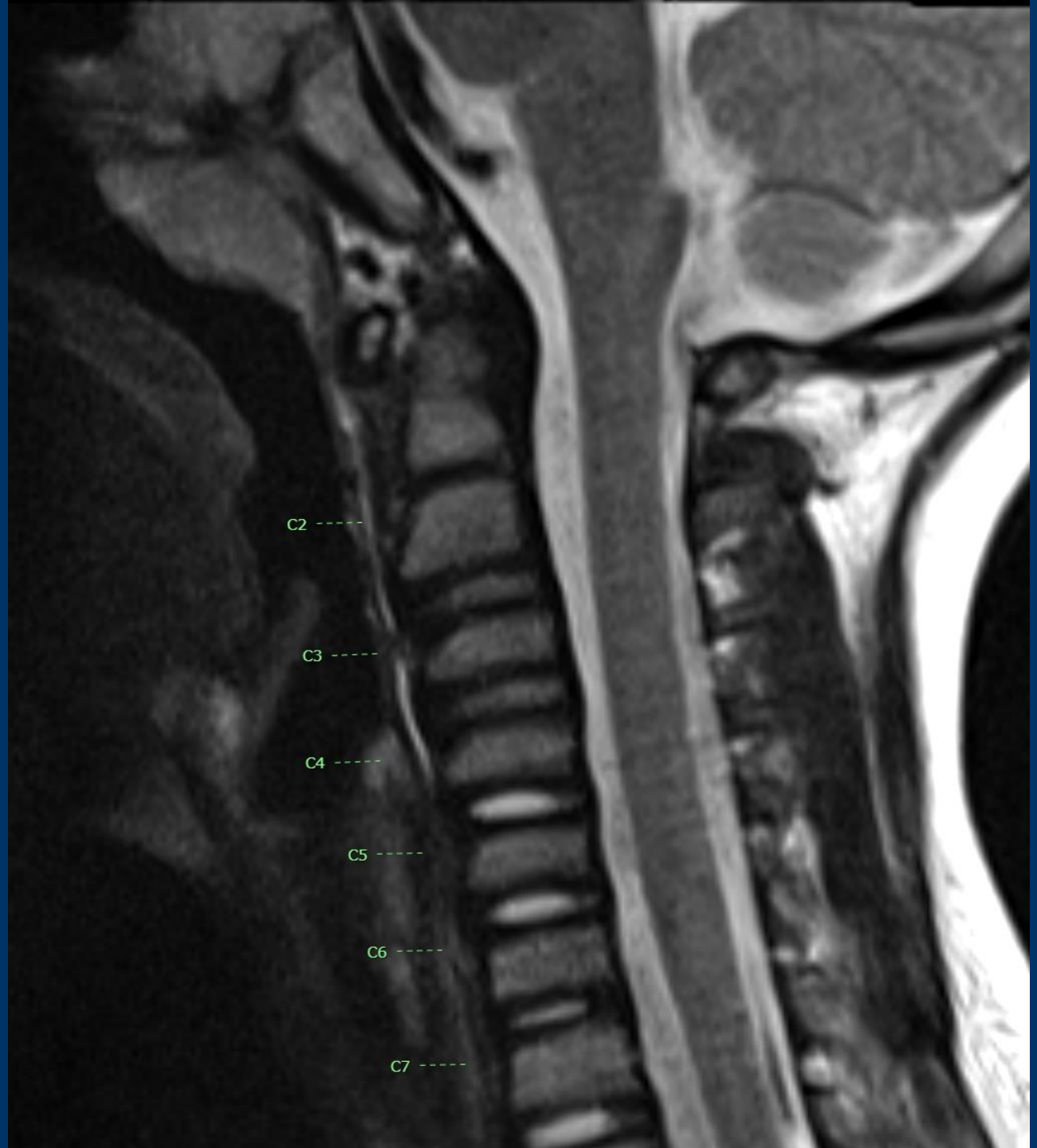
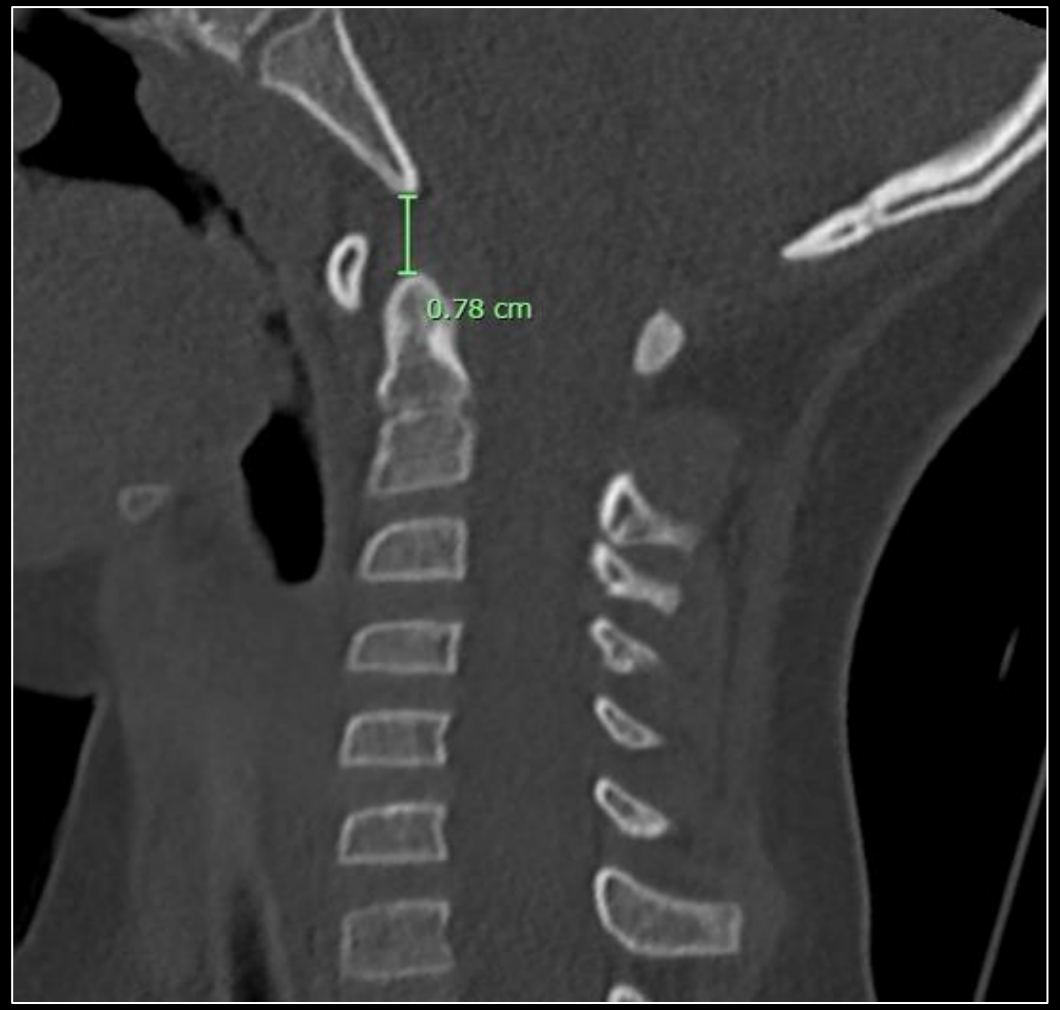

C2 -----
C3 -----
C4 -----
C5 -----
C6 -----
C7 -----

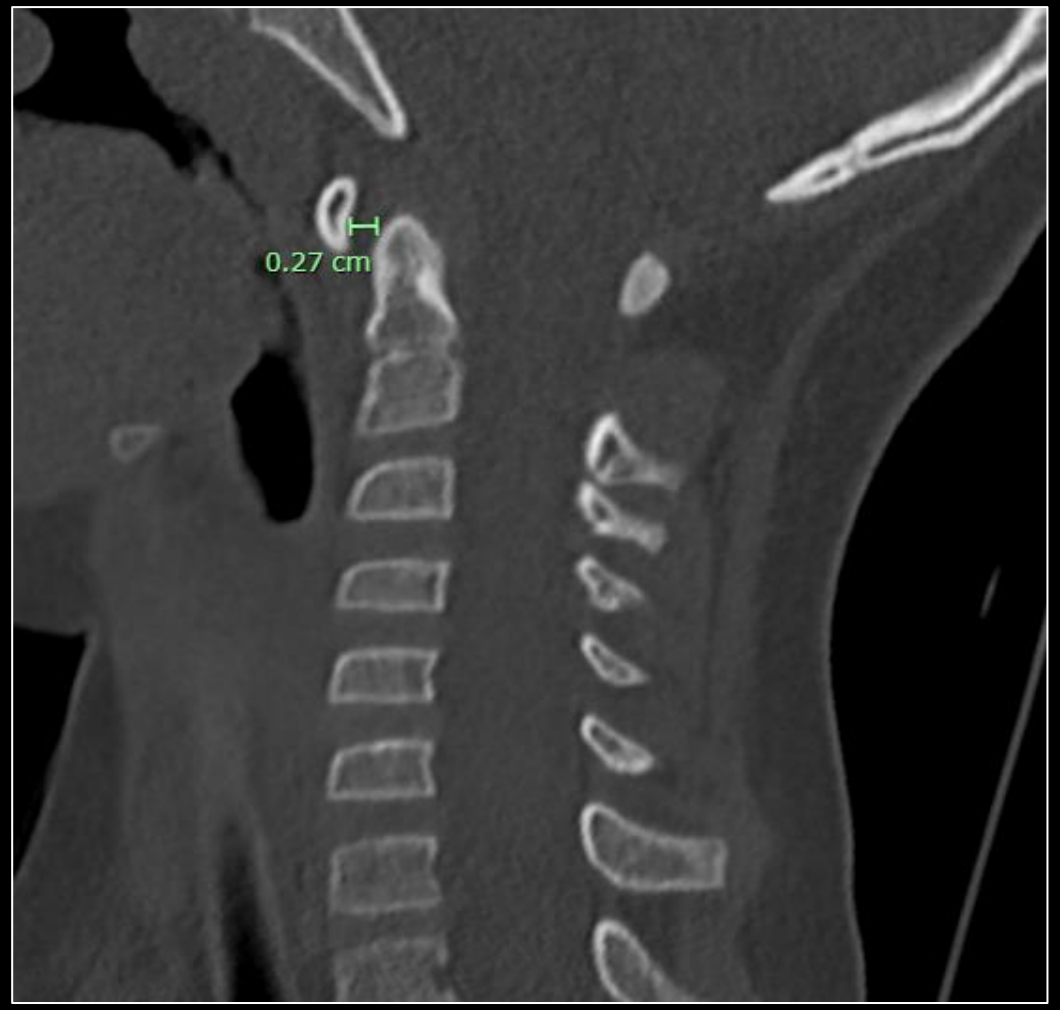
Vertebral morphology

- Anterior physiologic wedging
- Most pronounced at C3
- Upto 3mm wedging is normal

Pediatric Cervical Spine Imaging Markers of Injury

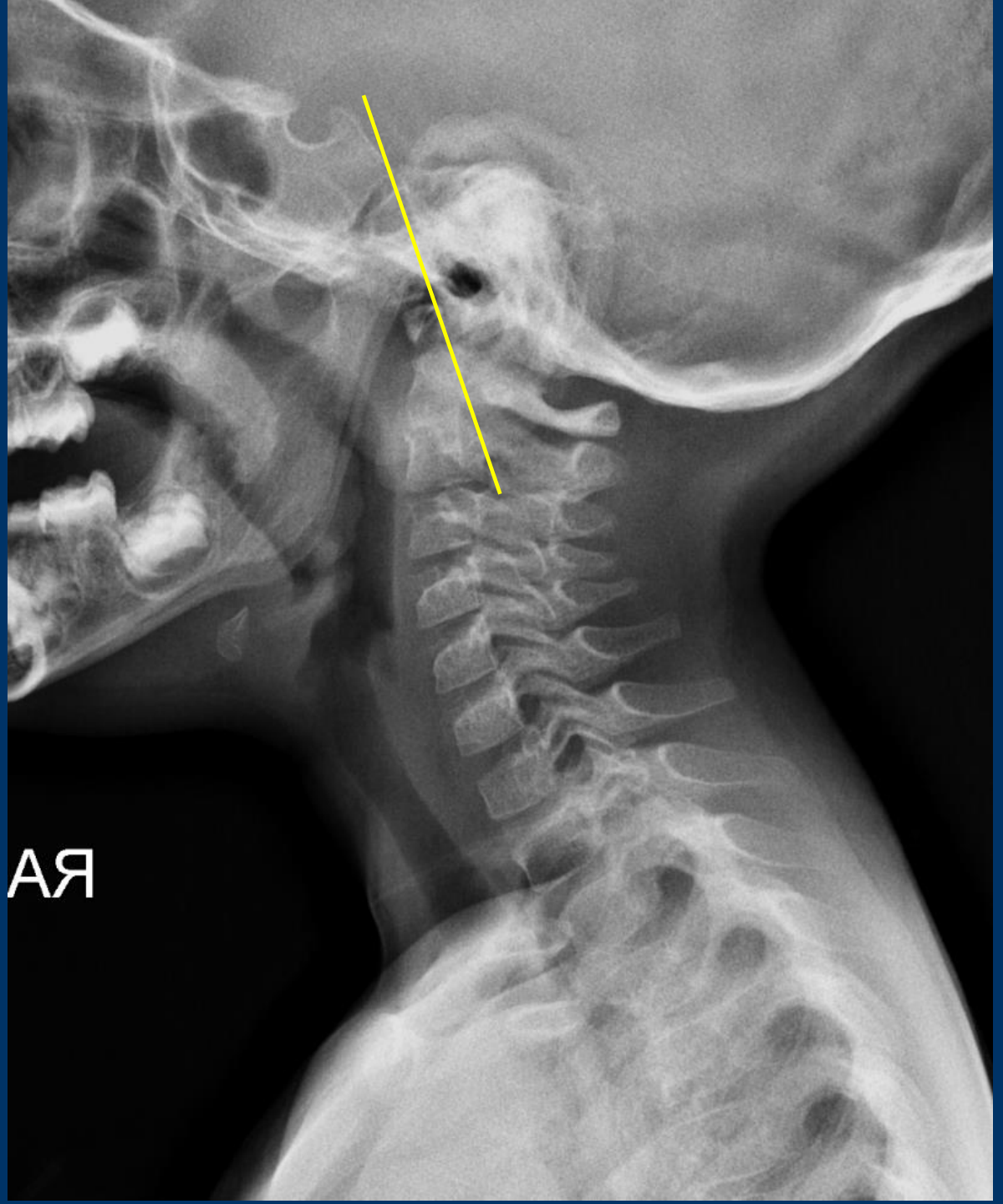


CVJ and upper cervical distraction injuries: Basion dens interval (normal <12mm)



Atlantodental interval (<6mm is normal)

The Wackenheim line is defined as a line along the posterior cortical margin of the clivus, which should normally intersect the posterior one third of the dens



Powers ratio

A normal Powers ratio *is less than 1*, and an abnormal ratio raises concern for craniocervical junction injury

C1-C2 interval/Interspinous ratio

- From inferior cortex of the posterior arch of C1 to the superior cortex of the posterior arch of C2
- Normal values are less than 12 mm

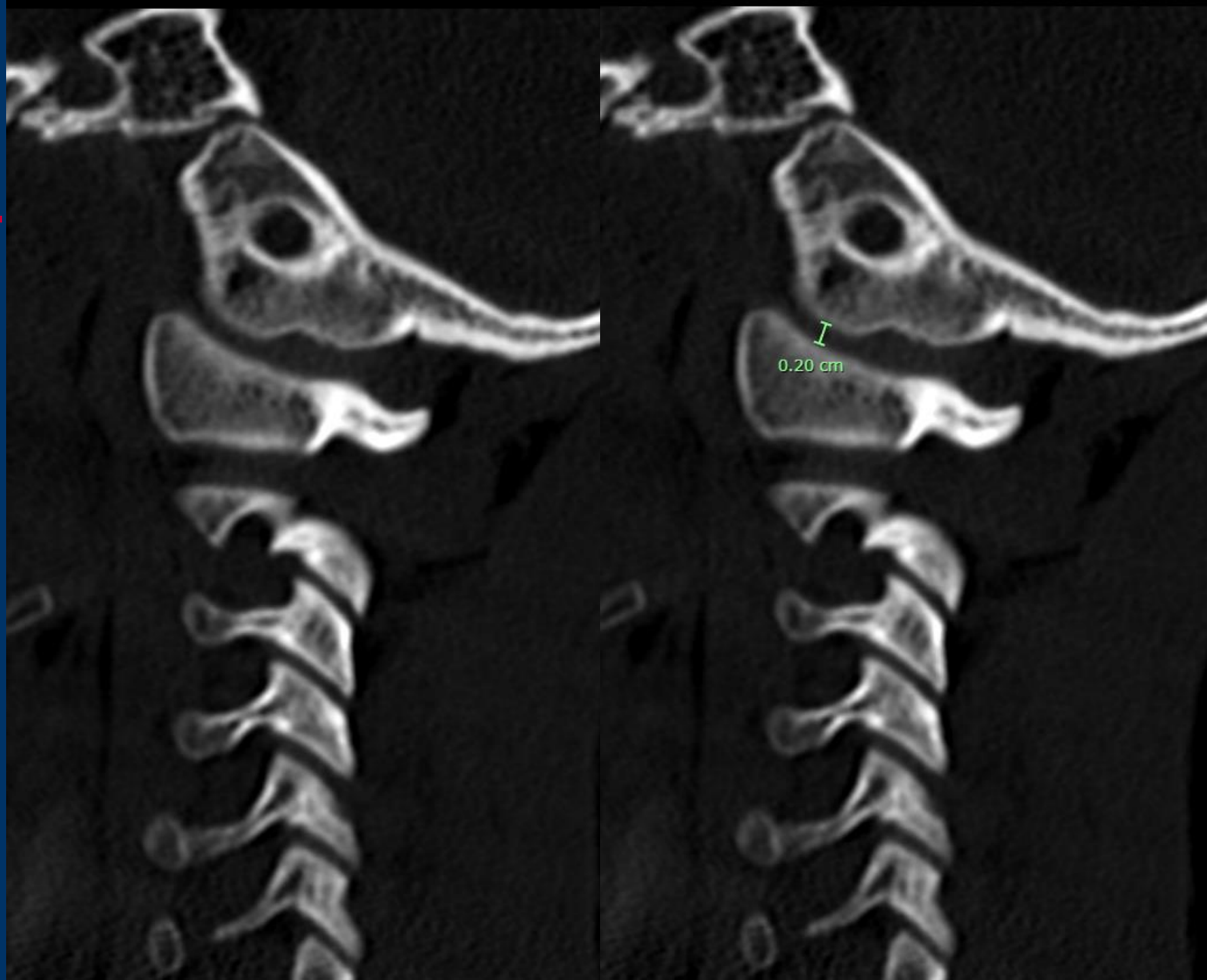
Atlanto-axial interval

<4 mm is normal

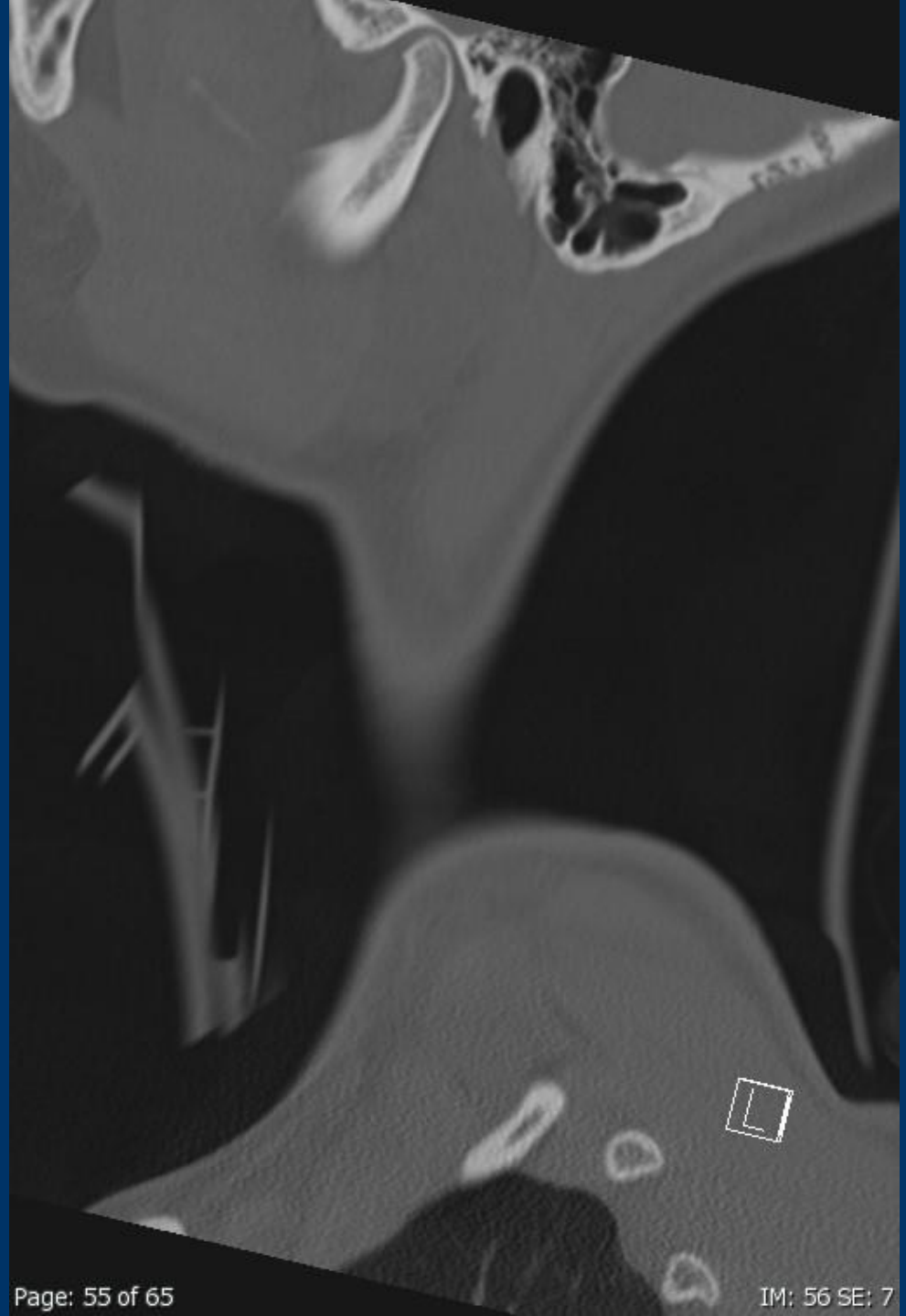
Occipital condyle C1 interval

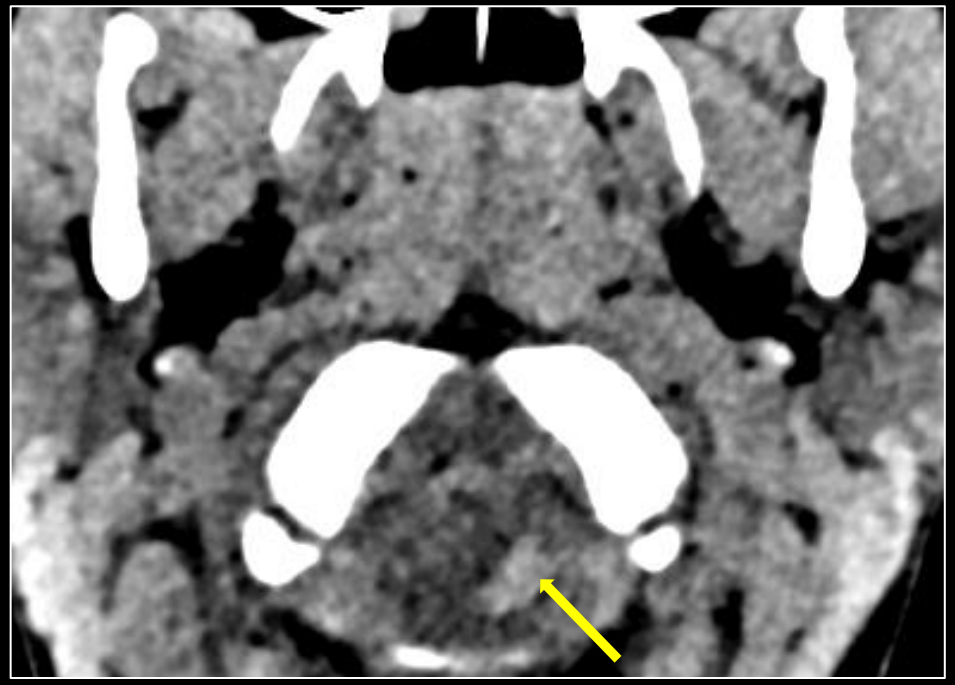
most sensitive and specific measurement for detecting atlanto-occipital dislocation

Less than 4mm is normal

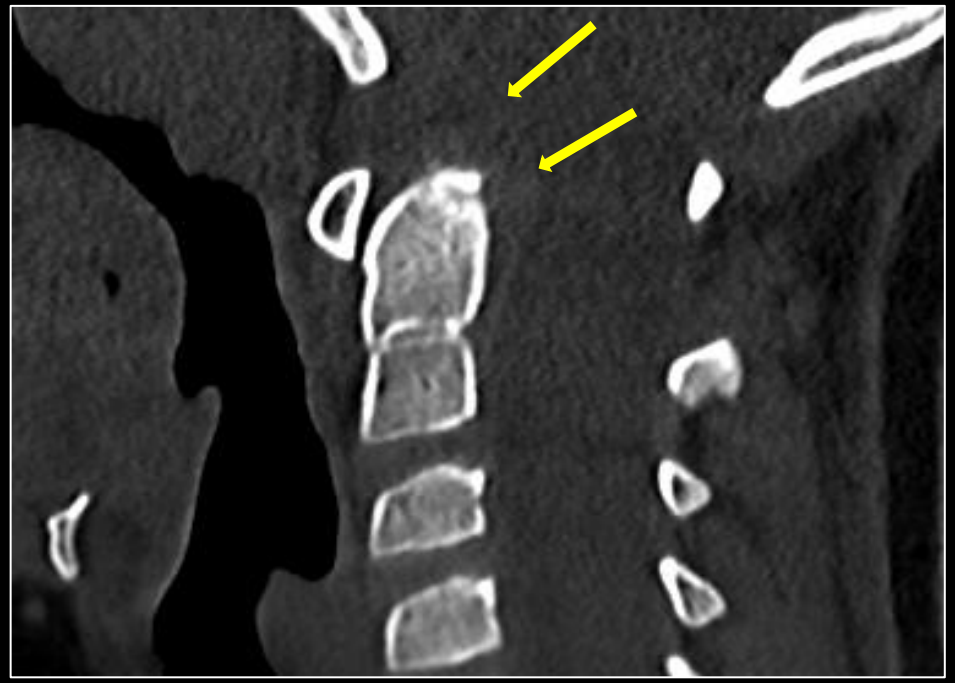


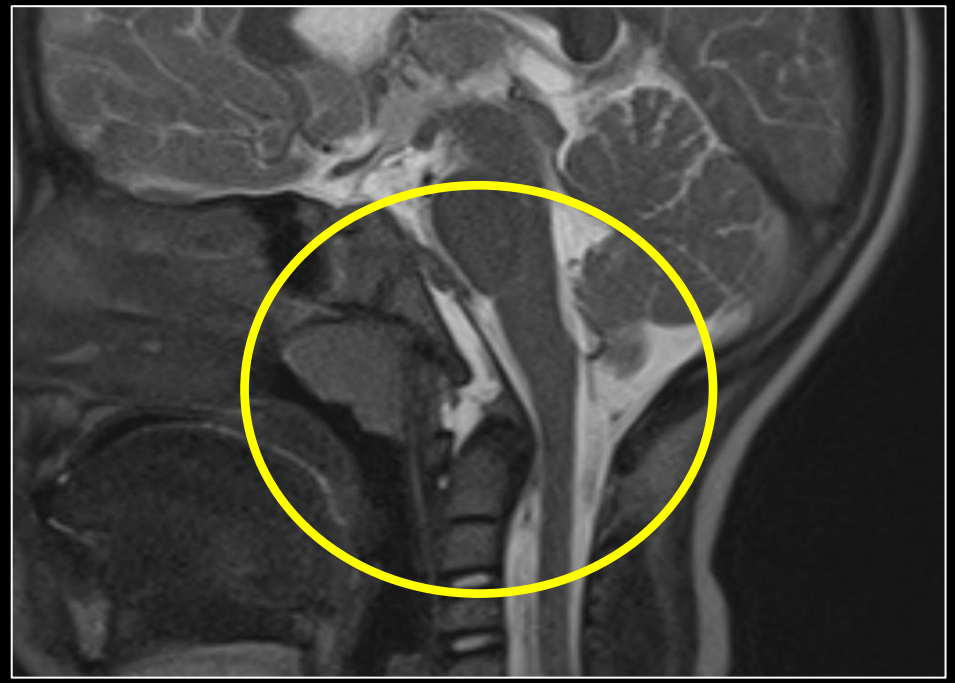
Normal CT



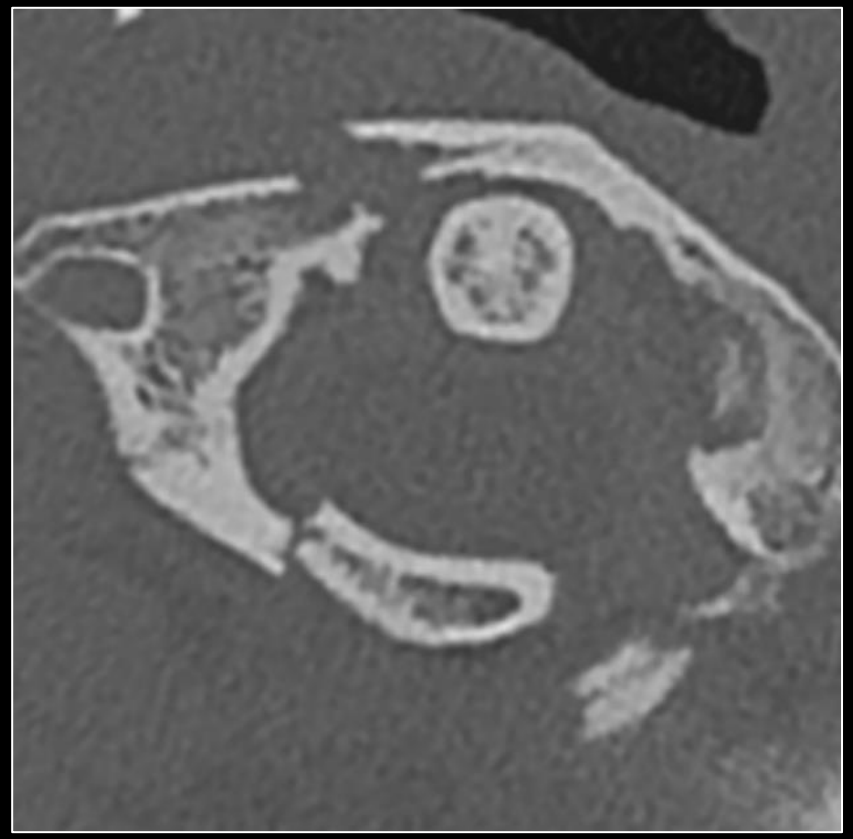


7yo
MVC

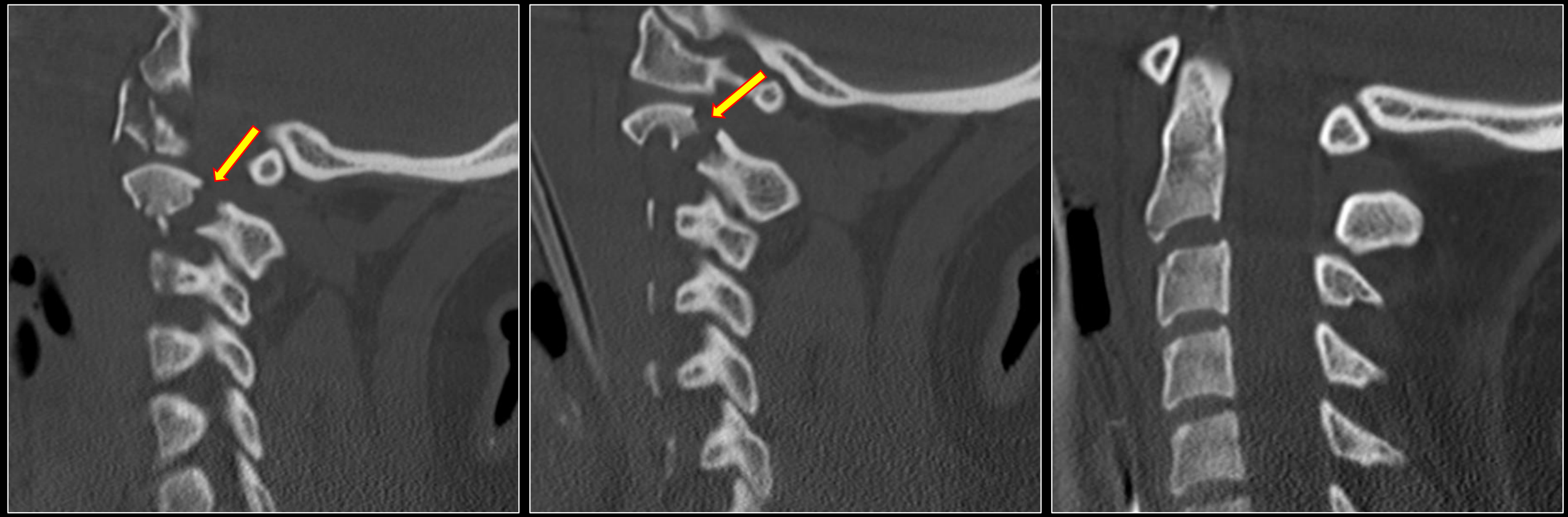


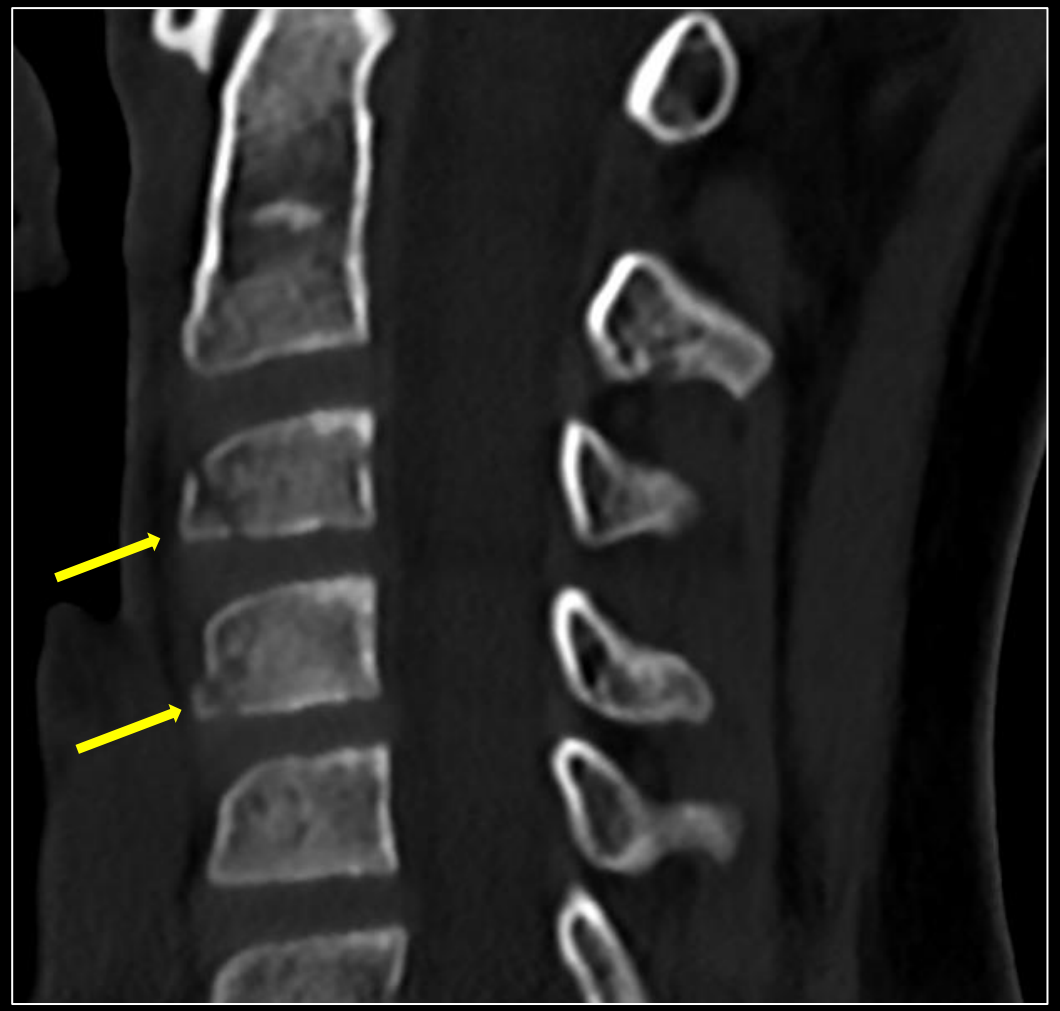


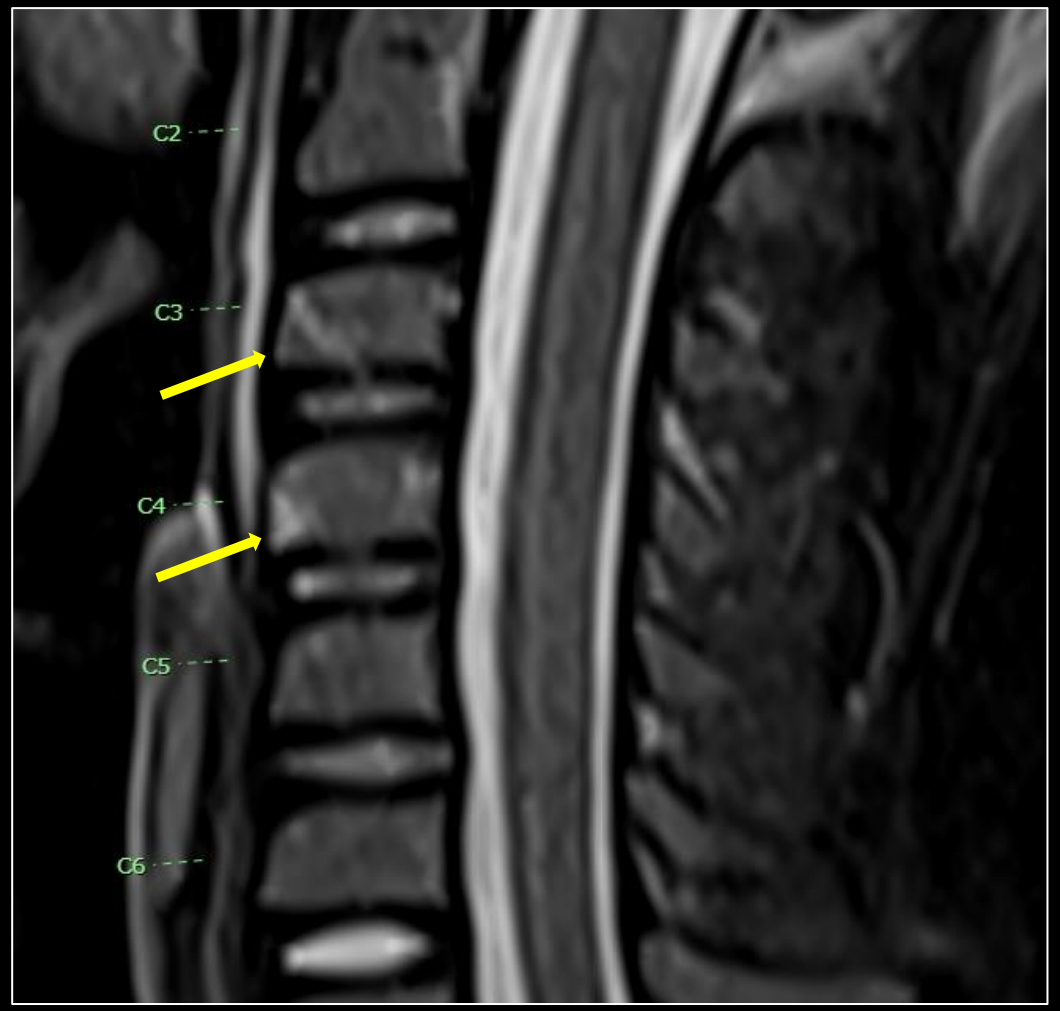
Jefferson fracture: Burst fracture of C1



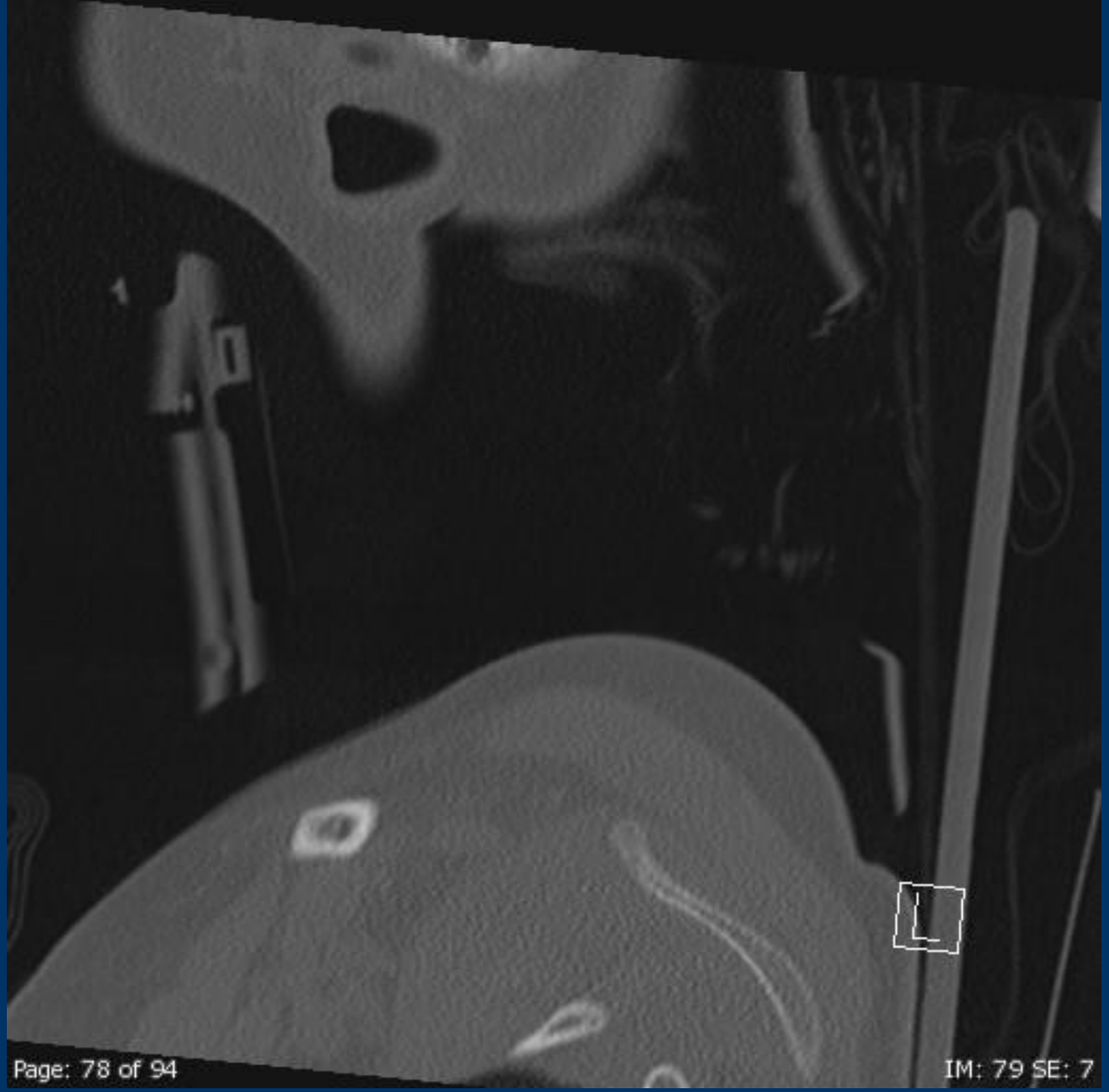
Hangman’s fracture







Flexion tear drop Injury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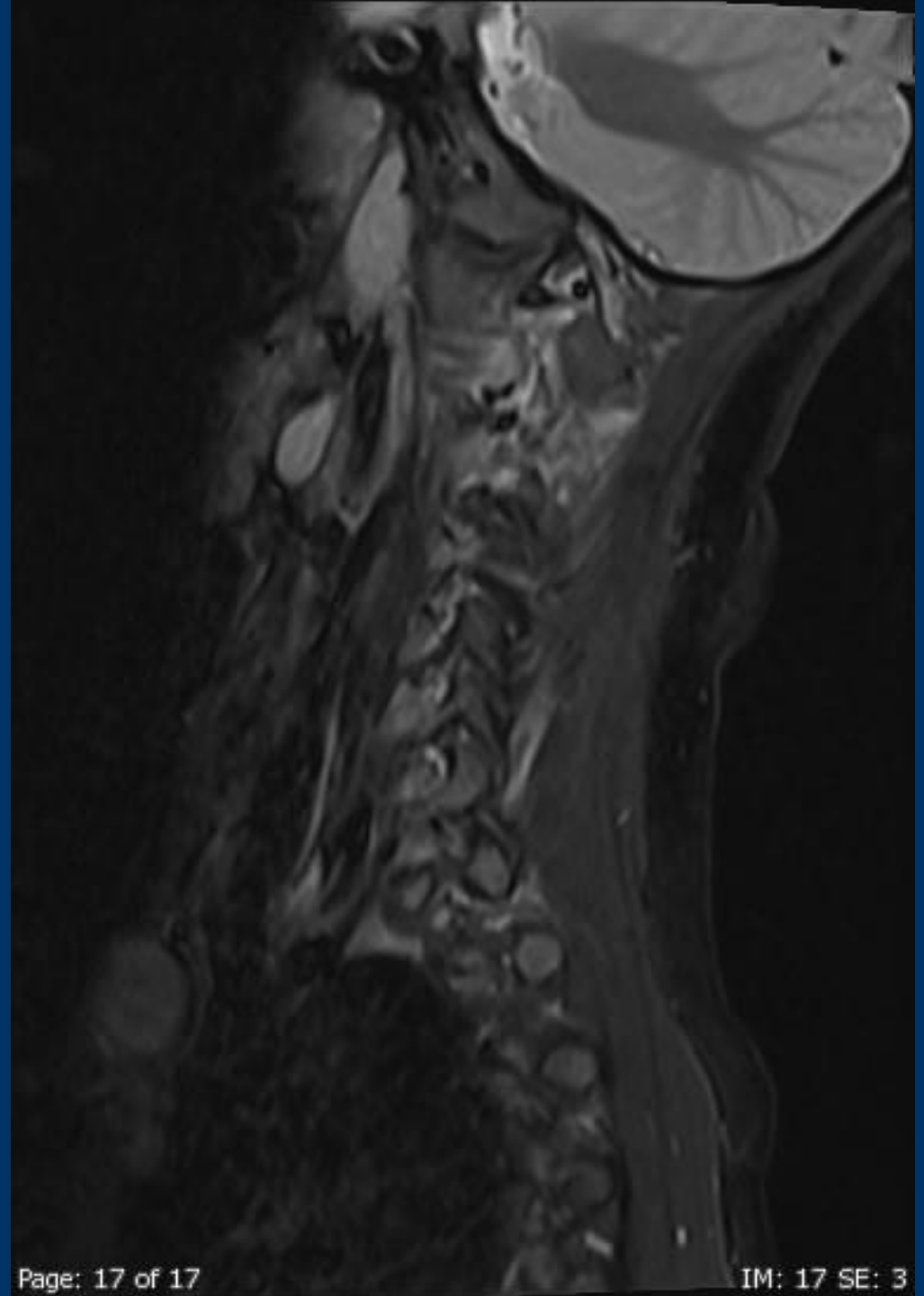
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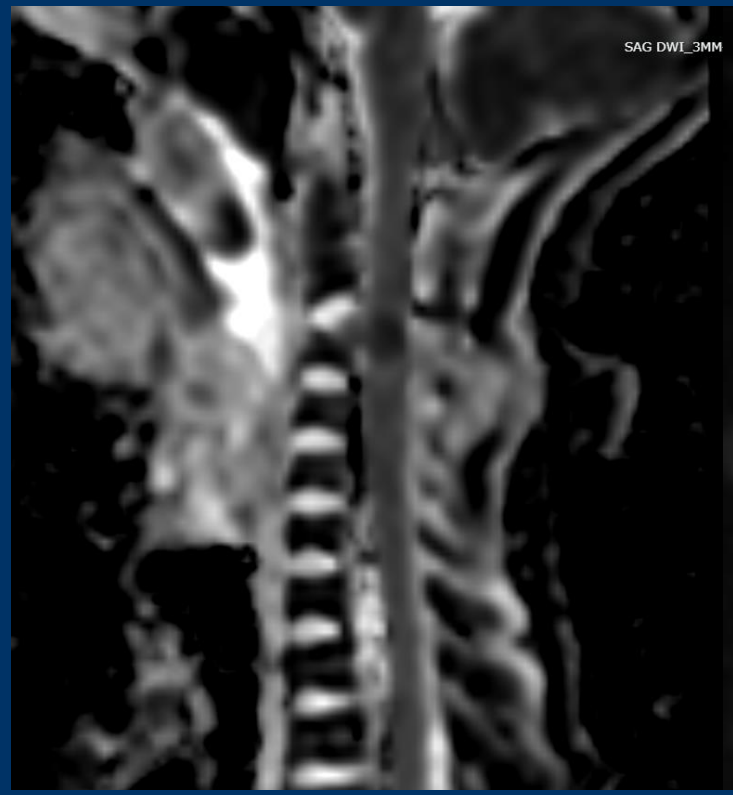
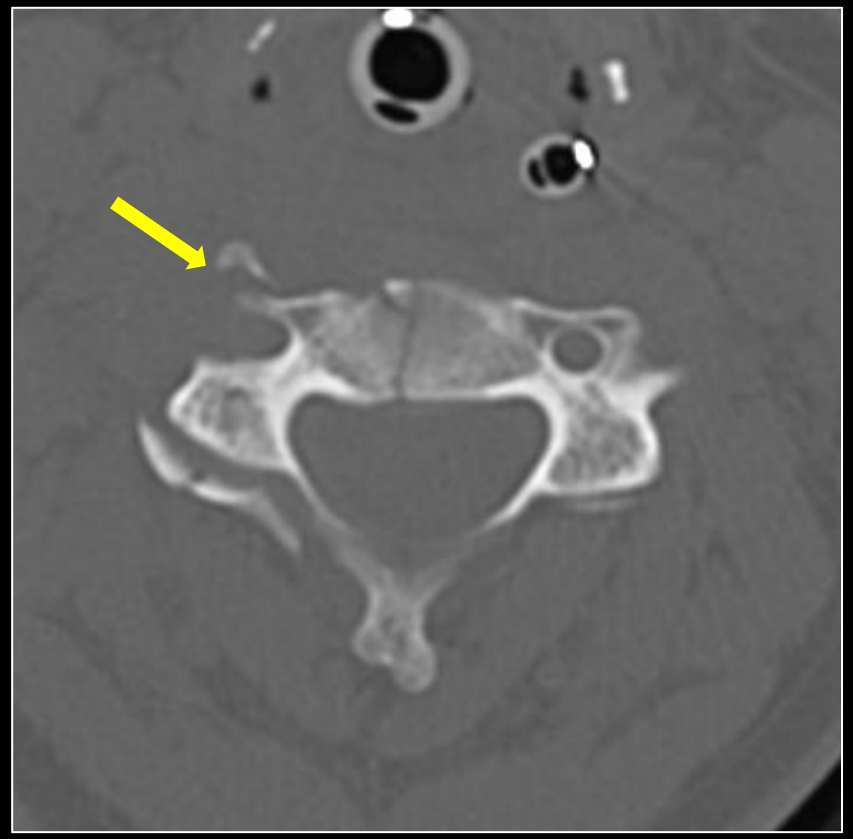

SAG DWI_3MM

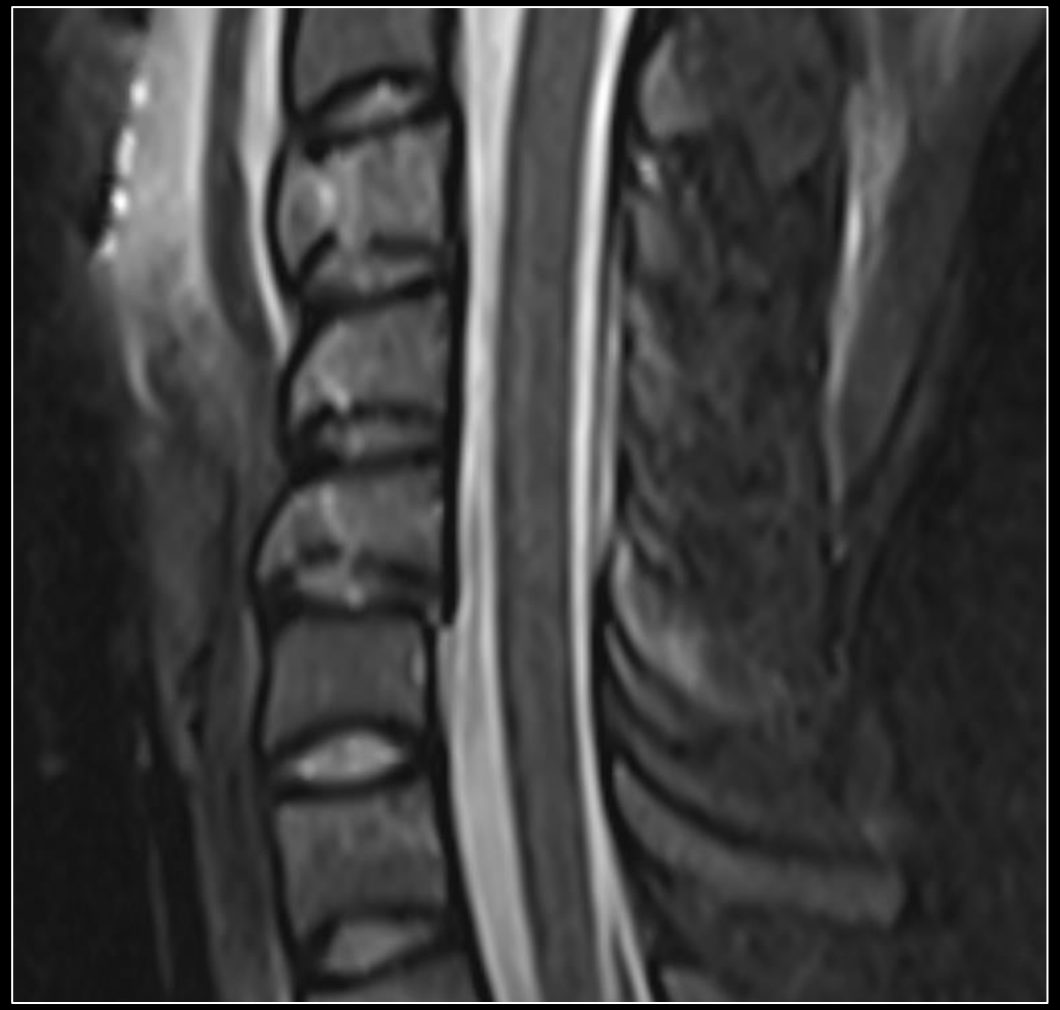

H

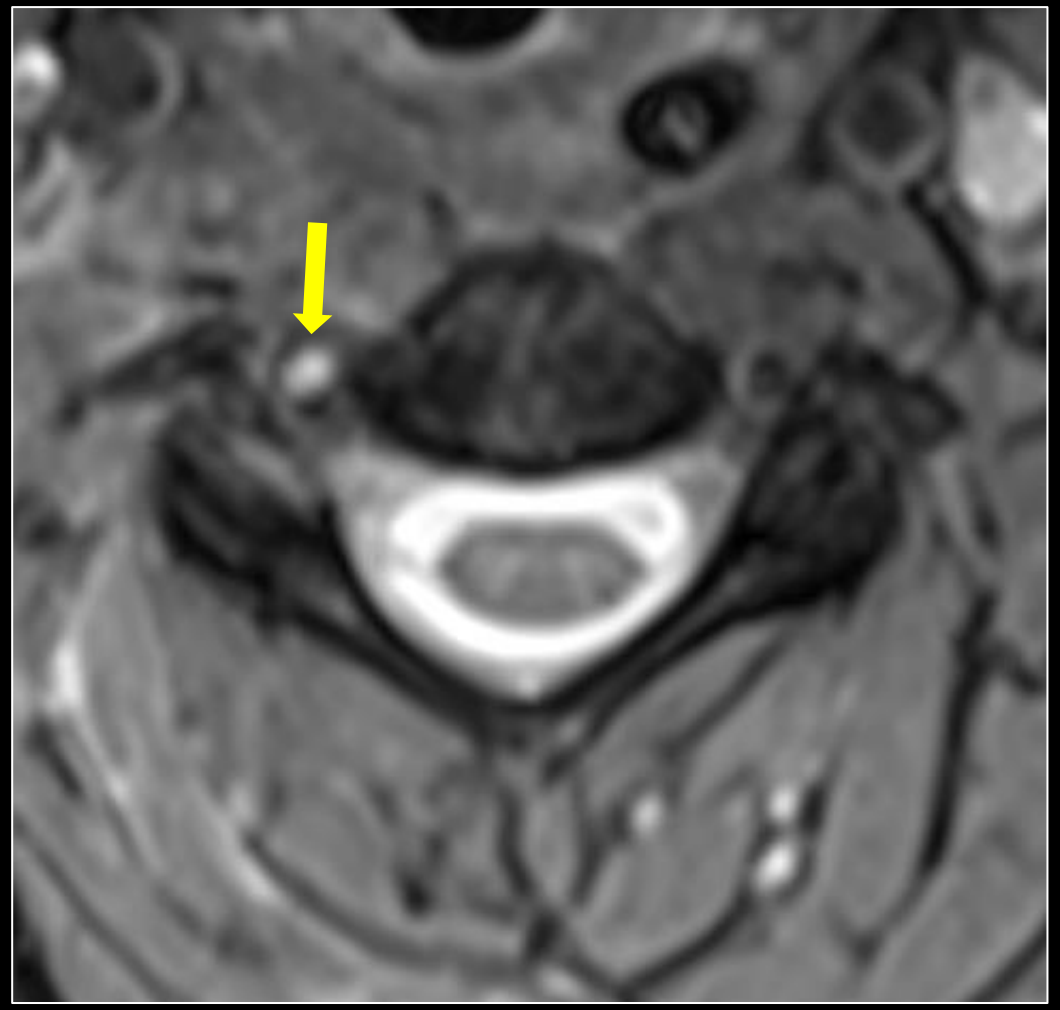
- Odontoid fracture in a 7 year old

Odontoid fracture in a 14-year-old

Vascular injury in an 18-year-old female

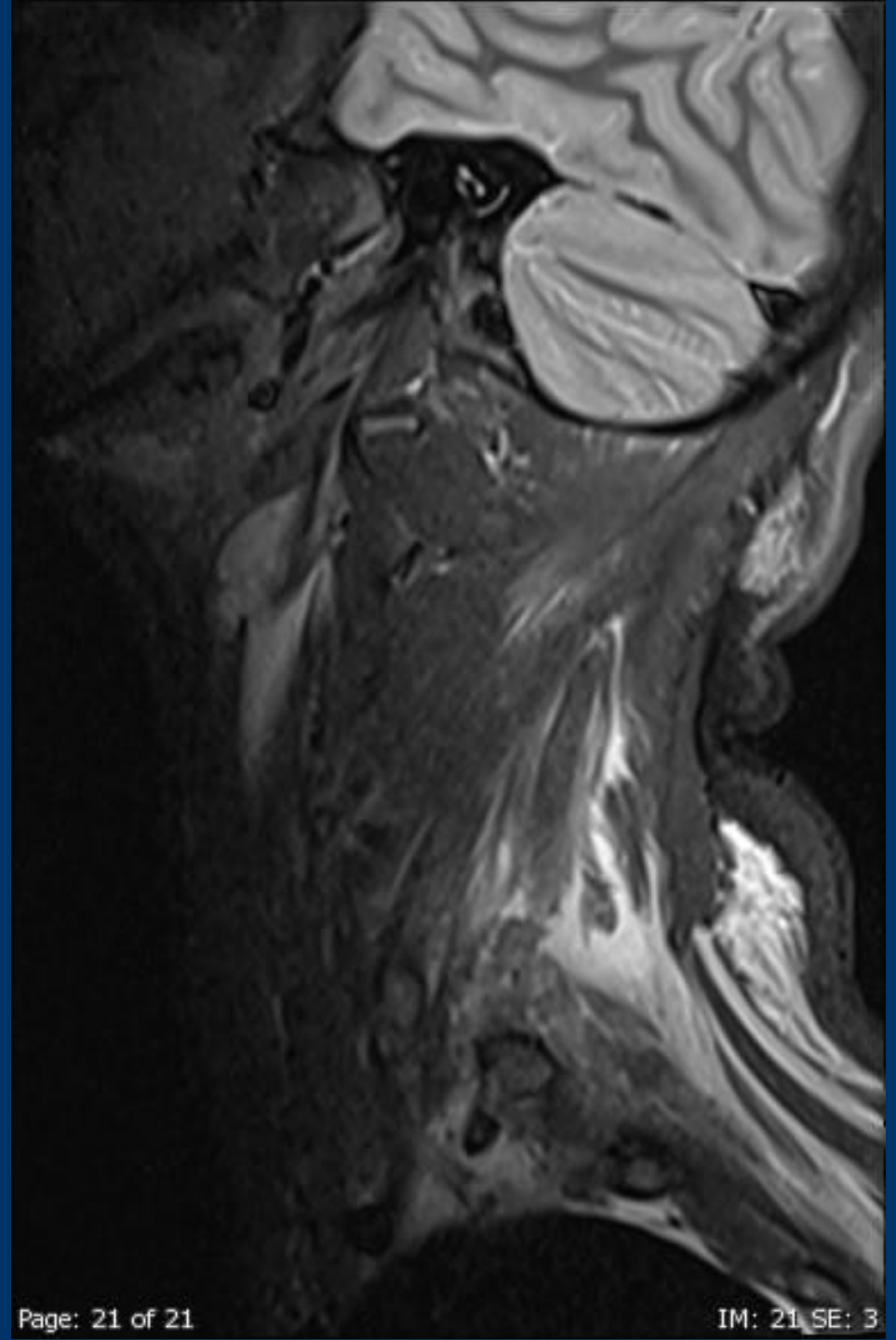






SCIWORA

- Spinal Cord Injury Without Radiographic Abnormality
- Clinical findings of cervical spinal cord injury with normal cervical spine radiographs and CT images
- SCIWORA is more common in pediatric patients.
- Responsible for 30%–40% of pediatric traumatic myelopathies
- There is normal spinal alignment with no identifiable fracture.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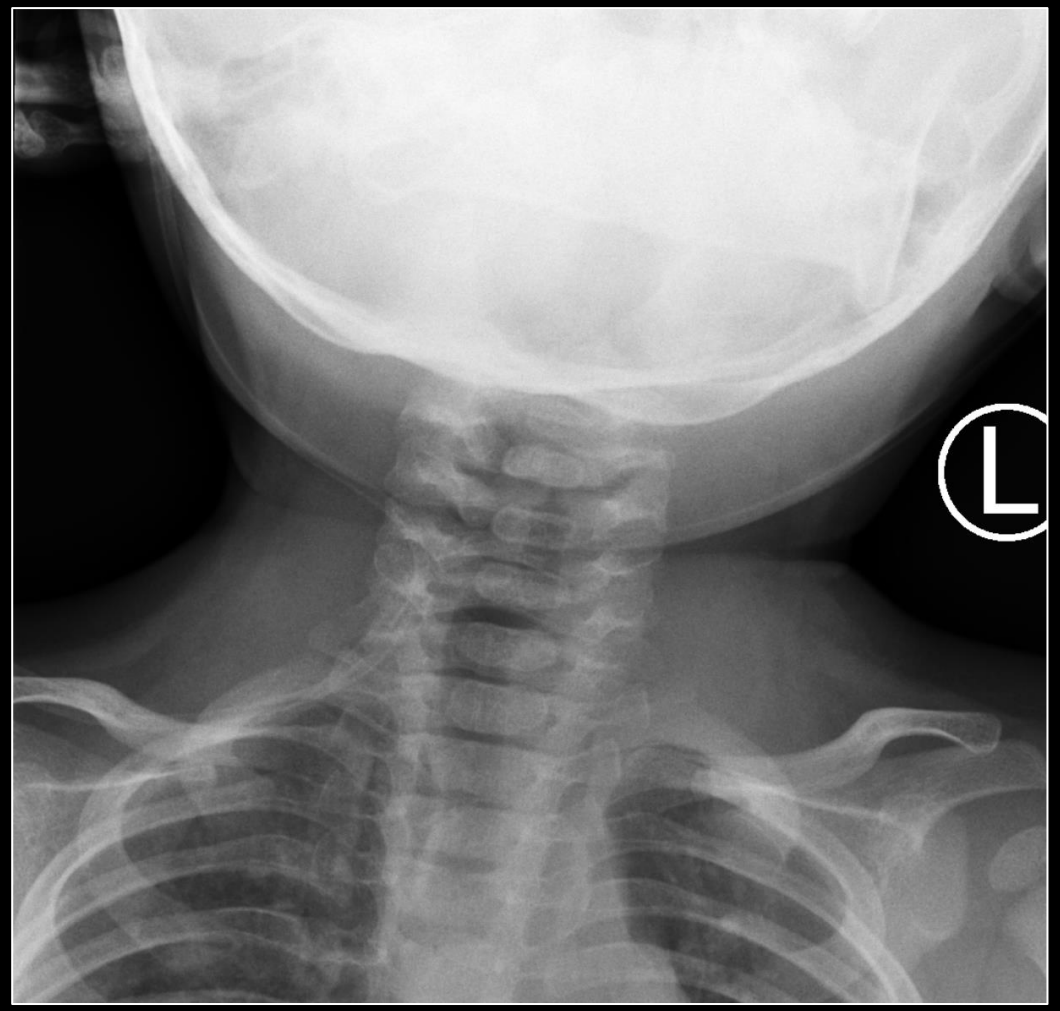
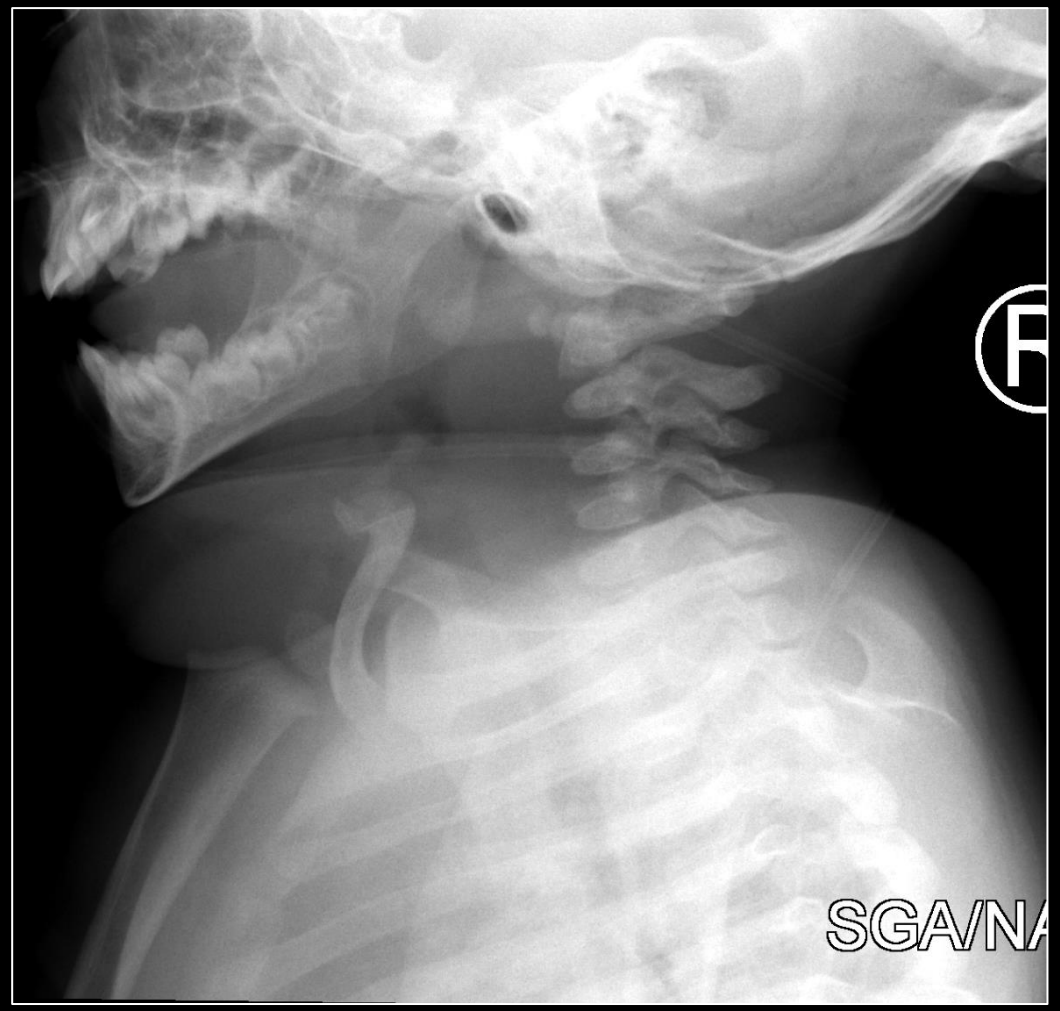
MRI

- The clinical significance of soft-tissue contusion, edema within the interspinous ligaments with intact anterior and middle pillars, or isolated disruption of the nuchal ligament is unknown.
- A normal MRI examination is useful to exclude the presence of significant CSI.

Imaging approach

- CT should be limited in children less than 10 years old due to increased sensitivity to radiation
- The use of MDCT in children under the age of 5 years has shown little clinical benefit
- MRI has been proven to be useful and cost-effective to clear the spine in patients who are not or will not be cleared within 72 hours


L

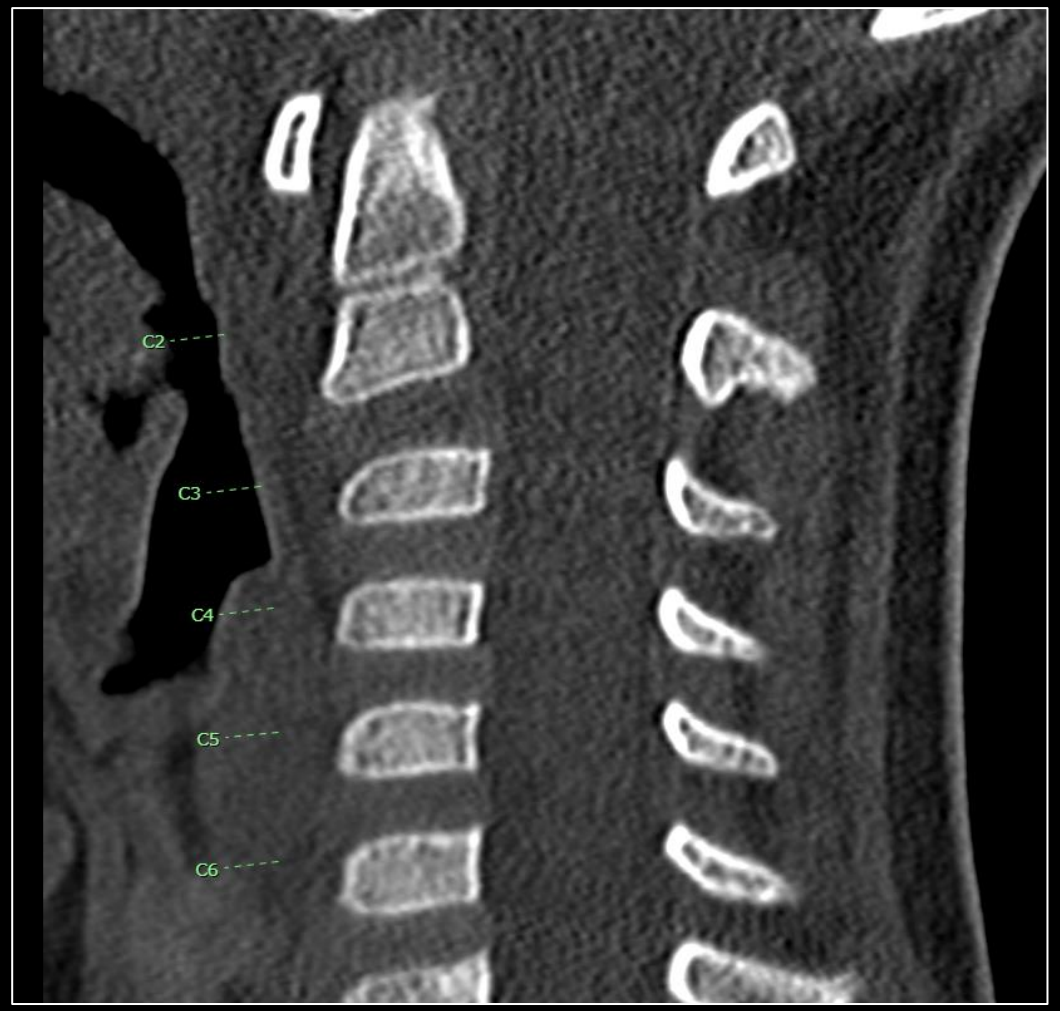

R
SGA/NA


L

Prevertebral Soft Tissues

In pediatric patients, widening of the prevertebral soft tissues can be a normal finding that is related to expiration.

When lateral radiography of the cervical spine in an infant with possible spinal injury shows wide prevertebral soft tissues, repeat lateral radiography in mild extension and in inspiration should be performed to determine if the apparent soft-tissue abnormality is real.


C2
C3
C4
C5
C6


C2


Thank
you!