Practices and Pitfalls in Pediatric Cervical Spine Trauma Imaging

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Purpose

This educational exhibit serves to demonstrate normal measurements in the skeletally immature cervical spine as a means to inform viewers of normal relationships, common injuries, and pitfalls.

Background

- Cervical spine trauma in children may present unique challenges for radiologists unfamiliar with pediatric anatomy.
- CT is primarily focused on osseous anatomy following cervical spine trauma.
- Children may be less likely to undergo CT due to:
  - Radiation exposure
  - Propensity for traumatic injuries to involve soft tissues and ligamentous structures
- Atlantoaxial injuries are more common in children; osseous injuries less commonly observed.

Educational Goals / Teaching Points

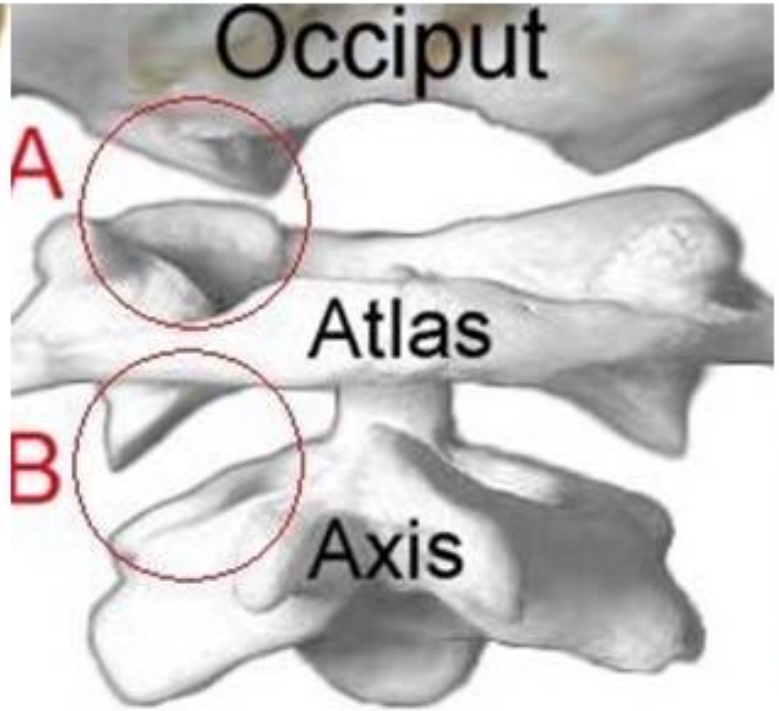
1. Normal relationships in the pediatric cervical spine are depicted including key anatomic landmarks.

2. Describe the Weisel-Rothman method for assessing craniocervical instability.

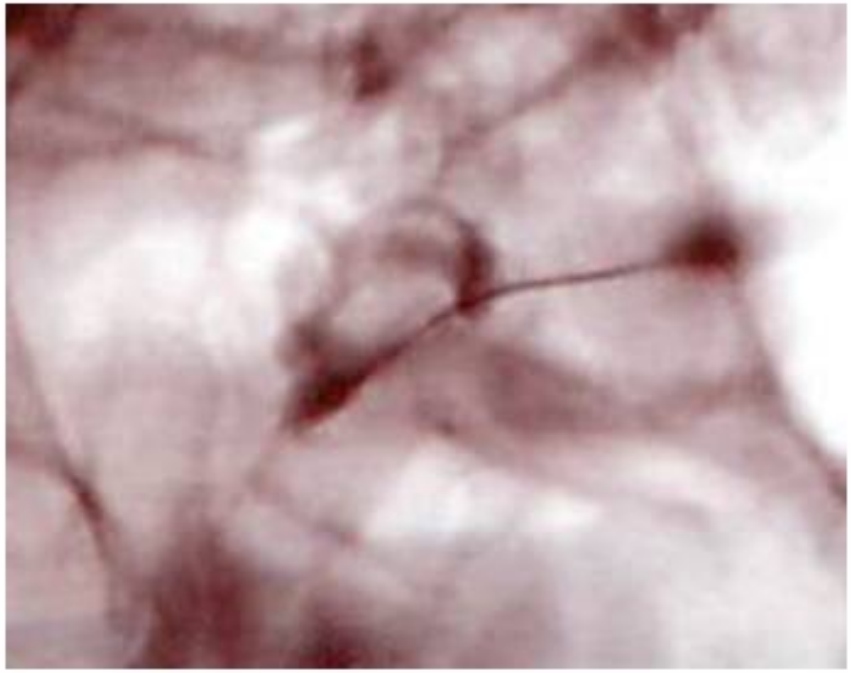
3. Abnormal imaging findings in injured children are highlighted.

4. The role of the Pediatric Emergency Care Applied Research Network (PECARN) is incorporated including the utility of MRI in pediatric cervical trauma.

Posterior View
Cervical Spine



A: Atlanto-Occipital Joint
B: Altanto –Axial Joint



X-ray image with needle in right atlanto-occipital joint which is outlined with contrast.

http://annabellelearnsortho.blogspot.com/2015/06/atlantoaxial-spine.html

What to order?

- CT of the cervical spine has largely fallen out of favor in pediatric facilities per the ACR Appropriateness Criteria®.
- Pieretti-Vanmarcke score (2-8 points) is used for children under 3.
- The ACR Appropriateness Criteria® refers to the PECARN or NEXUS criteria for guidance in children aged 3 to 16 years.
- Standard CT of the head and cervical spine for trauma should not be used by default in children.

Pediatric Emergency Care Applied Research Network (PECARN) Criteria

- Low risk criteria: ACR recommends no imaging.
- Radiography usually appropriate, CT may be appropriate if at least one criteria present.
- 8 factors associated with cervical spine injury: altered mental status, focal neurologic findings, neck pain, torticollis, substantial torso injury, conditions predisposing to cervical spine injury, diving, and high-risk motor vehicle crash. Having 1 or more factors was 98% (95% confidence interval 96% to 99%) sensitive and 26% (95% confidence interval 23% to 29%) specific for cervical spine injury.

Pieretti-Vanmarcke Score* Components

- GCS < 14 — 3 points
- GCS_{EYE} = 1 — 2 points
- Motor Vehicle Accident — 2 points
- Age 24-36 months — 1 point

*Less than 2 points total = 99.93% NPV

Cervical Spine Radiography in Children

- Flexion-extension views used to assess craniocervical instability.
- While largely supplanted by MRI in children with trauma, flexion-extension radiography (or "Davis series") is variably used to assess the craniocervical junction in children with Trisomy 21 prior to physical activity (e.g. Special Olympics).
- Assess predental space and spondylolisthesis on multiple radiographs.
  - Alternative: "Method of Weisel-Rothman"

Normal Relationships, Radiography

- Condylar gap: < 0.5 cm
- Powers ratio: < 1
- Predental interval: < 0.5 cm in ≤ 8 yo and < 0.3 cm in > 8 yo
- Basion axial interval: 1.2 cm anterior to 0.4 cm posterior
- Basion dens interval: < 1.2 cm
- C1–C2 interspinous distance: < 1.2 cm

Powers Ratio: (A-B)/(C-D)

- basion (A) and the posterior spinolaminar line of the atlas (B)

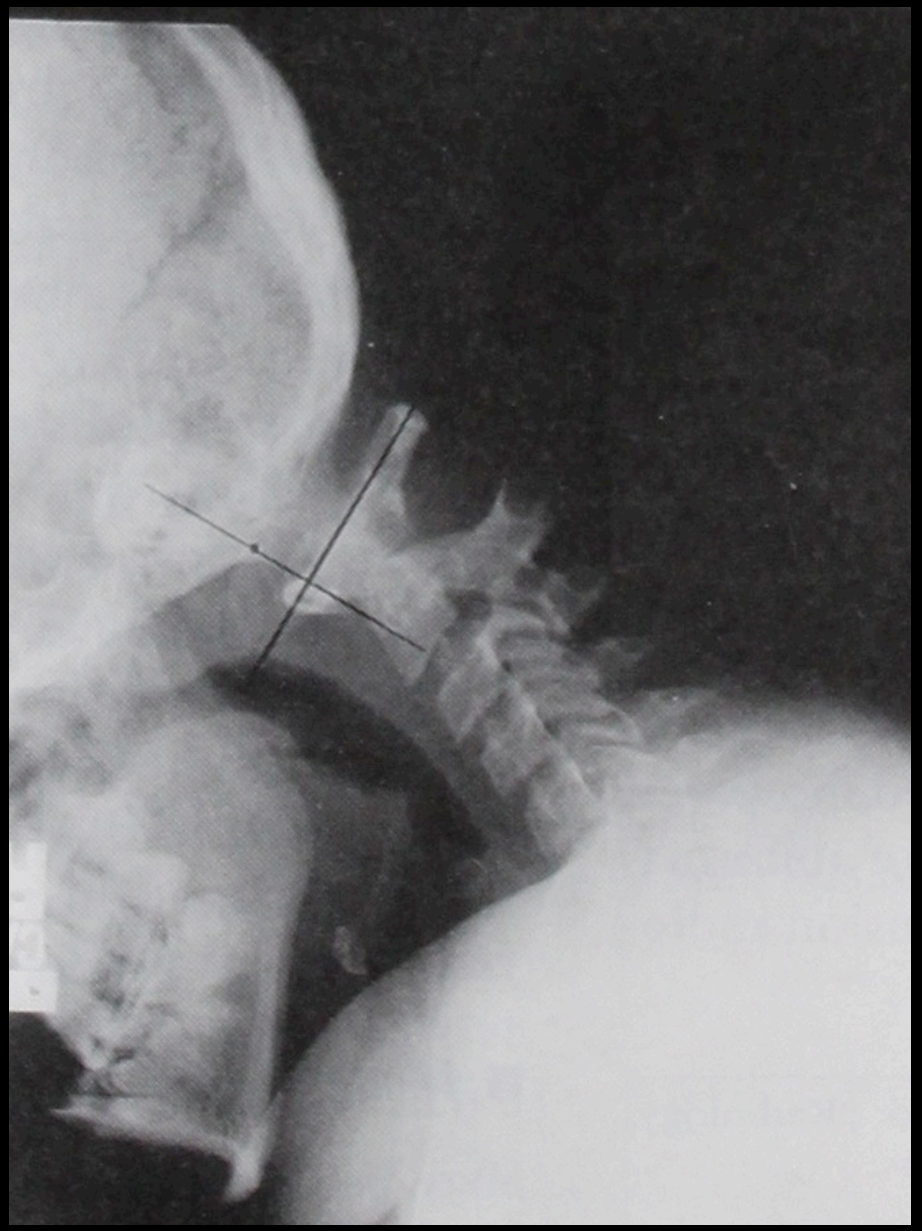
- opisthion (C) and the anterior arch of the atlas (D)

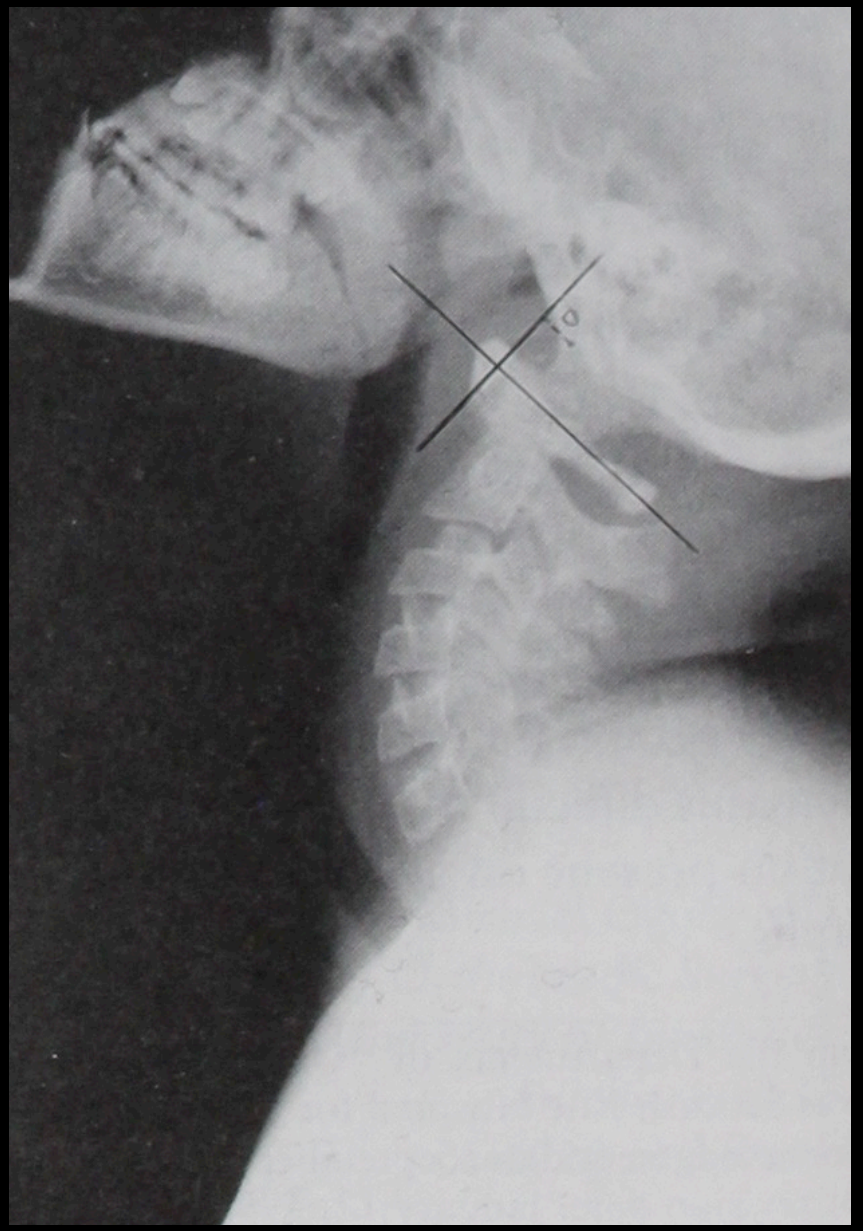
Basion-axial interval (BAI)

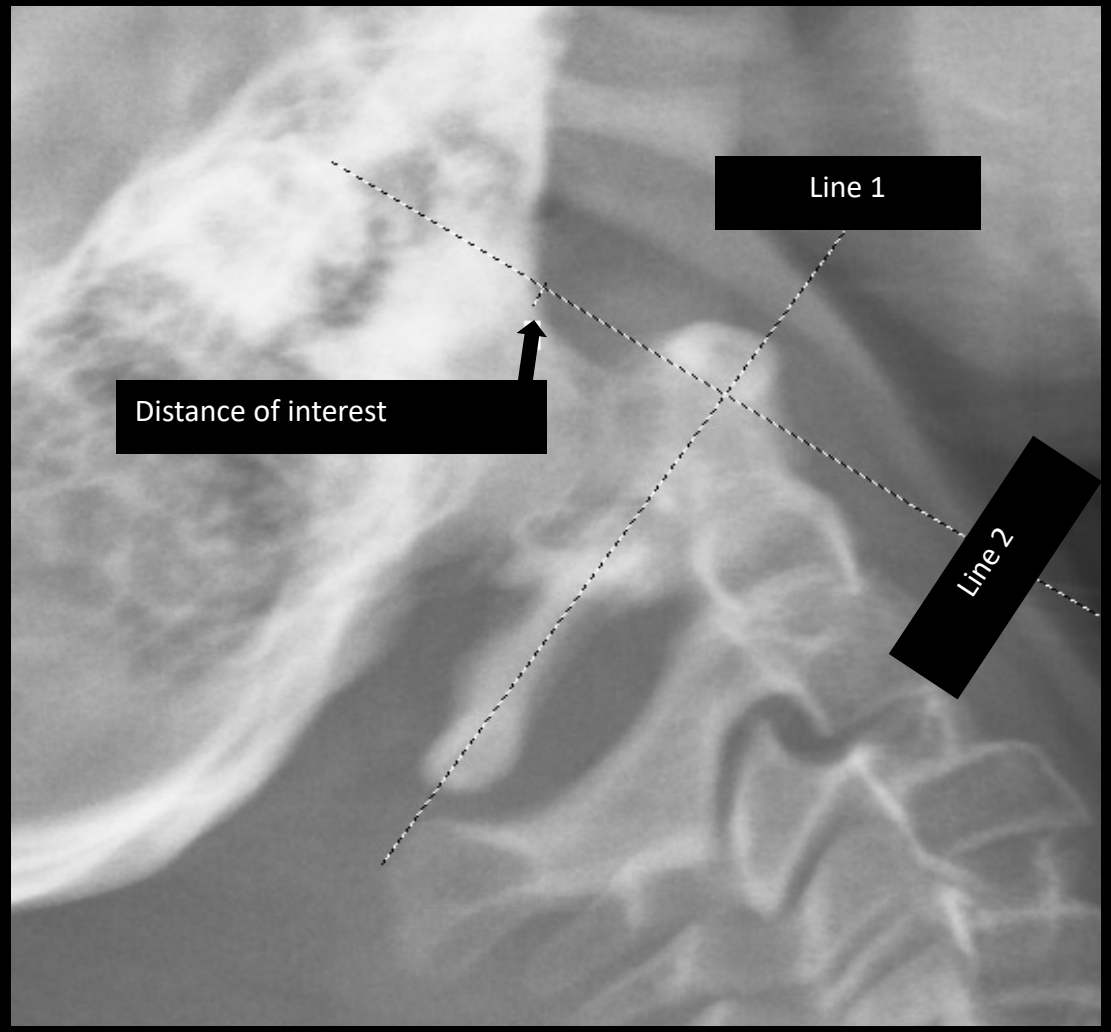
- Basion-axial interval (BAI)
  - Distance between basion and line drawn along posterior edge of the vertebral body of the axis

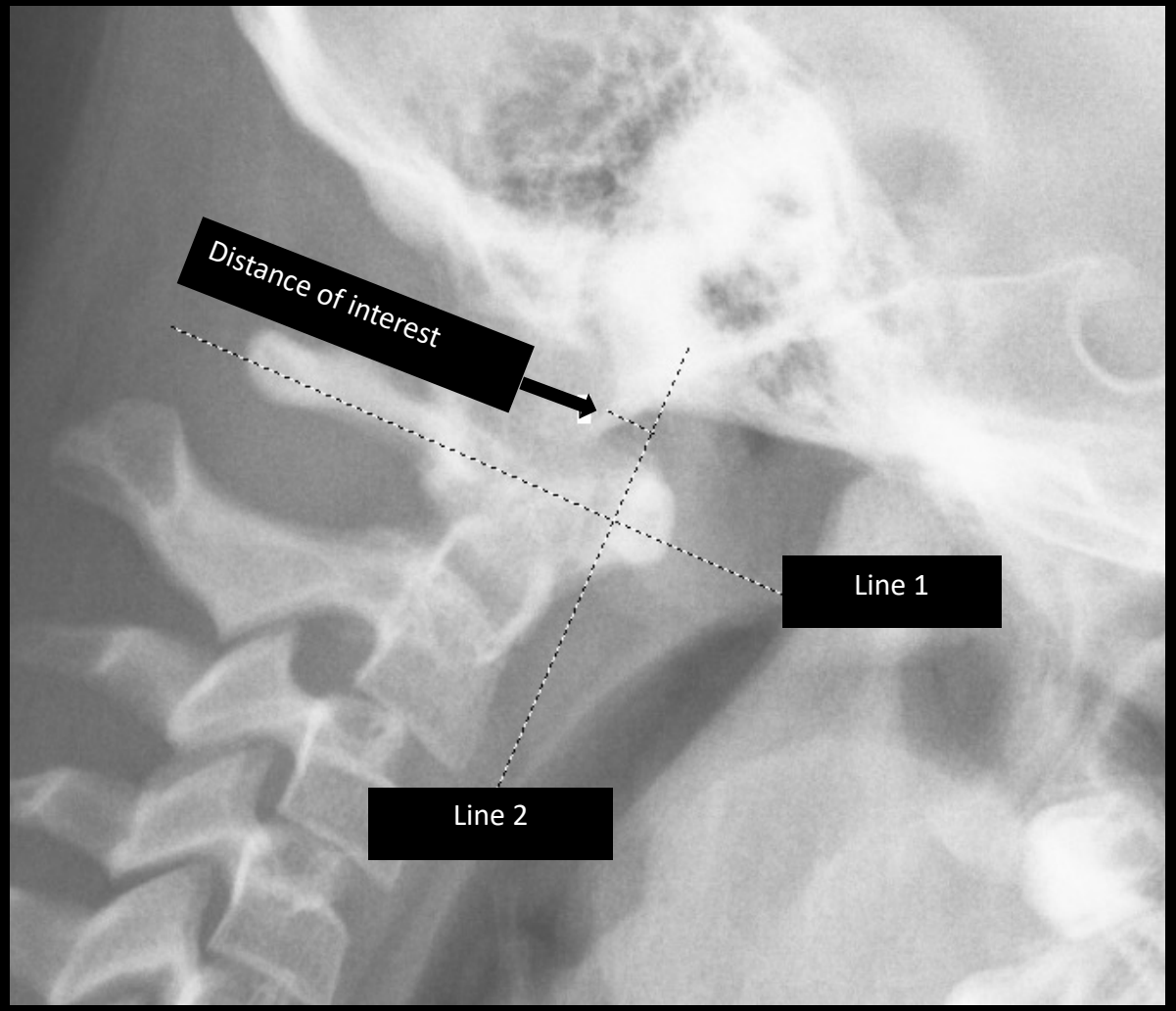
Wiesel-Rothman Technique

- Translational motion measured between occiput and C1 in flexion/extension radiographs
- Line drawn from most posterior point of the posterior arch of the atlas to the center of the anterior arch
- Line perpendicular to this line is constructed at the posterior edge of the anterior arch of the atlas
- Distance in mm between this line and the basion is measured
- Difference in this distance between flexion and extension is a quantification of occipitoatlantal instability
- Normal <1 mm in healthy ADULTS
- Trisomy 21 pts average 2.62 +/- 1.94 mm









Extension and flexion cervical spine radiographs in an 8-year-old female with trisomy 21.

Pitfalls of Wiesel-Rothman Technique

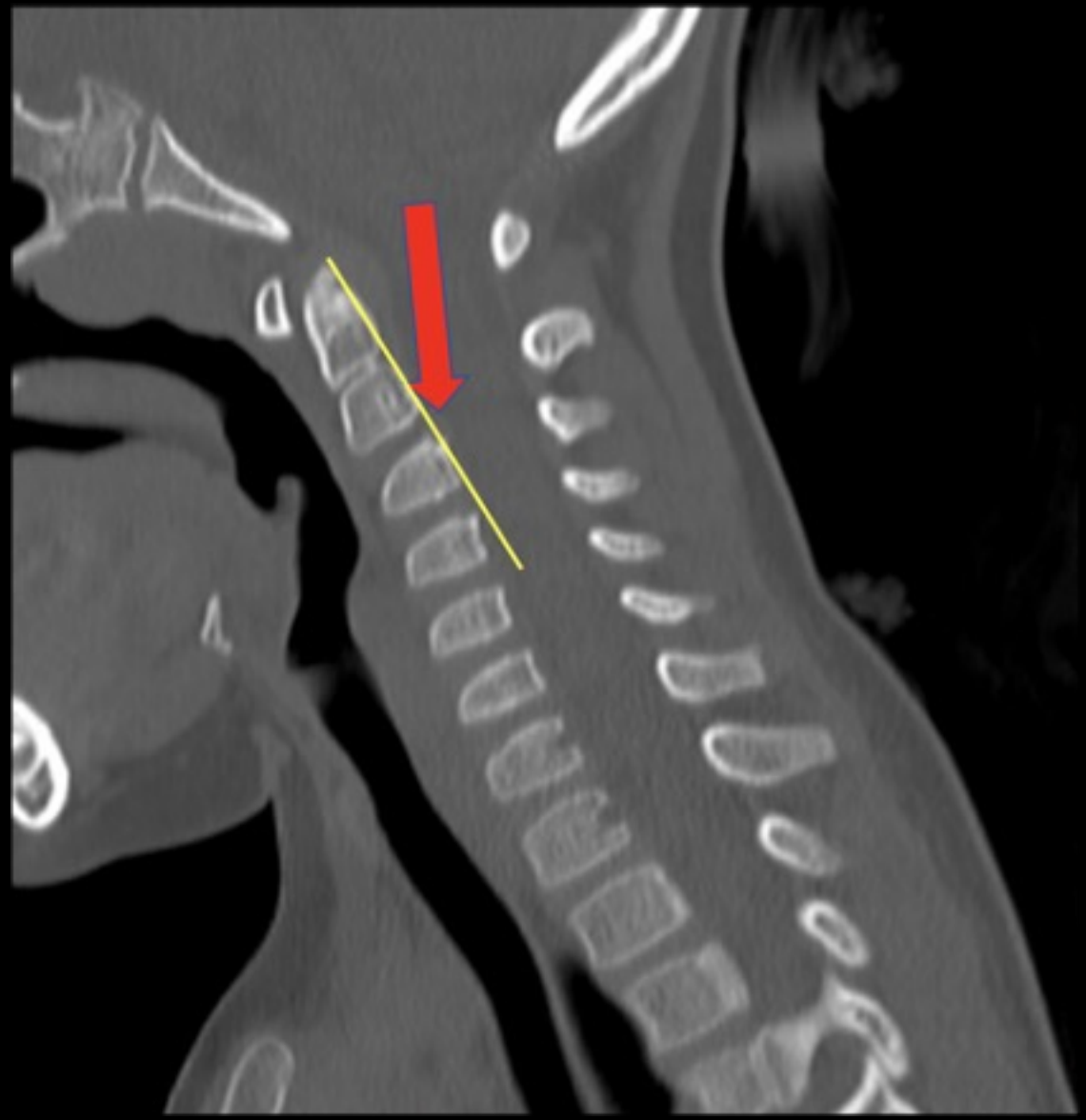
- It remains difficult to quantitate the amount of abnormal motion (dynamic) present on a static radiograph
- Magnification error (direct measurement)
  - Target to film distance variable
- Variability in establishing line connecting anterior and posterior arches of the atlas
  - Introduces discrepancies measured between perpendicular of this line and basion
- Atlas bone often distorted in Trisomy 21 population
  - Distortion of bony landmarks

Normal Relationships, CT

- Powers ratio: < 0.9
- Atlantooccipital interval: < 2.5 mm
- Atlantodental interval: < 2.6 mm
- Atlantoaxial interval: < 3.9 mm
- Basion dens interval
  - With ossification: < 9.5 mm
  - Without ossification: < 11.6 mm

Pseudosubluxation

- Minimal anterior translation of C2 over C3 in the young child
- Typically 2 mm or less
- 3-year-old female depicted here
  - Note: C2 line (yellow) contacts the posterior superior endplate of C3, but does not intersect it



Atlanto-occipital Interval (Normal < 2.5 mm)

Atlanto-occipital injury in a 4-year-old male

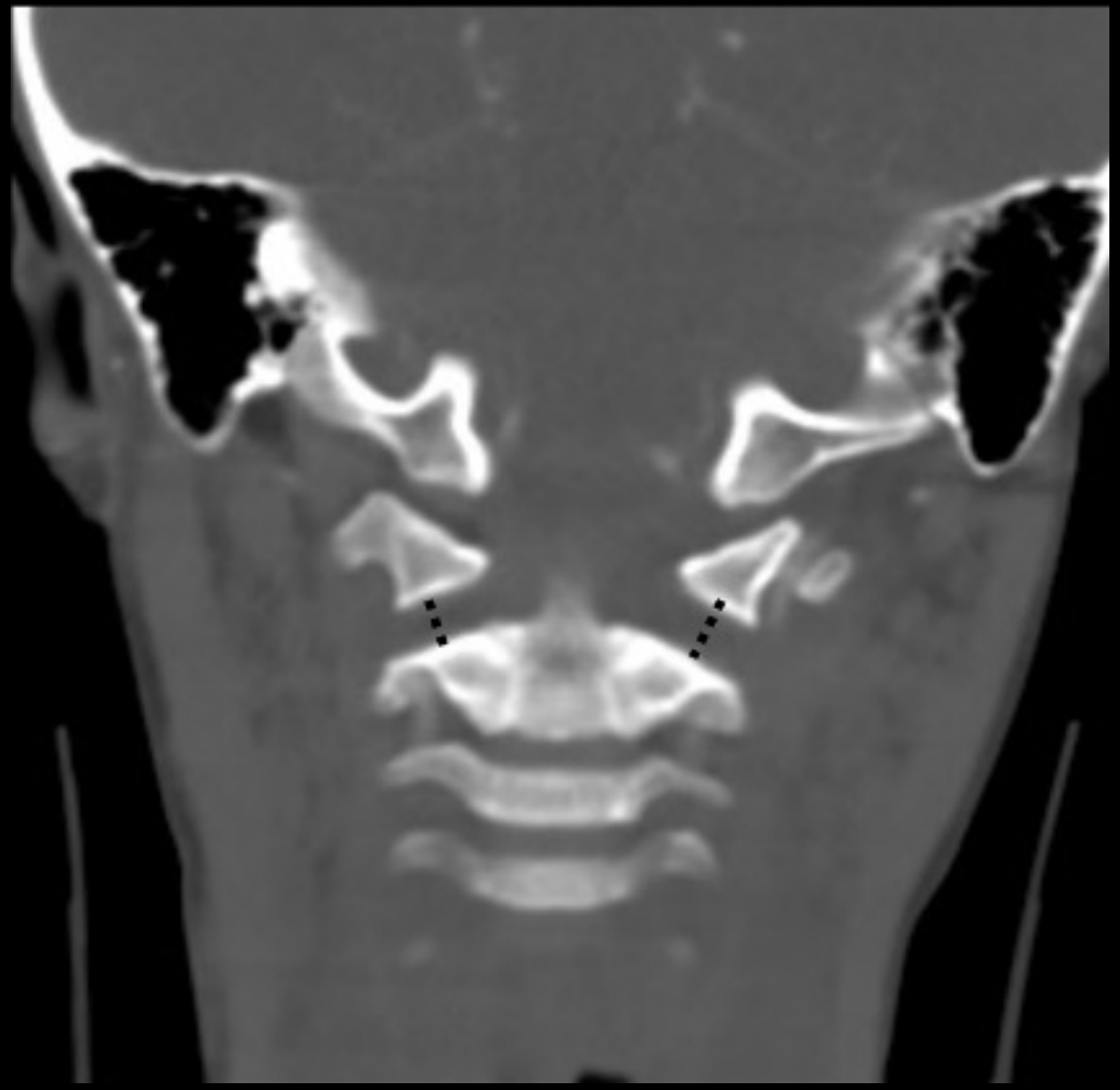
- Abnormal atlanto-occipital interval of 4.8 mm on the right (dotted line)
- Normal atlanto-occipital interval of 2.2 mm shown on the left for comparison

Atlanto-occipital Interval (Normal < 3.9 mm)

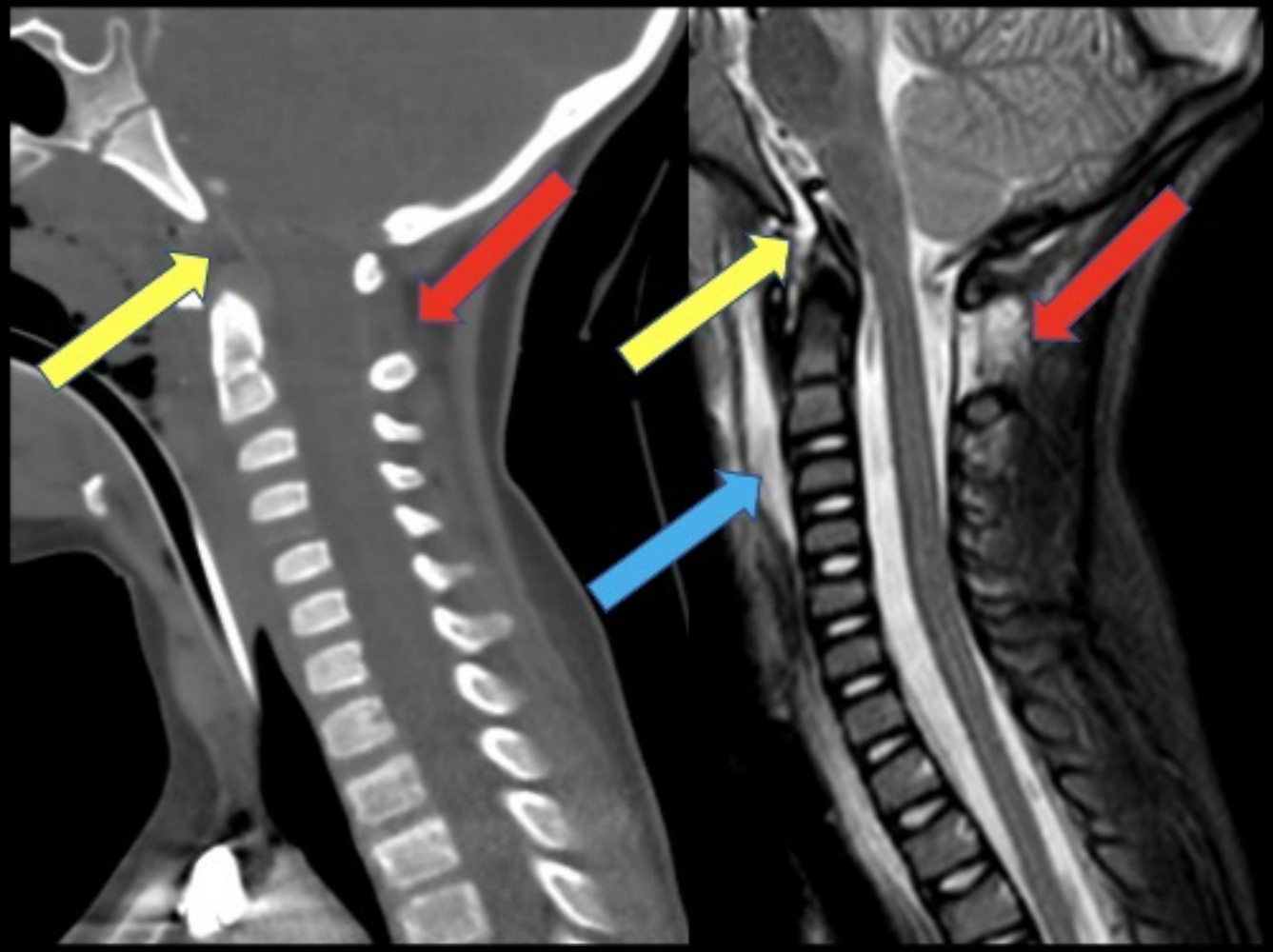
Left greater than right atlantoaxial injuries in a 4-year-old female

- Abnormal atlantoaxial interval of 4.9 mm on the right (dotted line)

- Abnormal atlantoaxial interval of 5.9 mm on the left



Utility of MRI as a Supplement to CT

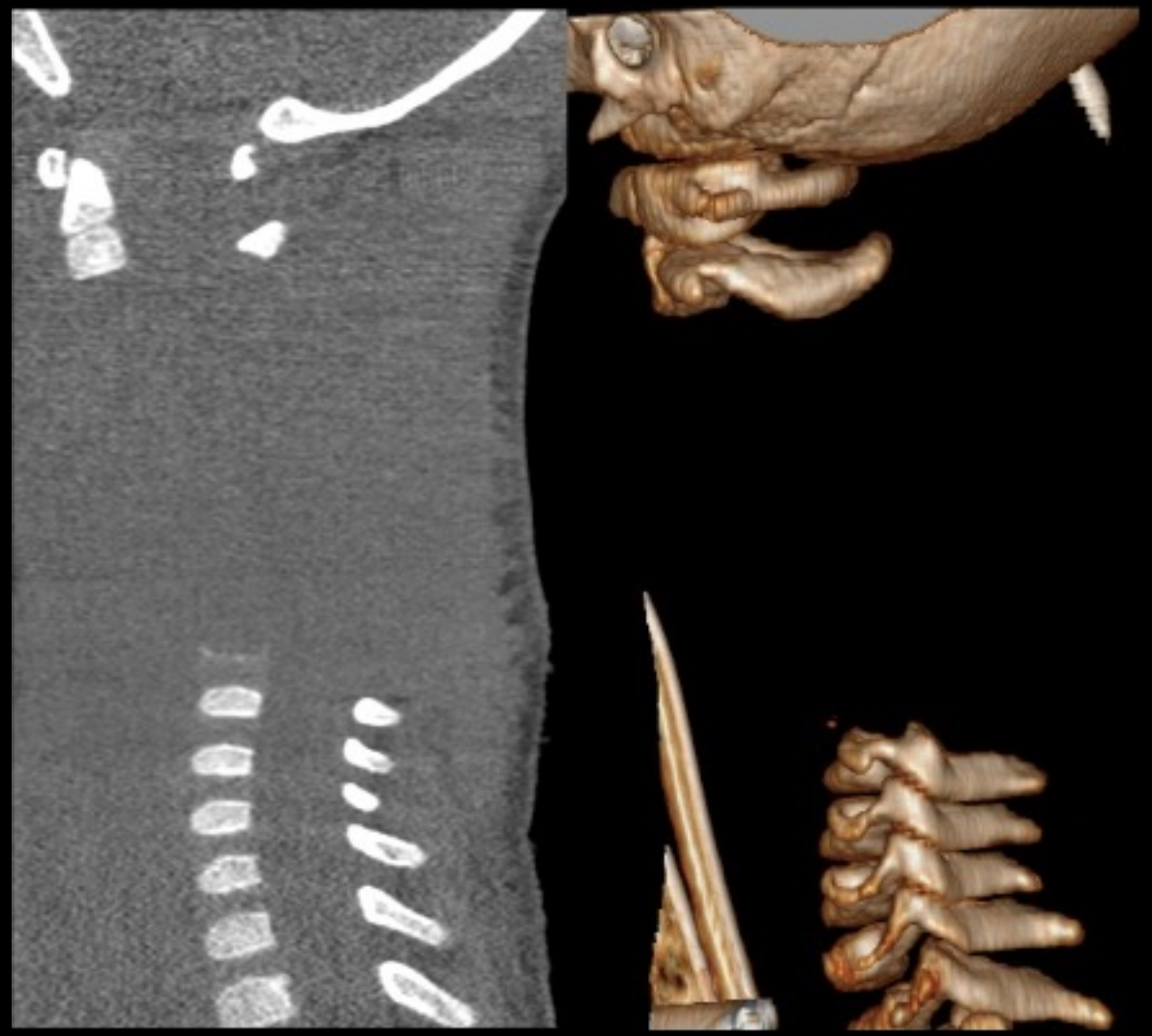


- Widened C1-C2 interspinous space on CT (left, red arrow) with confirmatory ligamentous injury on MRI (right)
- Increased T2 signal in the basion-dens interval on MRI with widening seen on CT (normal <11.6, yellow)
- Also note prevertebral edema better depicted on MRI (blue)

Vertebral Fracture/Dissociation

- Shown here is a 2-year-old female with a severe spinal fracture-dislocation that was ultimately fatal.

- Marked separation of the C2 vertebral body with severe distraction of the fracture fragments.



Conclusion

- The skeletally immature pediatric spine presents challenges to the radiologist unfamiliar with normal craniocervical relationships in children.

- Understanding normal and abnormal cervical spine anatomy and pathology in children is crucial in recognizing injuries.

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