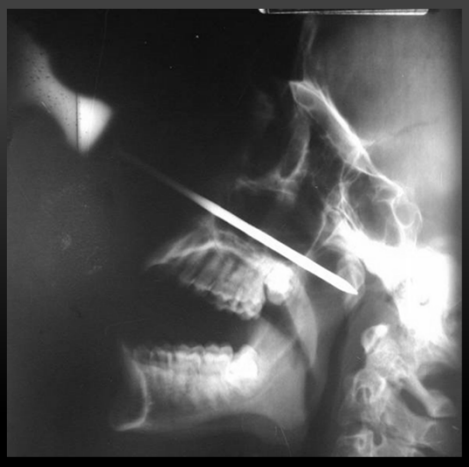
Imaging Head and Face Injuries



Chad D. Warshel, DC, MS, DACBR

1

Basics of Head Imaging

- Conventional radiographs
- CT
- MRI
- Ultrasound
- PET

2

Conventional Radiographs

- Limited applications in neuroradiology
  - Screening for orbital metal before MRI
    - Waters view of the skull
  - Imaging of facial trauma
    - Only good for gross fractures
    - And if there are fractures, CT follow up

3

4

CT w/o Contrast

- Limited list drawn from ACR (American College of Radiology) Criteria
  - Acute head trauma
  - Ischemic stroke
  - Suspected intracranial hemorrhage
    - thunderclap headache from subarachnoid hemorrhage
  - Fractures of skull or face
  - Identification of intracranial calcifications
  - Spinal trauma
  - Temporal bone abnormalities
  - When MRI is contraindicated

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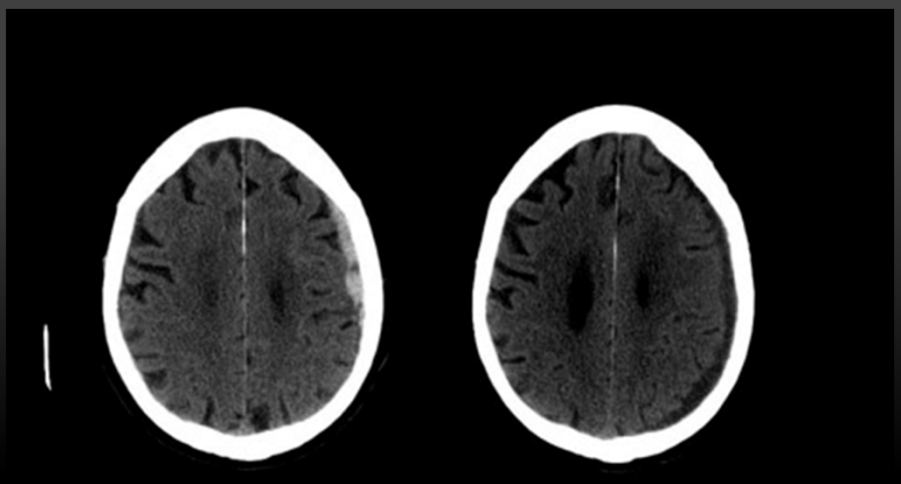

ACUTE

Hyperattenuating fluid collection

CHRONIC

4 weeks later, hypoattenuating fluid collection

6

MRI

- Commonly performed
  - MRI (noncontrast)
  - MRI with IV contrast
  - MRA – magnetic resonance angiography
- Exams of limited use to chiropractic practice
  - MRI perfusion
  - Diffusion tensor imaging
  - Tractrography
  - fMRI
  - CSF flow
  - MR spectroscopy

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Brain MRI without Contrast

- Limited list drawn from ACR Criteria
  - Ischemic stroke
    - Higher sensitivity than CT in the very early phases
    - CT better option due to availability and faster scan times
  - Subacute to chronic
    - Head trauma (after 4-48 hours)
    - Intracranial hemorrhage (can be used to age blood)
  - Chronic vascular disease
  - Vascular malformations and anomalies
  - Congenital disease
  - Neurodegenerative conditions

8

Brain MRI w/wo Contrast

- Limited list drawn from ACR Criteria
  - Neoplastic conditions
  - Infections
  - Inflammatory conditions including demyelinating diseases

9

Craniofacial Trauma

10

Traumatic Brain Injury

- Measures of severity
  - Glasgow coma scale
    - Primarily on field sports docs, ambulance, and ED staff
  - Loss of consciousness (LOC)
    - Mild < 30 mins
    - Moderate 31 mins to 6 hours
    - Severe > 6 hours
  - Post-traumatic amnesia (PTA)
    - How long from the time of injury until there is situational awareness and memory
      - Mild < 60 minutes
      - Moderate 1-24 hours
      - Severe > 1 day

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Glasgow Coma Scale

Behavior	1	2	3	4	5	6
Eyes	No response	Open to pain	Open to speech	Open spontaneously	n/a	n/a
Verbal	No response	Incomprehensible sounds	Inappropriate words	Confused	Oriented x3	n/a
Motor	No response	Abnormal extension	Abnormal flexion	Flexion withdrawal from pain	Moves to localized pain	Obeys commands

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Traumatic Brain Injury

- Mayo Head Injury Classification
  - Moderate to Severe TBI
    - LOC > 30 mins
    - PTA > 24 hours
    - Imaging demonstrated intracranial injury
  - Mild TBI
    - LOC < 30 mins OR
    - PTA < 24 hours OR
    - Depressed basilar or linear skull fracture
  - Symptomatic TBI
    - None of the above are present
    - Have symptoms of
      - Blurred vision, confusion, dizziness, headache, nausea, vomiting

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Traumatic Brain Injury

Concussion:

- Clinical syndrome characterized by immediate and transient alteration of brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma
  - American Association of Neurological Surgeons

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Traumatic Brain Injury

- 60% of head trauma patients have mild or minimal TBI
- Of those
  - < 10% have positive CT findings
  - < 1% require neurosurgery

Traumatic Brain Injury

- Clinical positive predictive factors for positive CT findings
  - Headache
  - Vomiting
  - Loss of short term memory (PTA)
  - Age > 60
  - Intoxication
  - Physical evidence of trauma
  - Bleeding disorders / coagulopathy
  - Seizure

Imaging Decisions

- When dealing with a patient with head trauma, there are 3 main imaging options
  - X-ray: NEVER
    - Aside from nasal, sinus and linear skull Fx evaluation, conventional radiographs are useless in head trauma
    - Nasal, sinus, and linear skull Fx is BETTER evaluated with CT
  - CT: acute head trauma or stroke
    - Excellent for bony lesions such as fracture
    - Excellent for acute blood products (first 4 hours)
  - MRI: subacute to chronic head trauma or stroke
    - Good for aging blood products in the brain

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Imaging Guidelines

- New Orleans Criteria (NOS)
- Canadian CT Head Rules (CCHR)
- National Emergency X-Ray Utilization Study (NEXUS)-II

- These are used to determine who does NOT need a CT in acute head trauma with minor or mild acute closed head injury

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New Orleans Criteria

INCLUSION

- GCS=15
- Age > 18
- Head trauma within 24 hours with LOC, PTA, or disorientation

No CT unless any 1 of these is present

Headache
Vomiting
Age> 60
Intoxication
Short term memory deficits
Visible trauma above the clavicles
Seizure

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Canadian CT Head Rule

EXCLUSION criteria

- Age < 16
- Minimal injury
  - No LOC, PTA, disorientation
- No clear trauma Hx
- Obvious skull injury
- Acute focal neuro deficit
- Unstable vitals
- Bleeding disorder
- Return to the ED with the same injury
- Pregnancy

No CT unless any 1 is present

- GCS<15 2 hrs post injury
- Suspected skull Fx
- Any signs of basilar skull Fx
- ≥ 2 episodes of vomiting
- Age ≥ 65
- Retrograde amnesia ≥ 30 mins
- Dangerous mechanism
  - Auto vs ped, ejection from MV, fall from a height

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NEXUS-II

- Head CT is not required if **ALL** of these are absent
  - Age ≥ 65
  - Evidence of significant skull Fx
  - Scalp hematoma
  - Neurologic deficit
  - Altered level of alertness
  - Abnormal behavior
  - Coagulopathy
  - Recurrent or forceful vomiting

Imaging Decisions

- Acute head trauma
  - Minimal/mild injury
    - Use above guidelines
    - CT without contrast is most appropriate
  - Moderate to severe
    - CT without contrast
  - Short term F/U w/o neurologic deterioration, delayed recovery, or unexplained deficits
    - CT without contrast
  - Short term F/U w neurologic deterioration
    - CT without contrast is most appropriate
    - MRI can be useful as an adjunct
- Subacute to Chronic TBI
  - MRI without contrast
- Advanced neuroimaging techniques are NOT recommended
    - PET, SPECT, DTI, fMRI

Imaging Decisions: Concussion

- For the patient with an mTBI considered a concussion, imaging is rarely recommended, unless there is unexplained persistence of symptoms or deteriorating neurologic picture
- The advanced neuroimaging techniques such as susceptibility weighted imaging (SWI), diffusion tensor imaging (DTI) and functional MRI (fMRI) hold promise, but are only being performed in academic settings and do not currently demonstrate clinical applicability

Imaging Findings

- CT:
  - Acute free blood is hyperattenuating
- MRI
  - As blood goes from oxyhemoglobin to deoxyhemoglobin to methemoglobin to free ferritin
  - Mnemonic
    - It Be IdDy BiDy BaBy DooDoo

It Be IdDy BiDy BaBy DooDoo

Stage	Time	T1	T2
Hyperacute	< 8 hrs	Iso	Bright
Acute	8-72 hrs	Iso	Dark
Early subacute	3-7 days	Bright	Dark
Late subacute	1-4 weeks	Bright	Bright
Chronic	4+ weeks	Dark	Dark

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Evaluating Head CT

- Start by looking at the scout
- Then the entire study needs to be viewed in 3 windows
  - Soft tissue to look at the superficial structures
  - Bone window to look for fractures
  - Brain windows to look for hemorrhage

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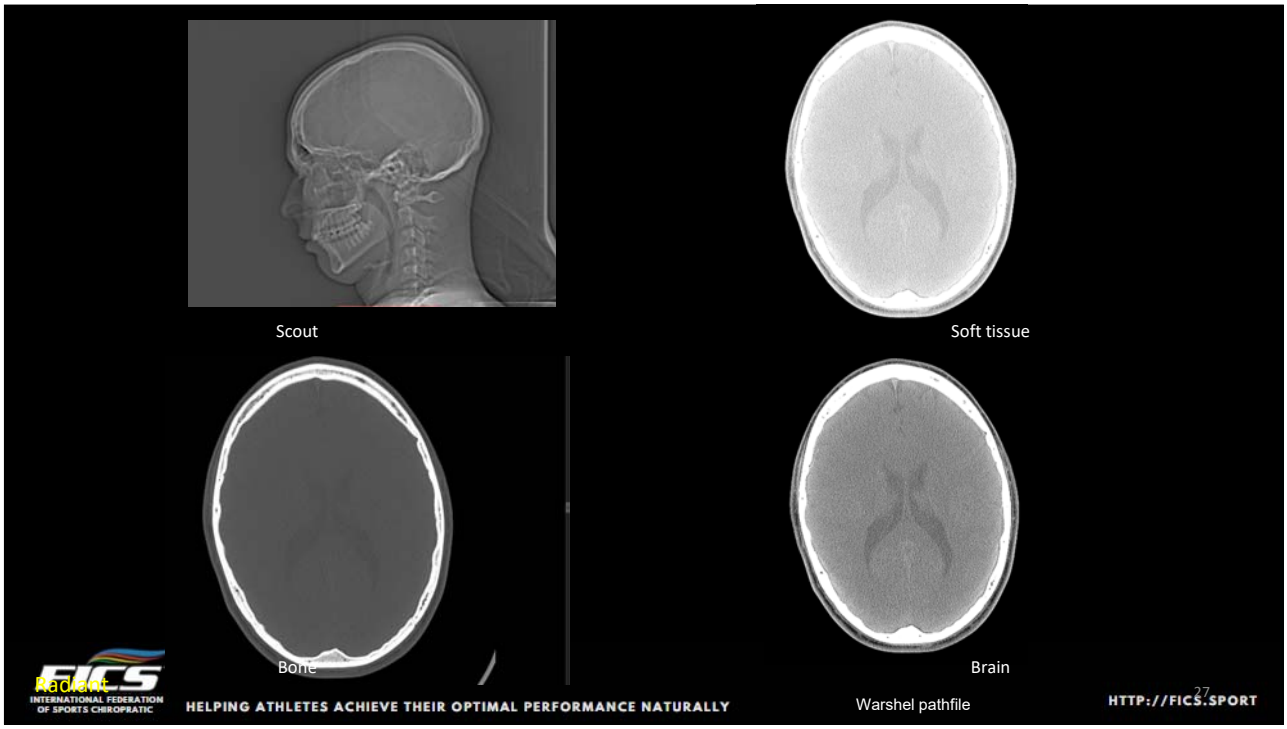

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Calvarium Fractures

- Frequently have associated brain injuries:
  - It isn't the fracture that is so important, it is the underlying brain injury
- 3 types of calvarium fractures
  - Linear
    - Possible leptomeningeal cyst ("growing fracture") in children
  - Depressed
    - The inward motion of skull bone can indent the brain
  - Diastatic
    - Typically only in newborns and infants

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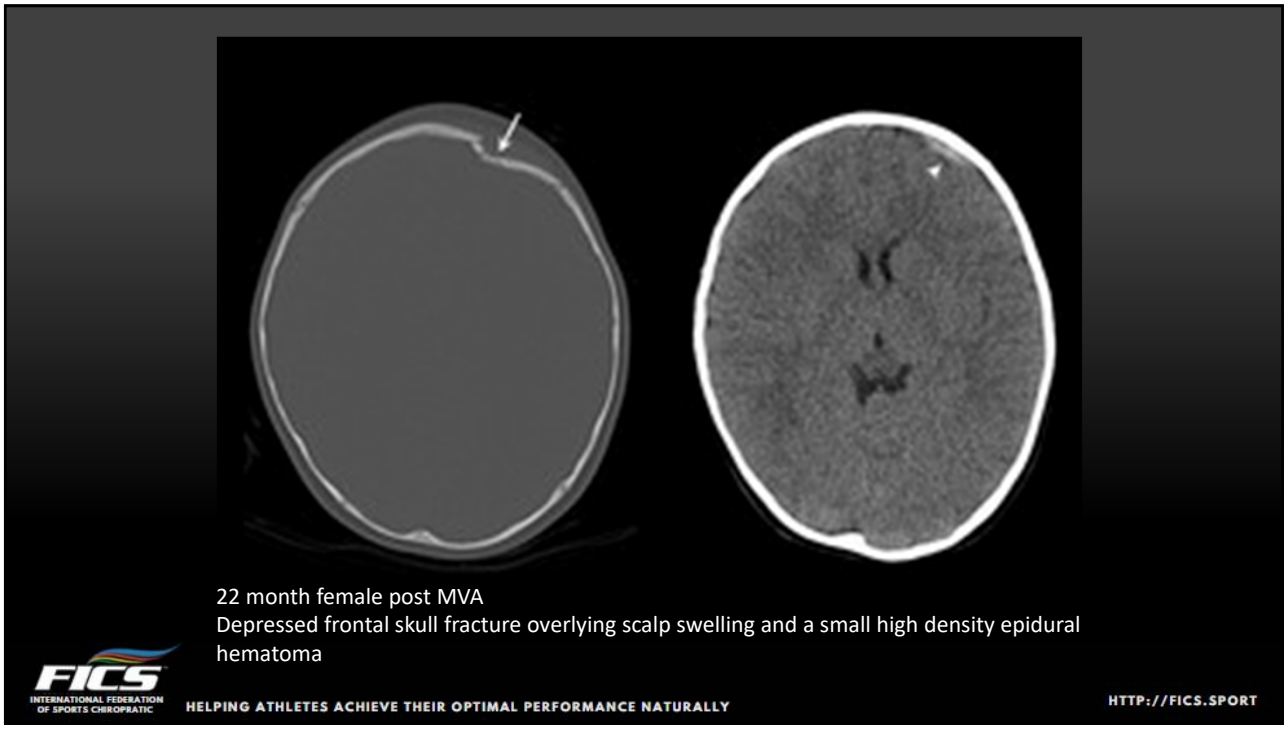
22 month female post MVA
Depressed frontal skull fracture overlying scalp swelling and a small high density epidural hematoma
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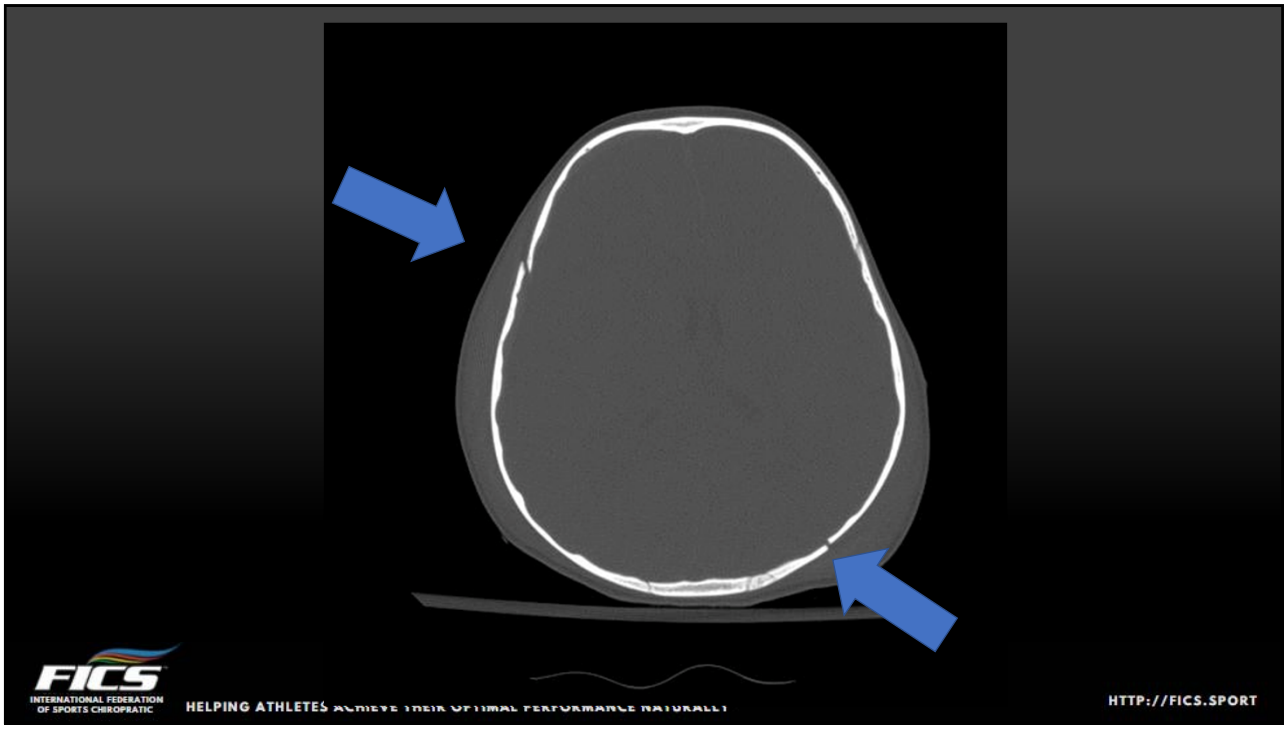
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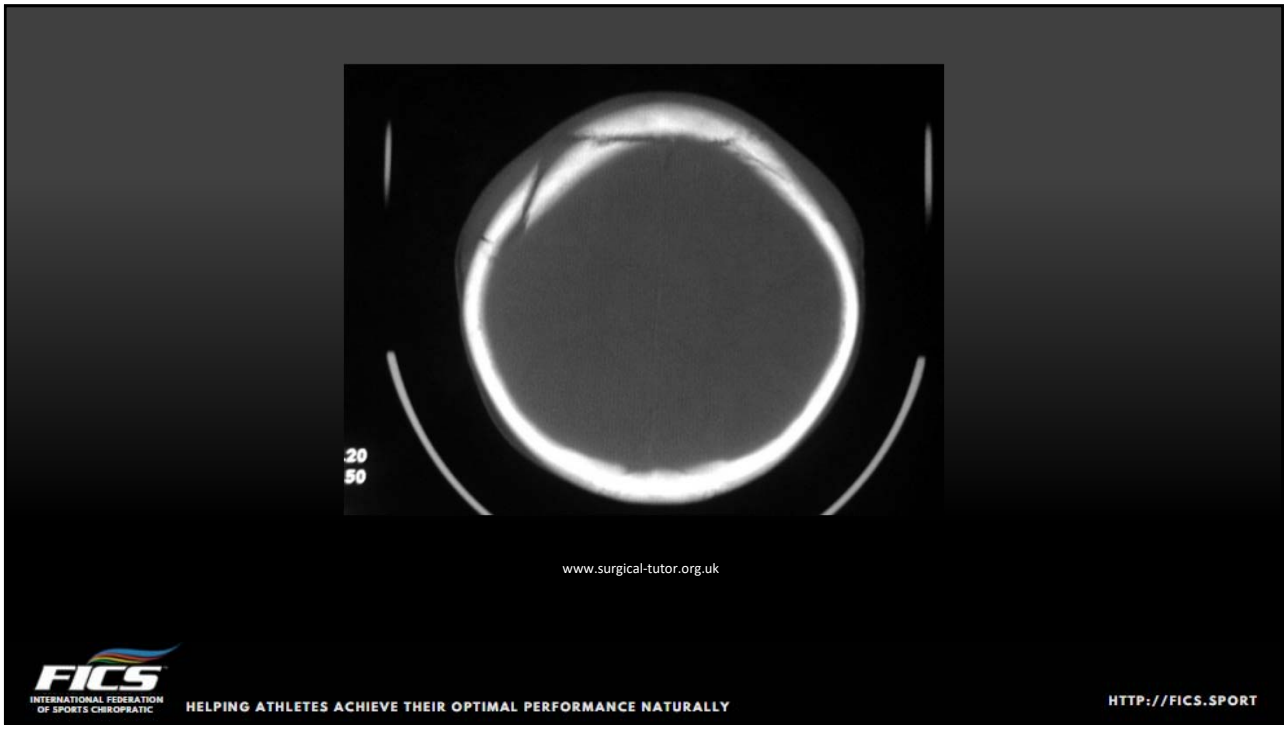
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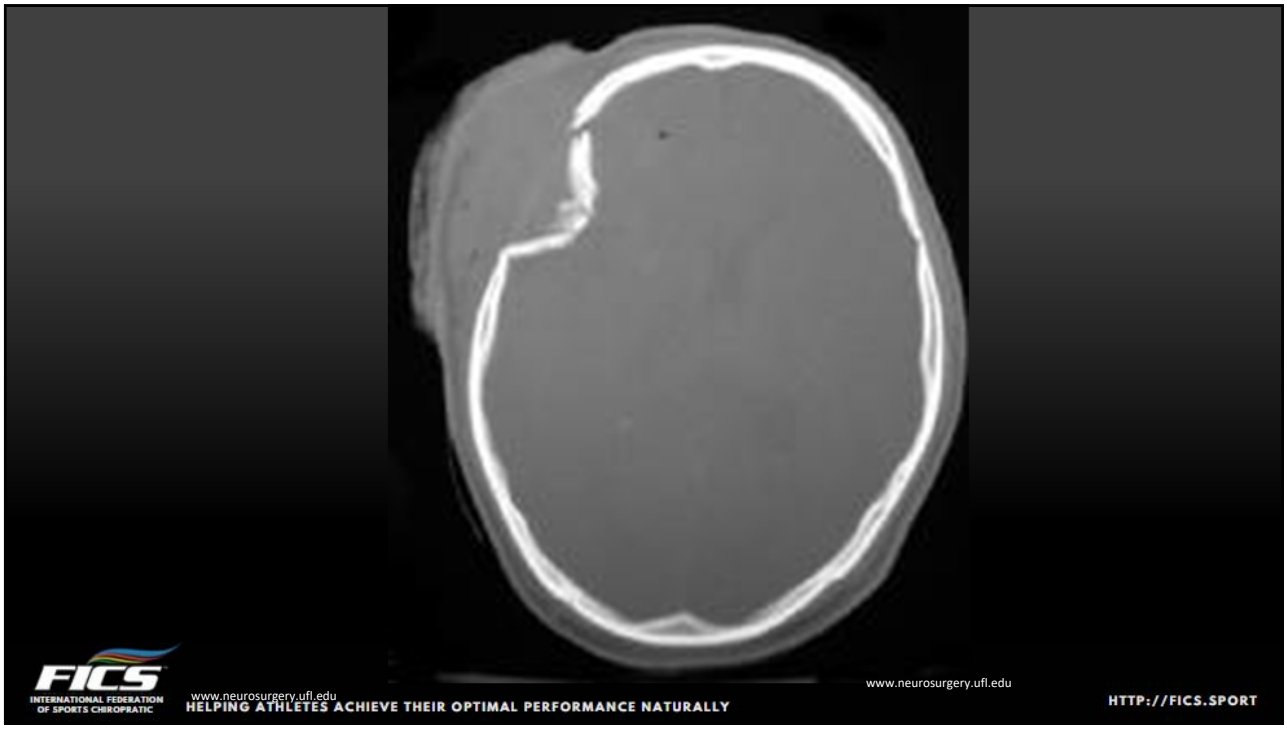
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Leptomeningeal Cyst

- Leptomeninges = arachnoid and pia
- Pachymeninges = dura
- A linear skull fracture which creates a defect in the dura, allowing progressive herniation of the arachnoid and pia
- The pressure of the CSF causes progressive enlargement of the fracture

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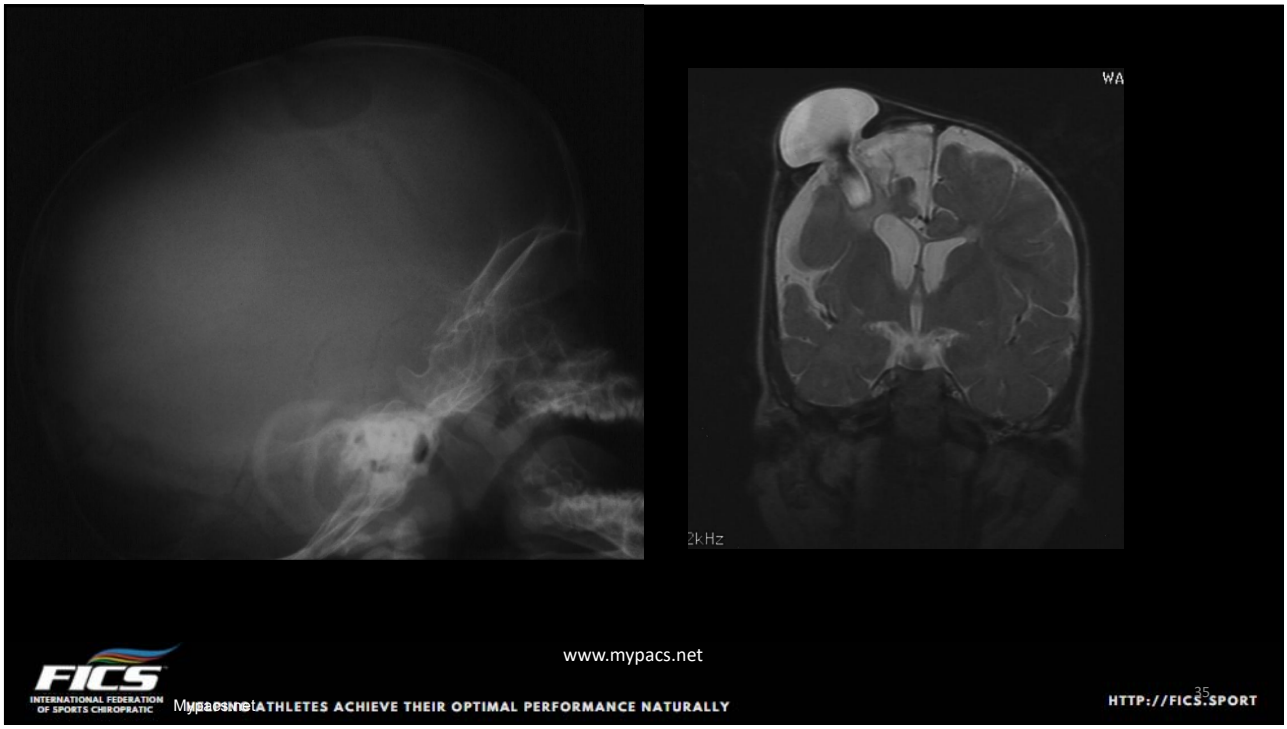

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Hematomas and Hemorrhages

- Extra-axial bleeds
- In order of frequency:
  - Subarachnoid hemorrhage
    - MC extra-axial hemorrhage
  - Subdural
  - Epidural

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Epidural Hematoma

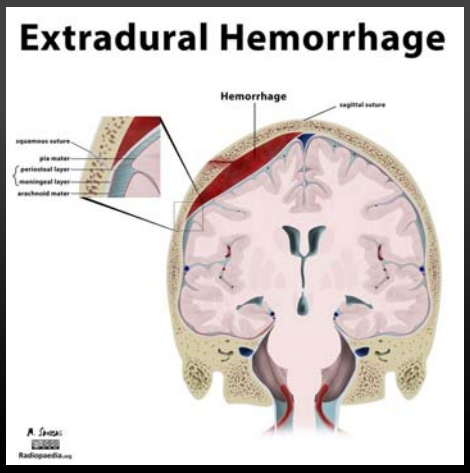
- Most commonly associated with temporal bone fractures
- Damages the middle meningeal artery, its tributaries, or middle meningeal vein
- Allows for blood collection in the potential space between the skull and the dura

Epidural Hematoma

- After head trauma, approximately 50% of patients with an epidural will maintain consciousness and clarity
  - The “Lucid Interval”
- This will be followed by rapid deterioration as the mass effect kicks in
  - Headache, nausea, vomiting
  - Seizures, focal neuro deficits
  - Loss of consciousness

Epidural Hematoma

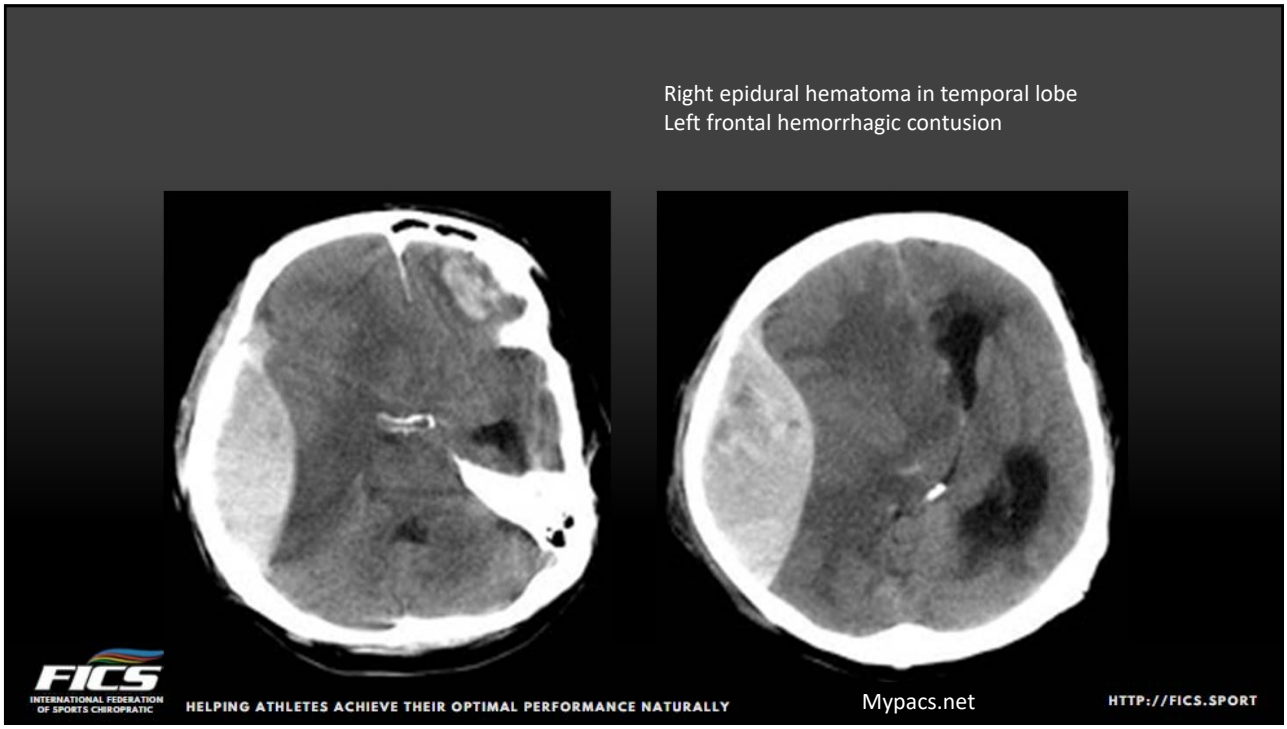
- Very characteristic "biconvex" appearance
  - Also called "lenticular"



Case courtesy of Dr Matt Skalski, Radiopaedia.org, rID: 21542

Epidural Hematoma

- The dura has some degree of adhesion to the inner table of the skull, and is firmly attached at the sutures of the skull
- An epidural hematoma will generally NOT cross a suture, because of the attachment
- On CT, the blood is hyper-attenuating (very white)
- On MRI, the blood appearance depends on the age of the bleed


Right epidural hematoma in temporal lobe
Left frontal hemorrhagic contusion
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Hyperdense, biconvex fluid collection over left cerebral hemisphere
Causing mass effect on lateral ventricle and midline shift
Acute epidural hematoma
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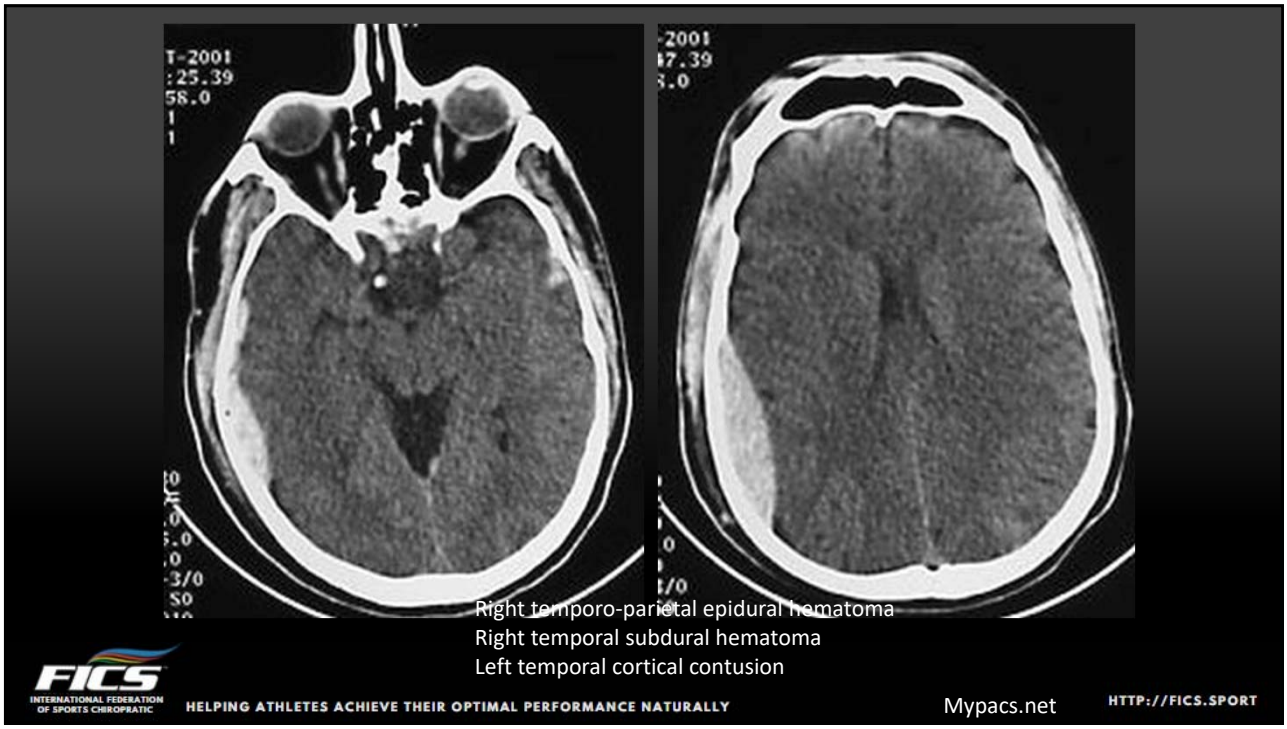

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Subdural Hematoma

- As the brain rotates within the skull from trauma, the bridging veins between the arachnoid and dura tear
- VERY high rate of mortality – 35-50%
  - Those that survive often have persistent deficits
- Worst prognosis comes from motorcycle accidents and falls
- Multiple SDH in a child should raise suspicion for child abuse

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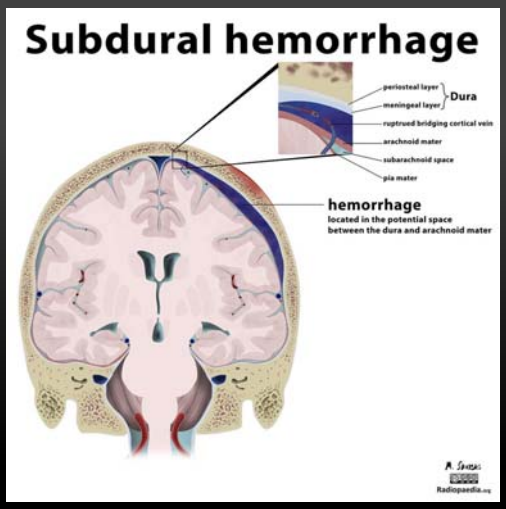
Subdural Hematoma

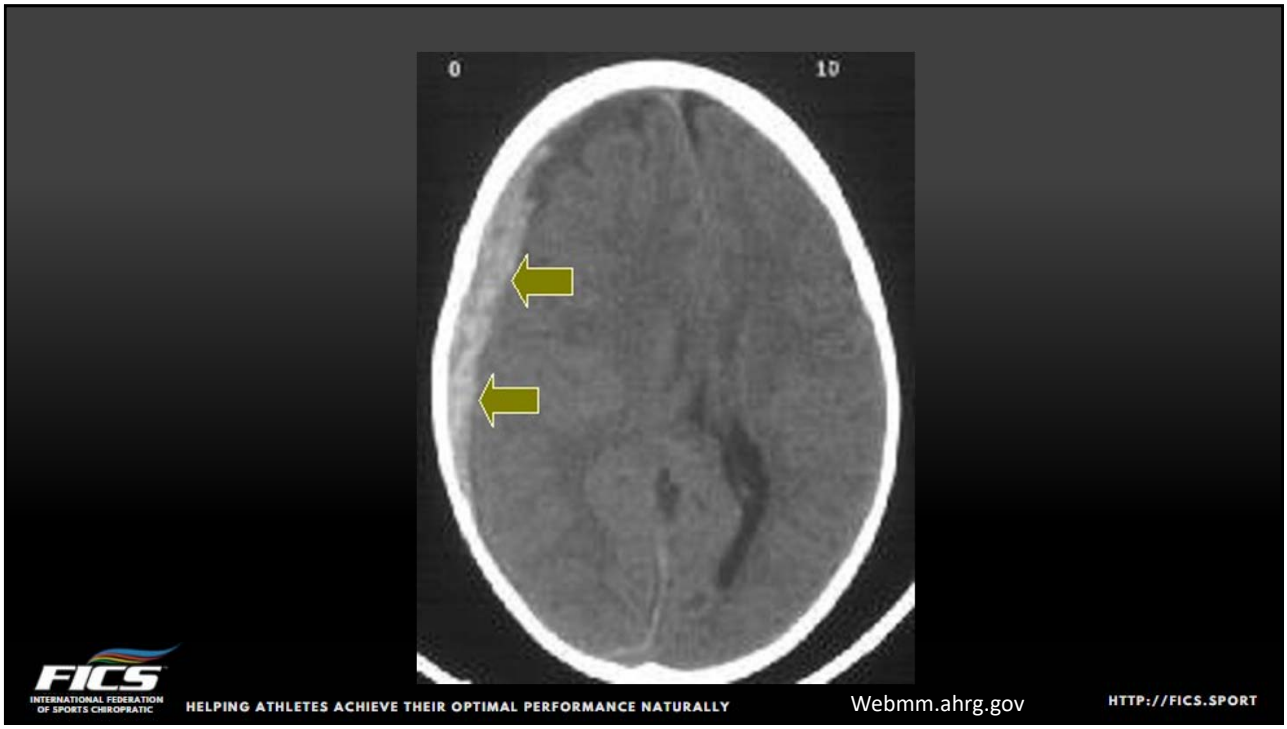
- Characteristic appearance is “crescentic”



Case courtesy of Dr Matt Skalski, Radiopaedia.org, rID: 21542

Subdural Hematoma

- Because this is deep to the dura, SDH can readily cross the skull sutures
- On CT, the acute blood is hyper-attenuating (very white)
  - Darkens over time
- On MRI, the blood appearance depends on the age of the bleed



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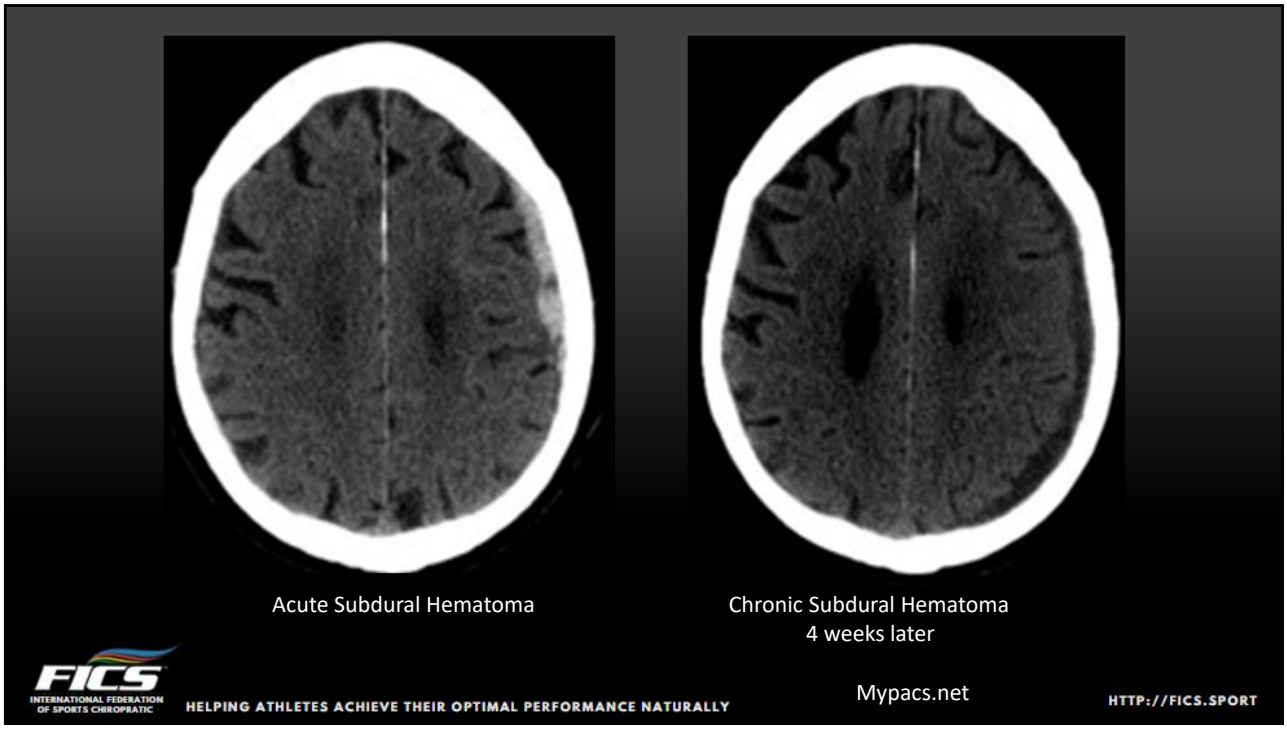

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Subarachnoid Hemorrhage

- Most common extra-axial bleed, typically due to trauma, but can be spontaneous
- "Thunderclap headache"
- Indicates a severe brain injury
  - Poor neurologic function, worse vocational outcomes

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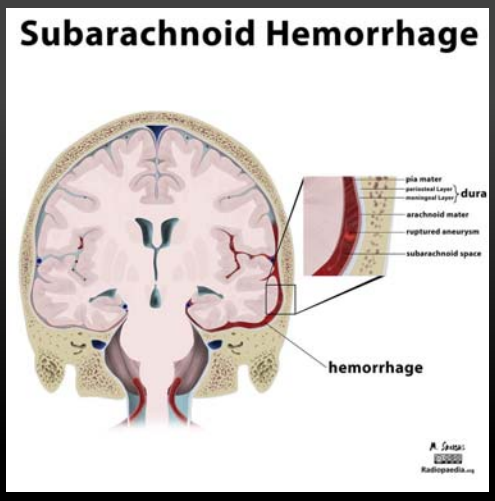
Subarachnoid Hemorrhage

- The blood flows freely into the gyri along with the CSF, resulting in a “dirty CSF” appearance.
- Blood appearance follows regular blood patterns on CT and MRI



Case courtesy of Dr Matt Skalski, Radiopaedia.org, rID: 21542

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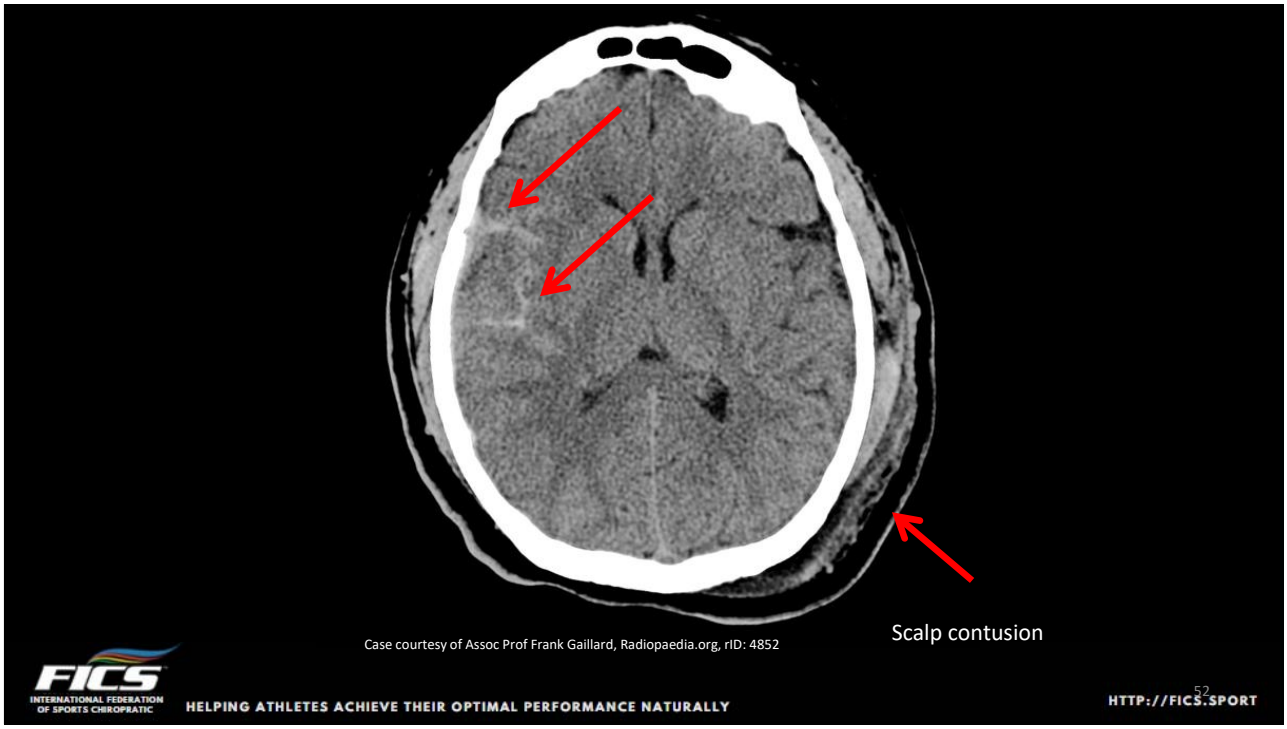

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 4852

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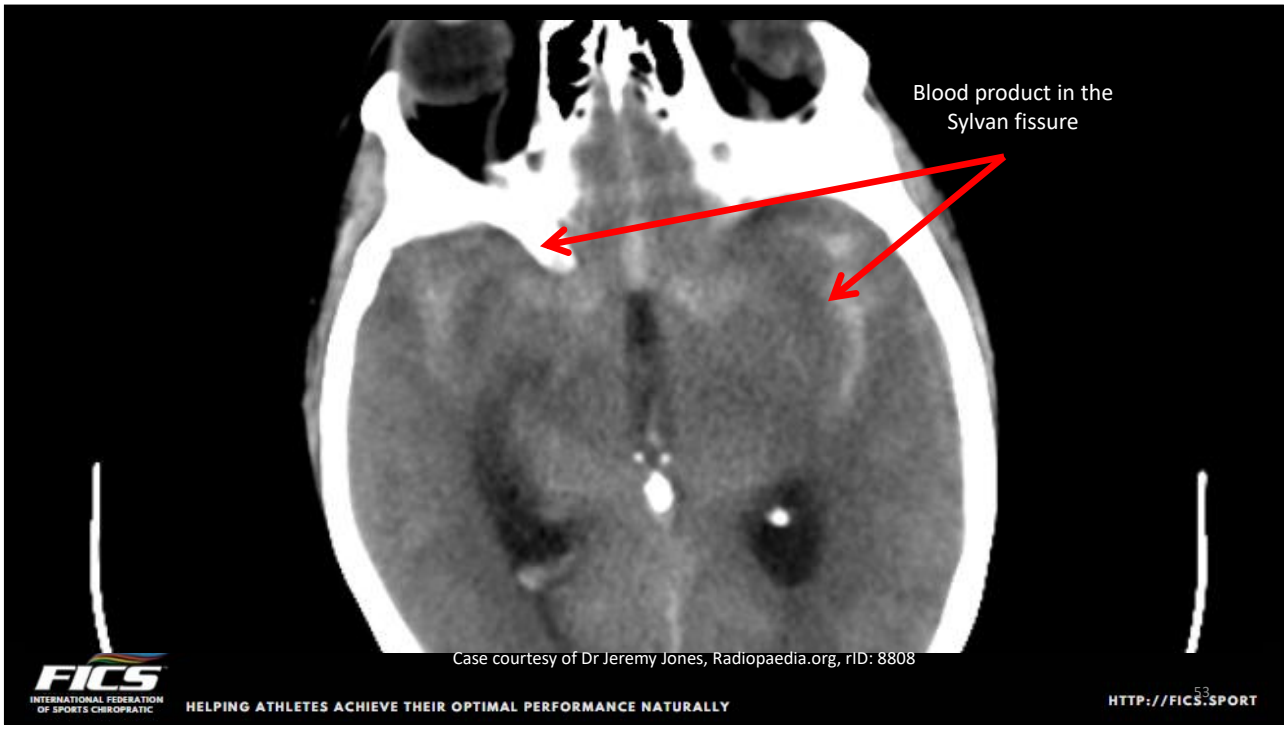
Blood product in the Sylvan fissure
Case courtesy of Dr Jeremy Jones, Radiopaedia.org, rID: 8808
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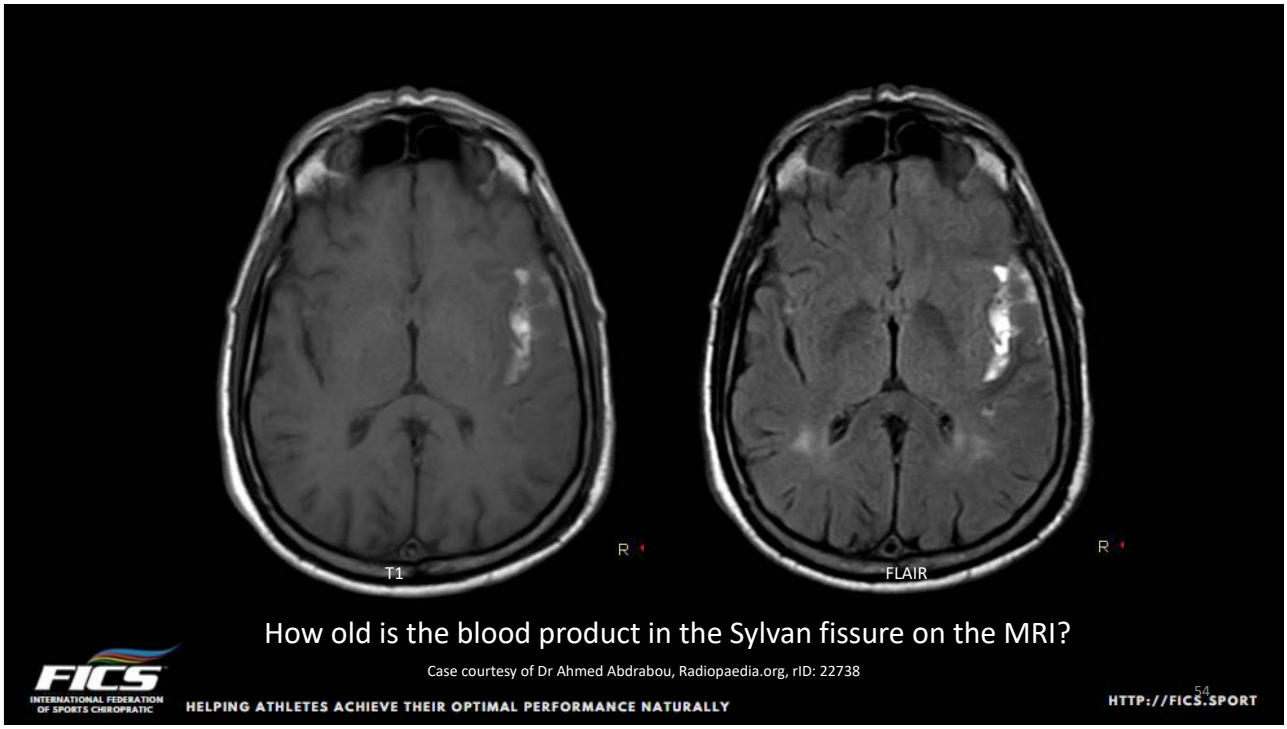
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How old is the blood product in the Sylvan fissure on the MRI?
Case courtesy of Dr Ahmed Abdrabou, Radiopaedia.org, rID: 22738
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Parenchymal Contusion

- Hematoma vs Contusion
  - Hematoma
    - A collection of free blood and/or blood product
  - Contusion
    - Injury to the soft tissues where there is damage to the capillaries, i.e. a bruise

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Parenchymal Contusion

- Either from direct trauma
  - e.g. skull fracture
- Or from acceleration/deceleration injury
  - Coup and countrecoup
- Mostly affects the gray matter due to vascularity, but can “bleed over” into adjacent white matter

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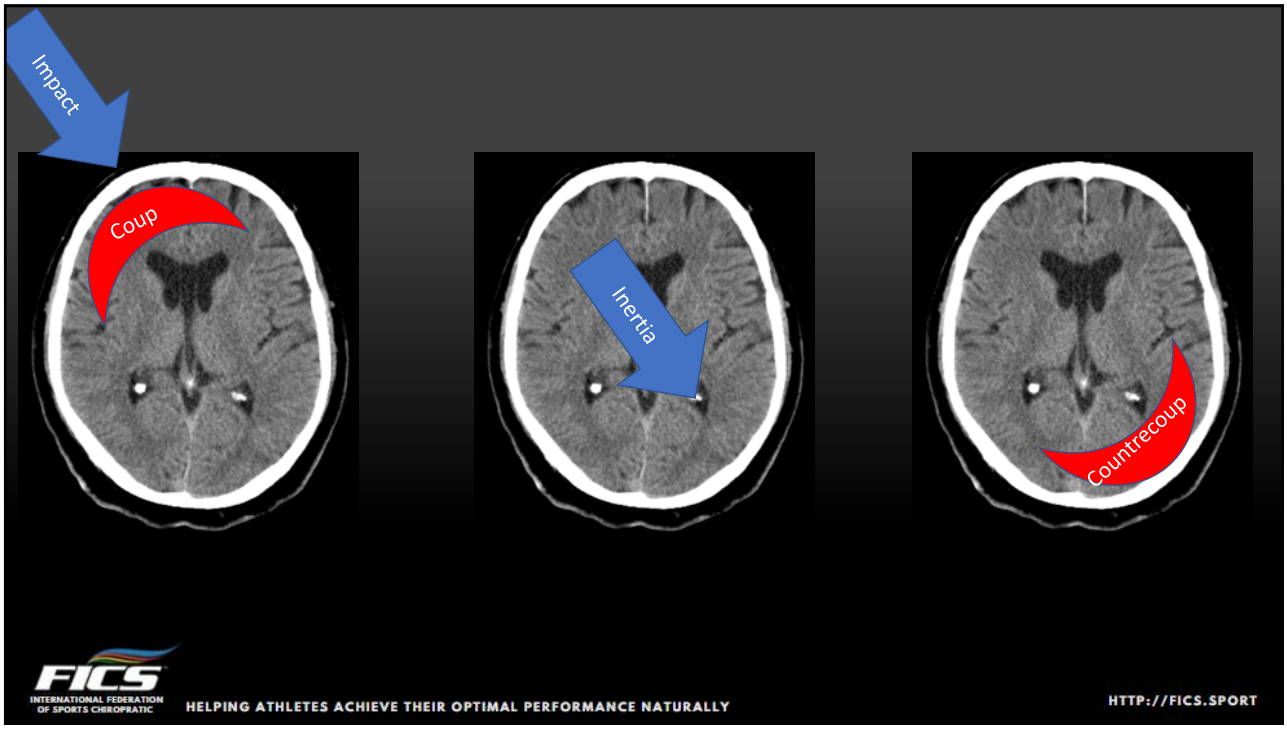

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Parenchymal Contusions

- May be difficult to detect on CT at first, but then becomes more prominent over hours to days
- High attenuation at the site of injury, with variable edema surrounding the hemorrhages
- On MRI, appear similar to hematomas

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Bifrontal cerebral contusions

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 7149

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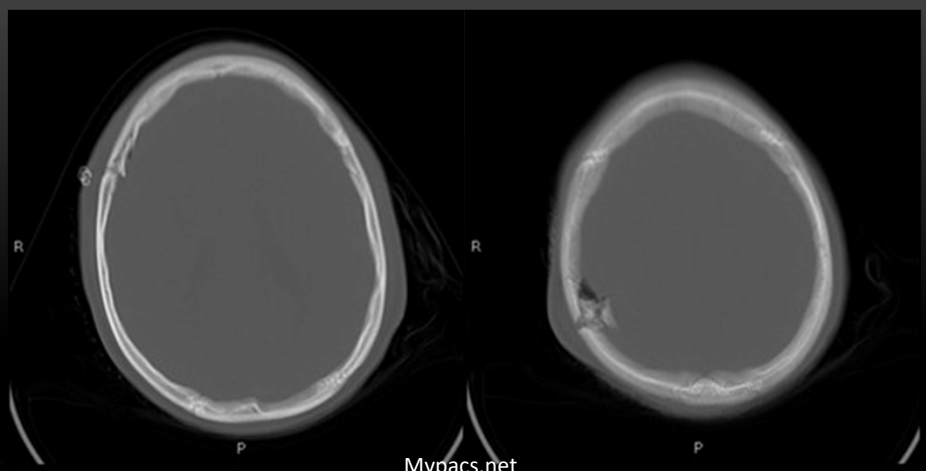
Assault, no recollection of injury, multiple lacerations and scalp swelling
Comminuted depressed skull fractures of right frontal and parietal bones, hemorrhagic contusions and bubbles of air at the parietal fracture



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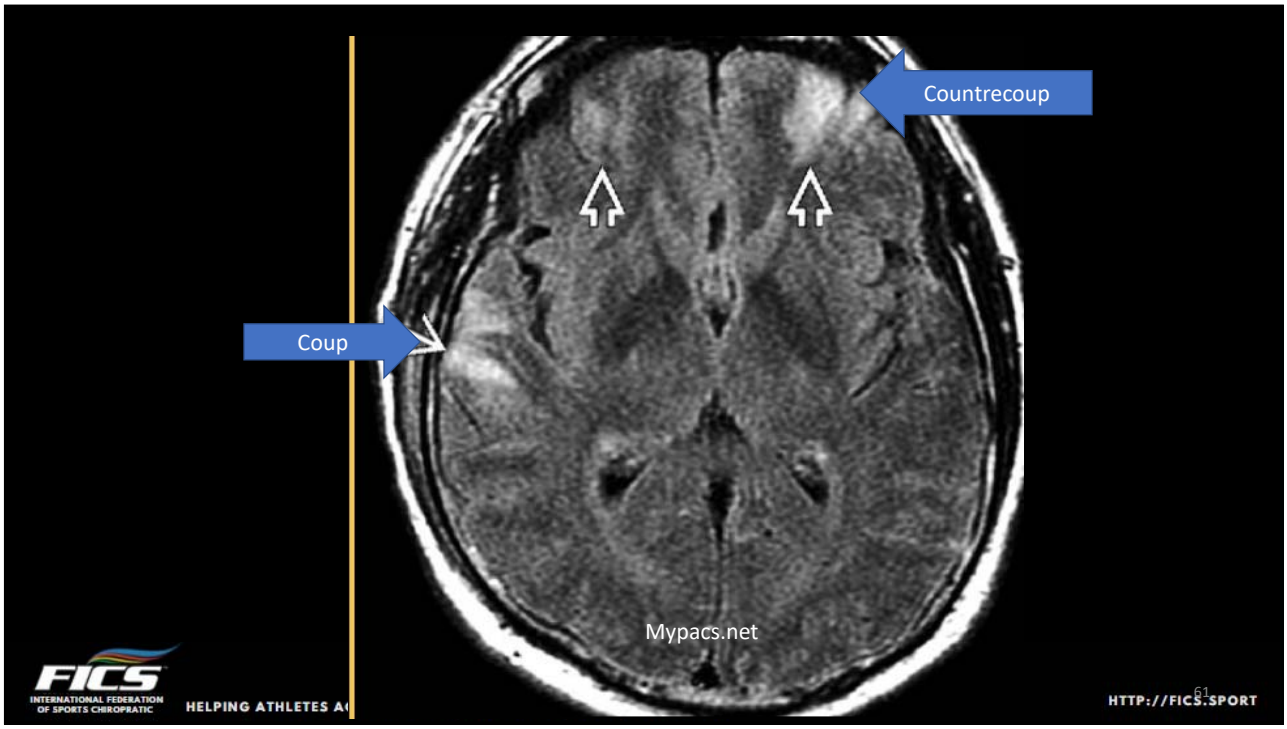

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Concussions

- Transient post-traumatic loss of awareness or memory lasting from seconds to minutes, without causing gross structural lesions in the brain and without leaving serious neurological residua
- There are **NO** reliable imaging findings for a concussion. Imaging is strictly to rule out other, more significant pathology
  - Diffuse tensor imaging holds promise, but is not readily available

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Post-Concussion Syndrome

- Commonly follows a mild head injury
- Consists of headache, dizziness, difficulty in concentration, amnesia, depression, apathy and anxiety
- There are NO imaging findings in the brain
- May experience these symptoms for weeks, months or years after a concussion

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Second Impact Syndrome

- Rare complication of concussions
- If a 2nd concussion occurs before the signs and symptoms of the 1st have resolved, this can result in severe, rapid brain swelling
- Most schools have very strict guidelines for the management of student athletes with concussions to prevent SIS

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Facial Fractures

Warshel pathfile and kid

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Orbital Blow Out Fracture

- Typically from a blow to the face increasing intra-orbital pressure and fracturing the wall of the orbit
- The orbital rim remains intact

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Orbital Blow Out Fracture

- The inferior blow out fracture is the most common
- Important clinical feature: loss of bilateral symmetry on assessing extraocular muscle movement due to trapping of the inferior rectus
  - "Lack of conjugate gaze"

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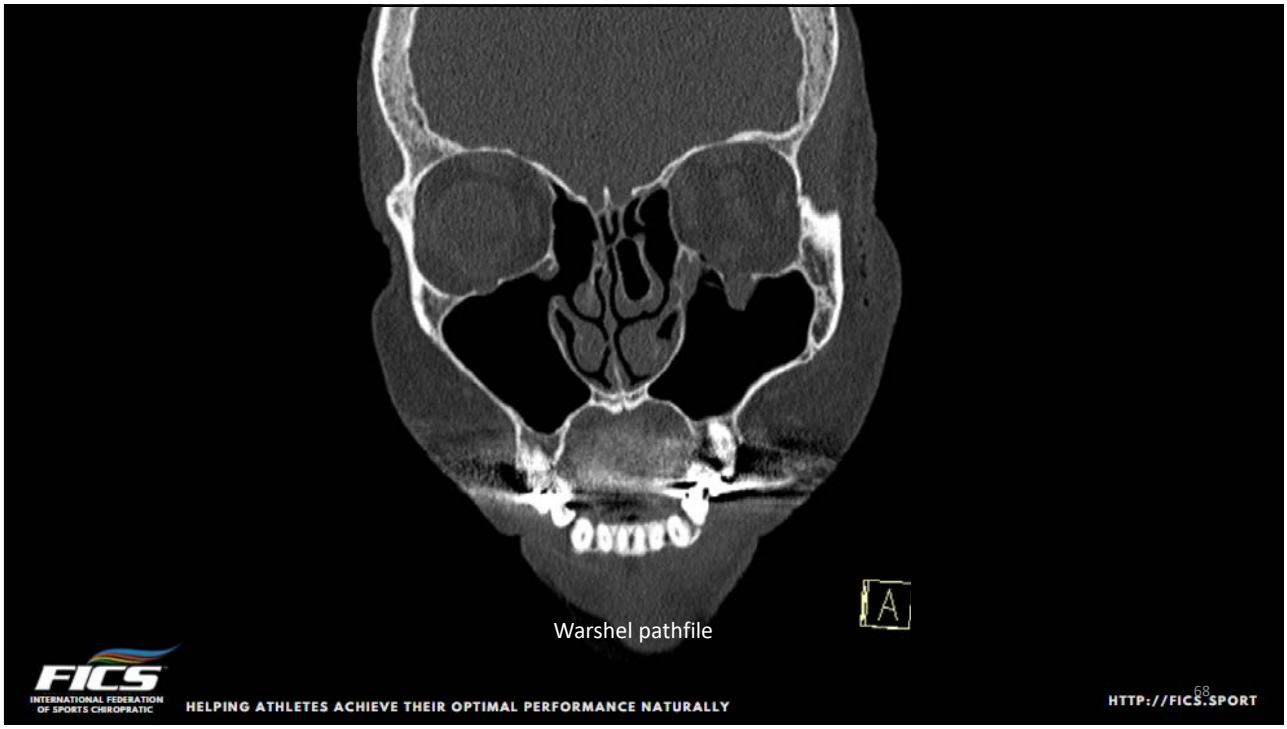

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Tripod Fracture

- 2nd most common facial fracture
  - Nasal Fx is most common
- A blow to the outside of the face fractures the lateral orbital rim, zygoma, and maxilla

Radiant

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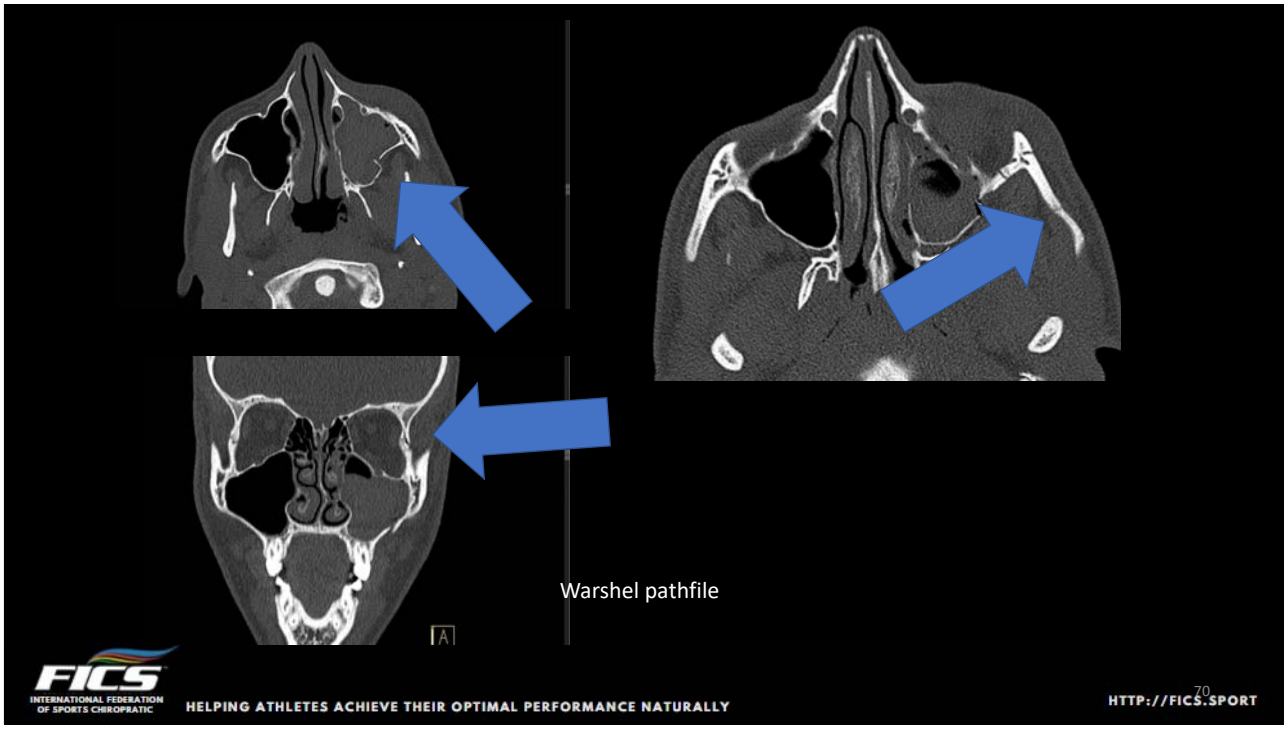

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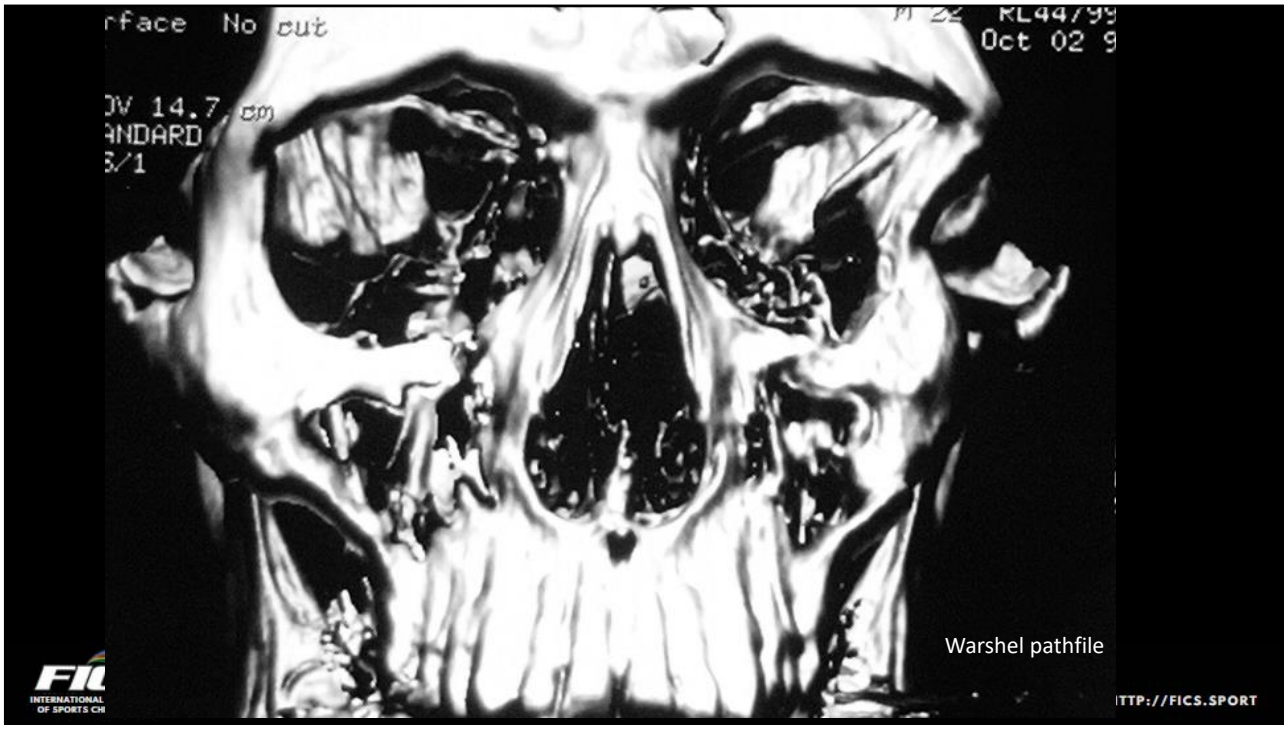
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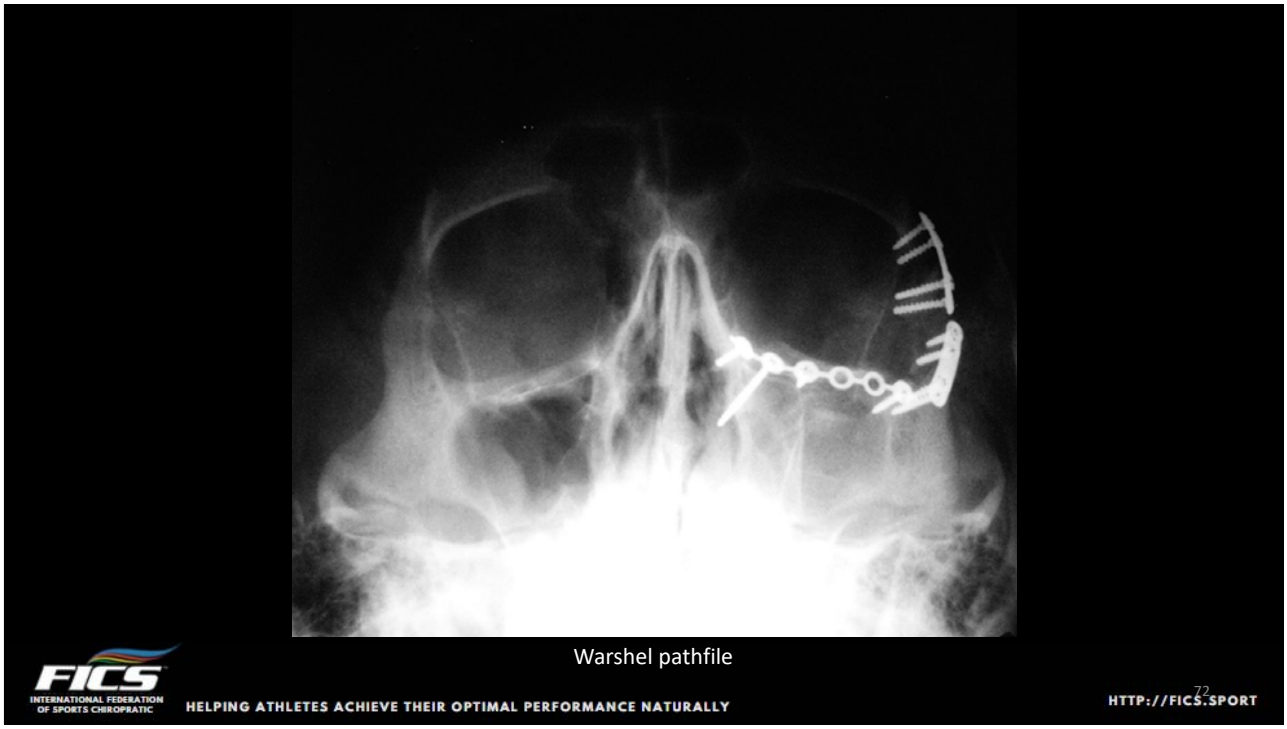
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LeFort fractures

- LeFort classified these fractures into 3 basic forms based on laboratory experiments on skulls
  - I (horizontal) through maxilla only
  - II (pyramidal) involve maxilla and orbit
  - III (transverse) involve orbit and zygomatic arch; also called craniofacial dissociation
- In facial trauma patients, always grab the upper incisors and shake to see if there is any abnormal motion

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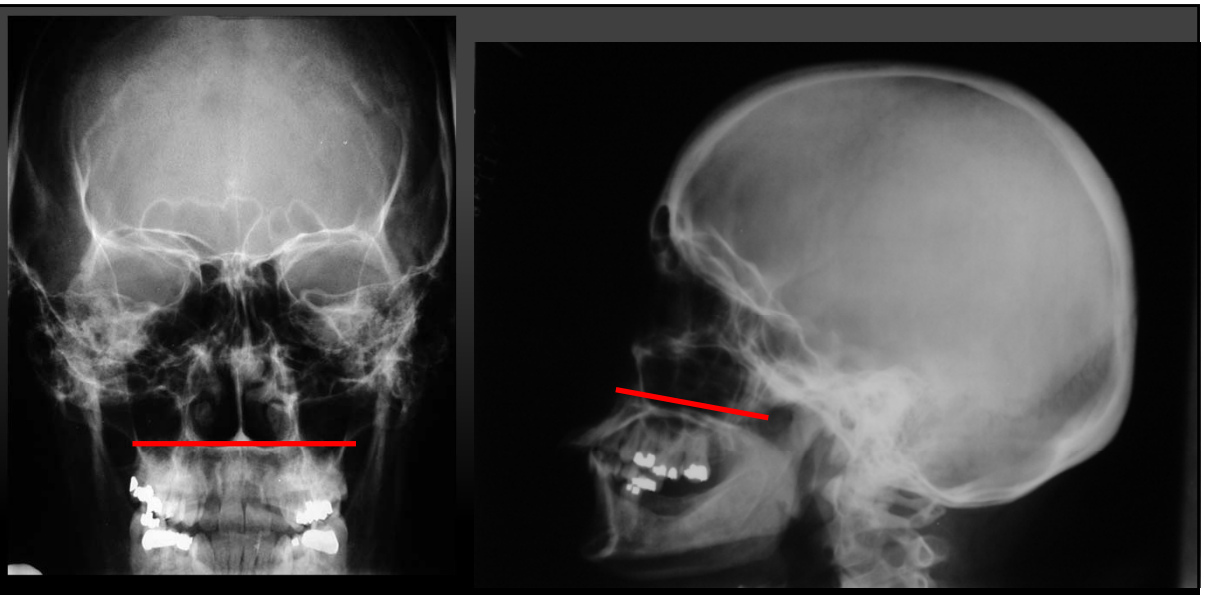

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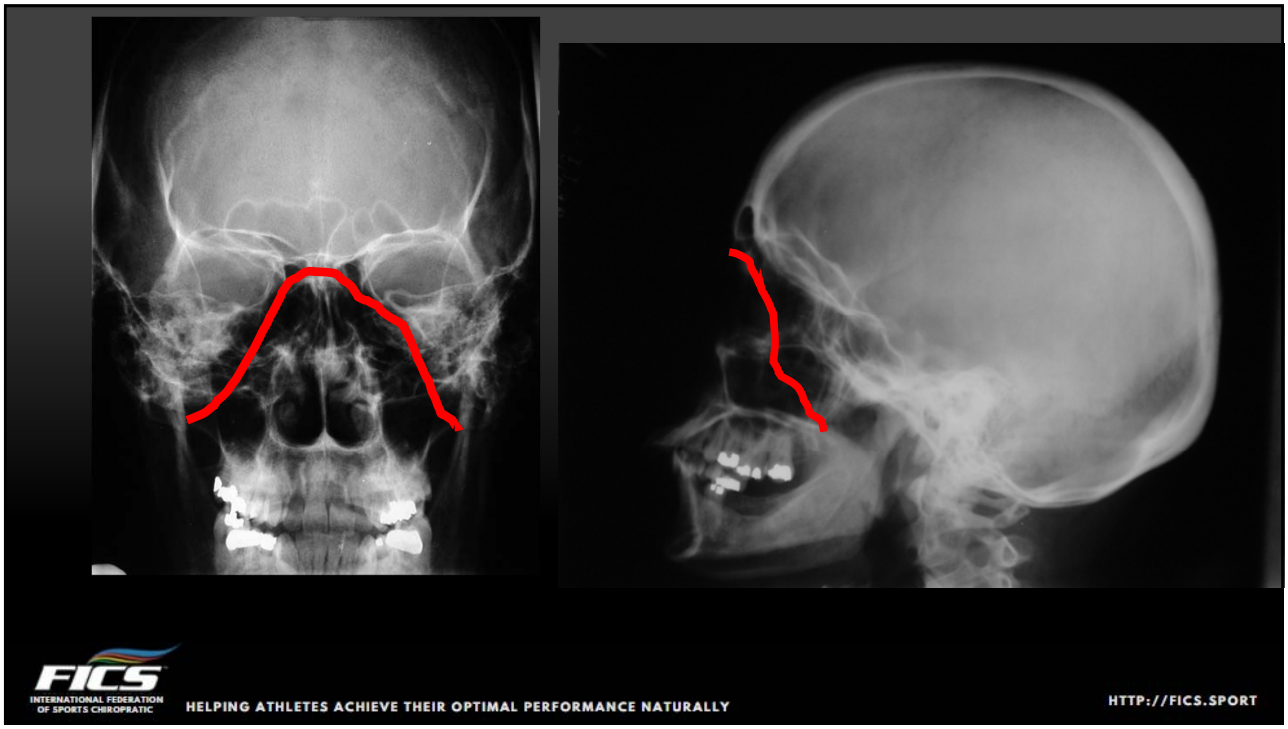
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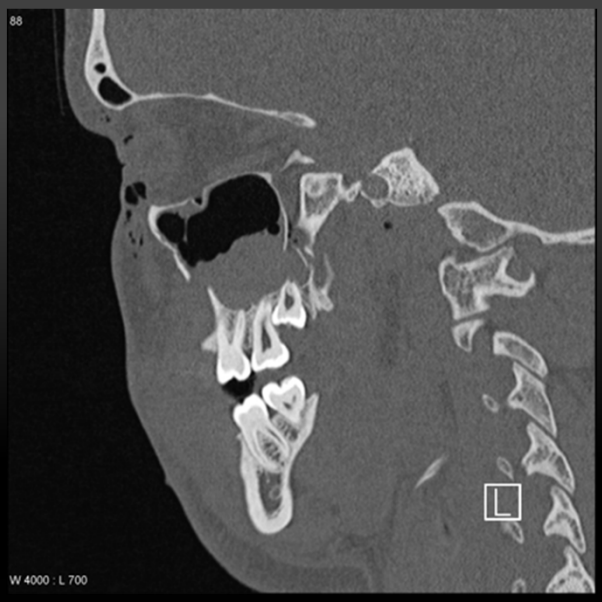
Lefort type 1



Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 4436

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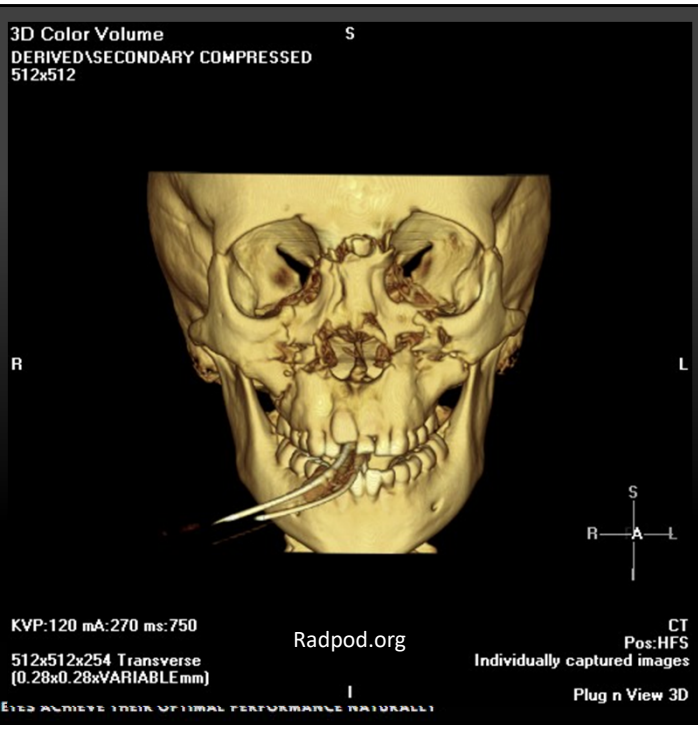
Lefort II



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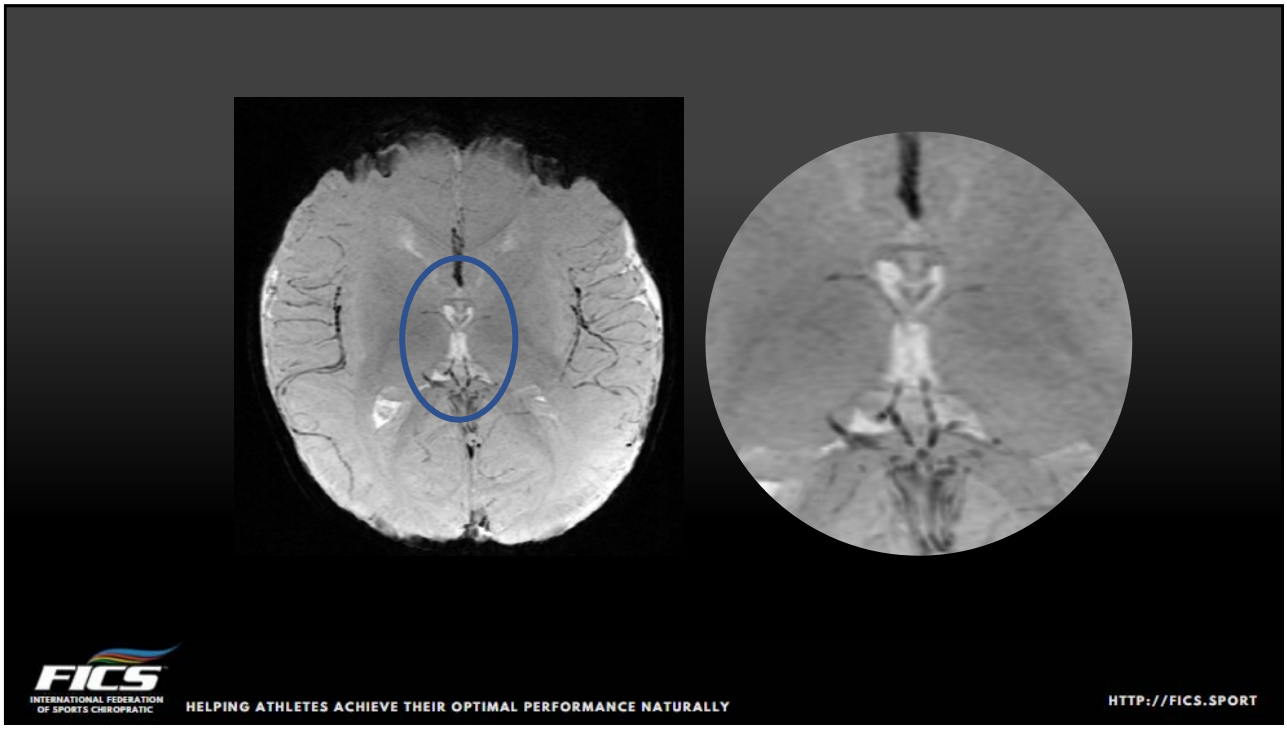
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