The background of the slide is a close-up, dark, and slightly blurred image of a human skull. A white grid is overlaid on the skull, with the grid lines following the contours of the facial bones. The skull's features, such as the eye sockets, nasal cavity, and upper jaw, are visible through the grid.

Midfacial Fractures

Alex Sun, MD

Introduction

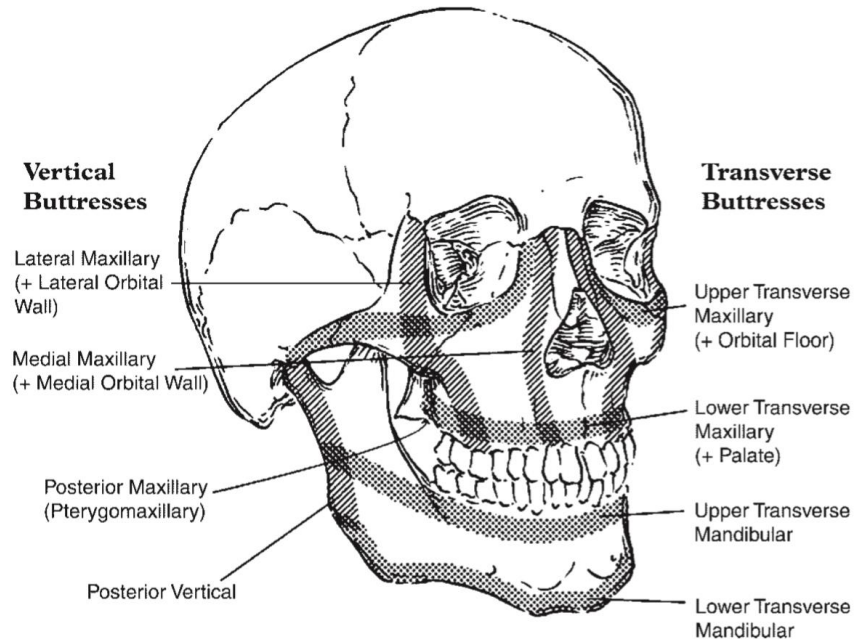
- CT best modality for midfacial fractures
- Midfacial fractures fall into predictable patterns
- Each pattern has unique management principles

Overview

- Anatomy
- Nasoseptal fractures
- Naso-orbitoethmoid (NOE) fractures
- Orbital blow-out fractures
- Zygomaticomaxillary complex (ZMC) fractures
- Le Forte maxillary fractures

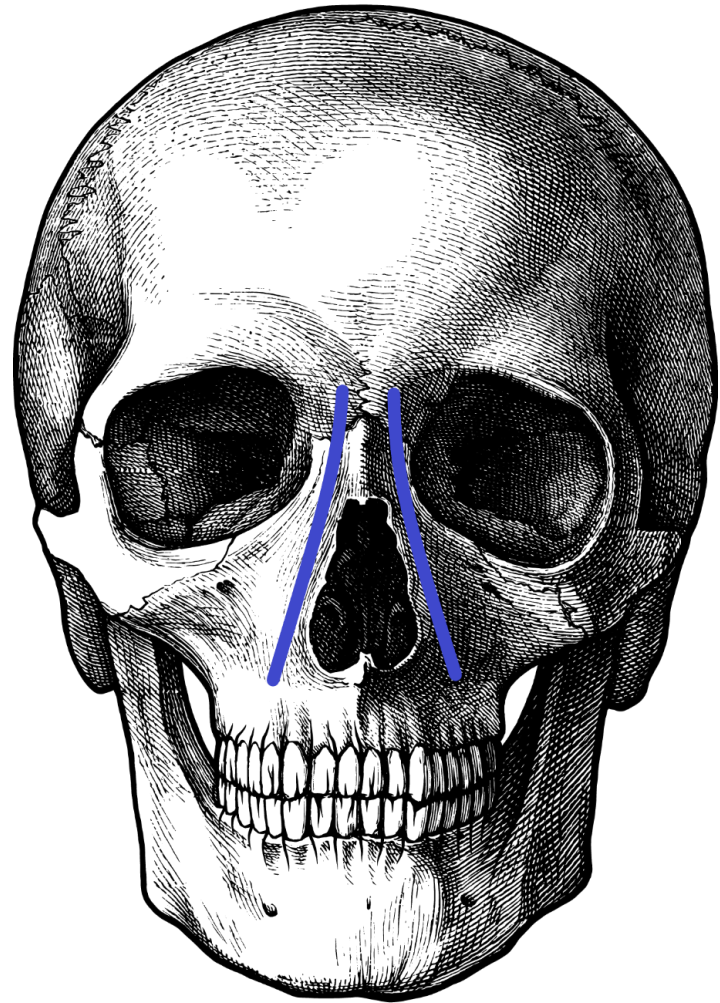
Anatomy

- Maxillofacial Buttresses
 - Areas of increased bone thickness
 - Maintains shape and form
 - Support functional units (eyes, airways, muscles)



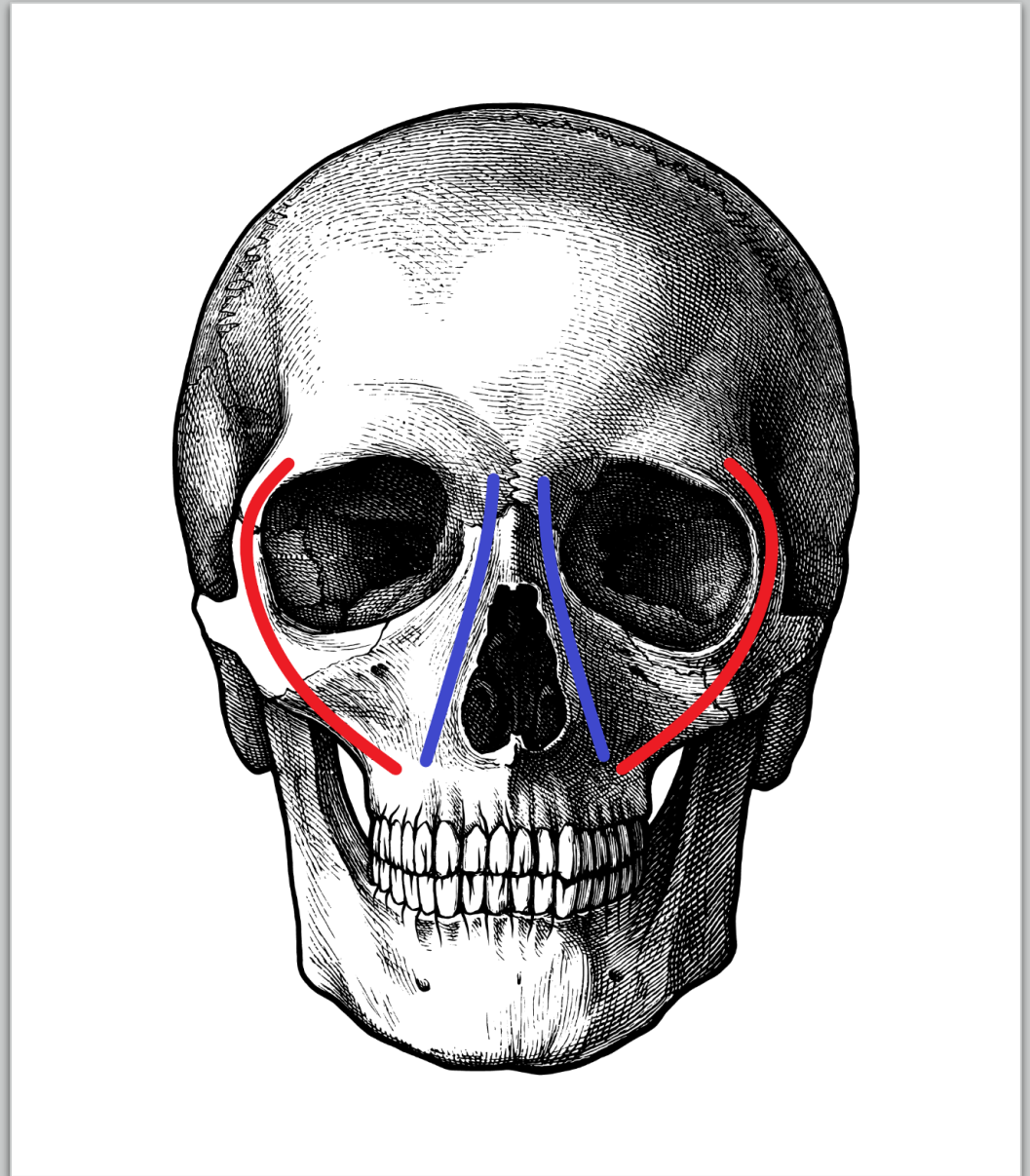
Medial Maxillary Buttress

- Medial orbital
- Lateral nasal walls



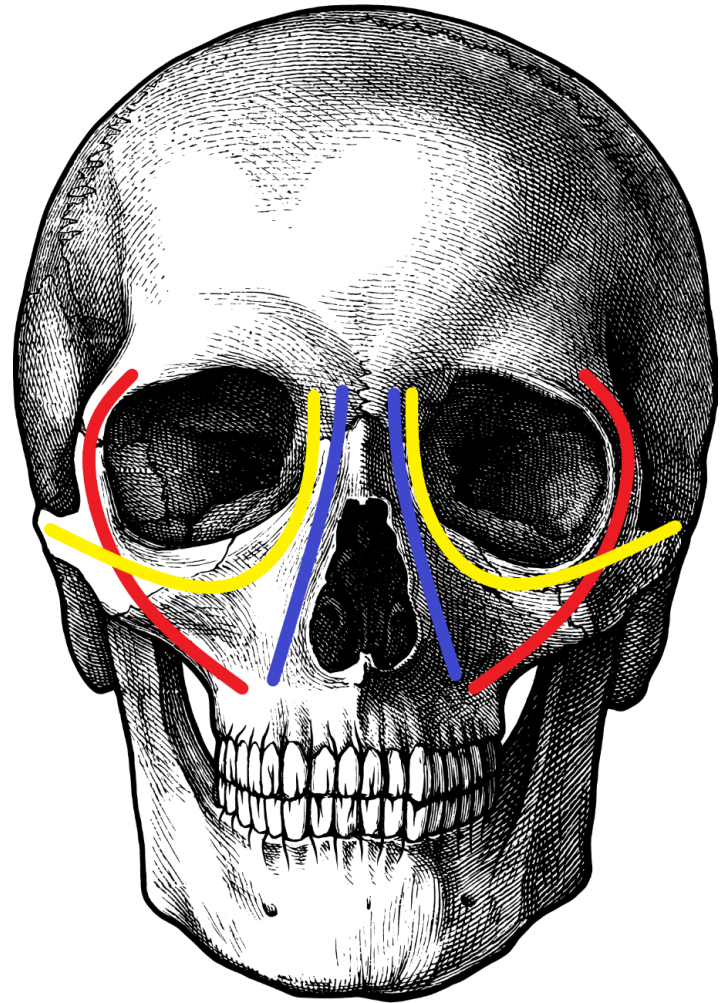
Lateral Maxillary Buttress

- Lateral walls of orbit
- Maxillary sinus



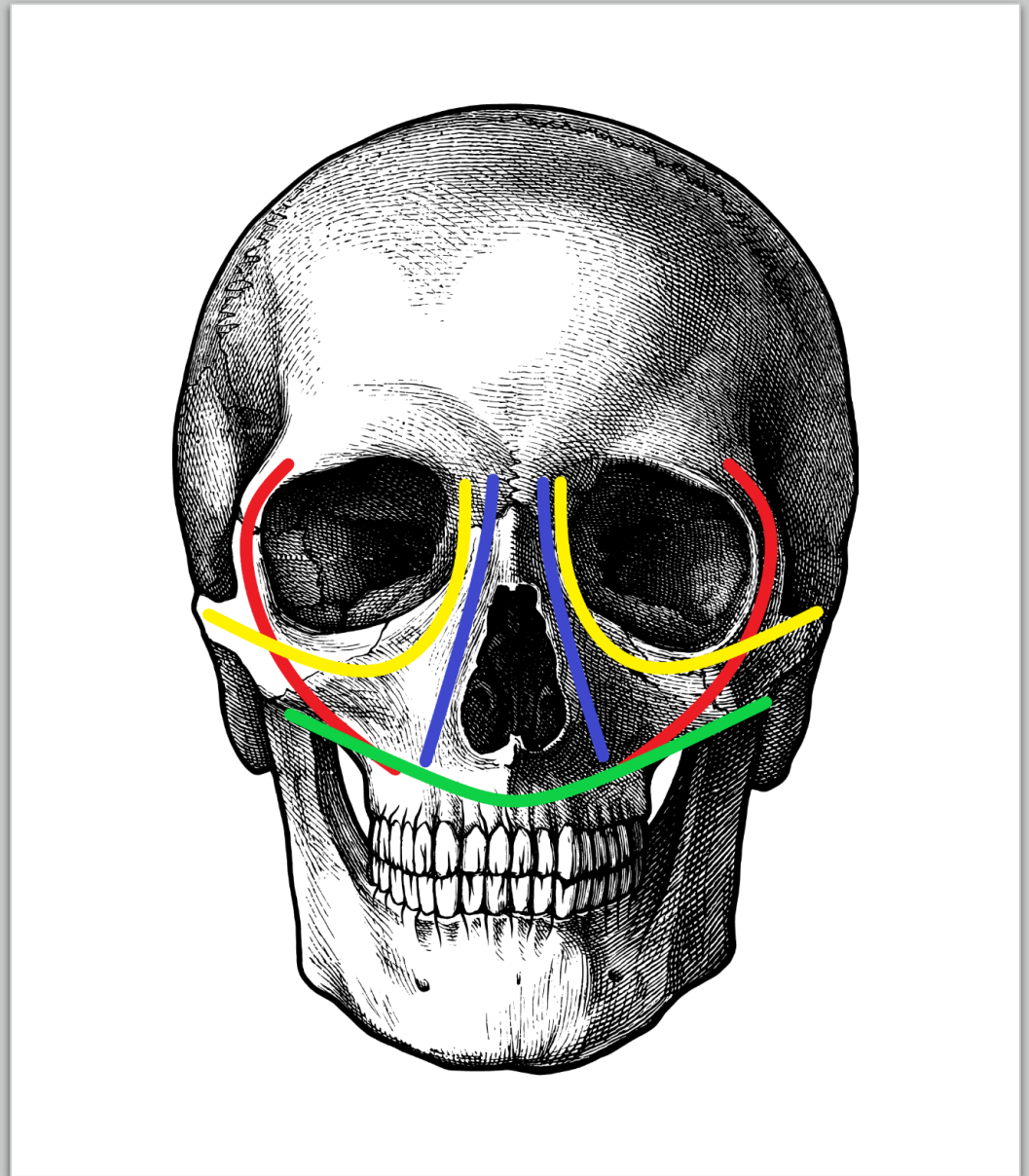
Superior Transverse Maxillary Buttress

- Orbital floor
- Zygomatic Arch

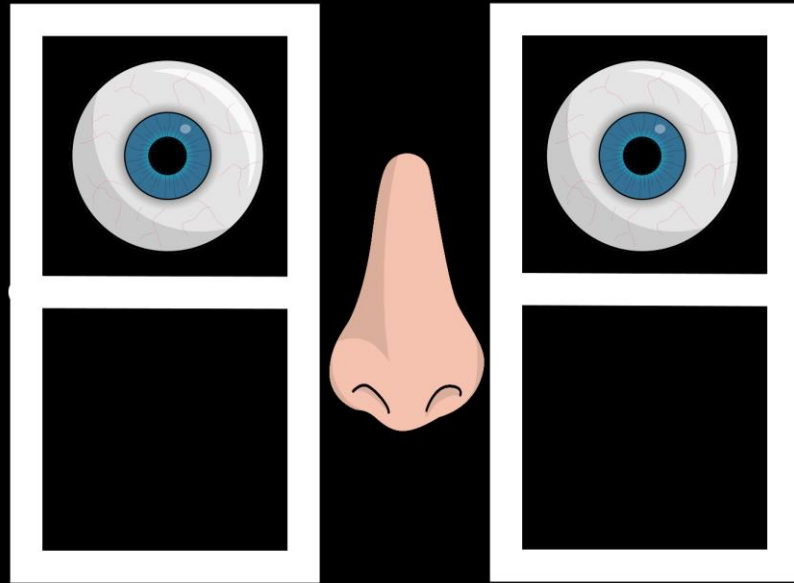


Inferior Transverse Maxillary Buttress

- Hard Palate



Buttress



Nasoseptal Fractures



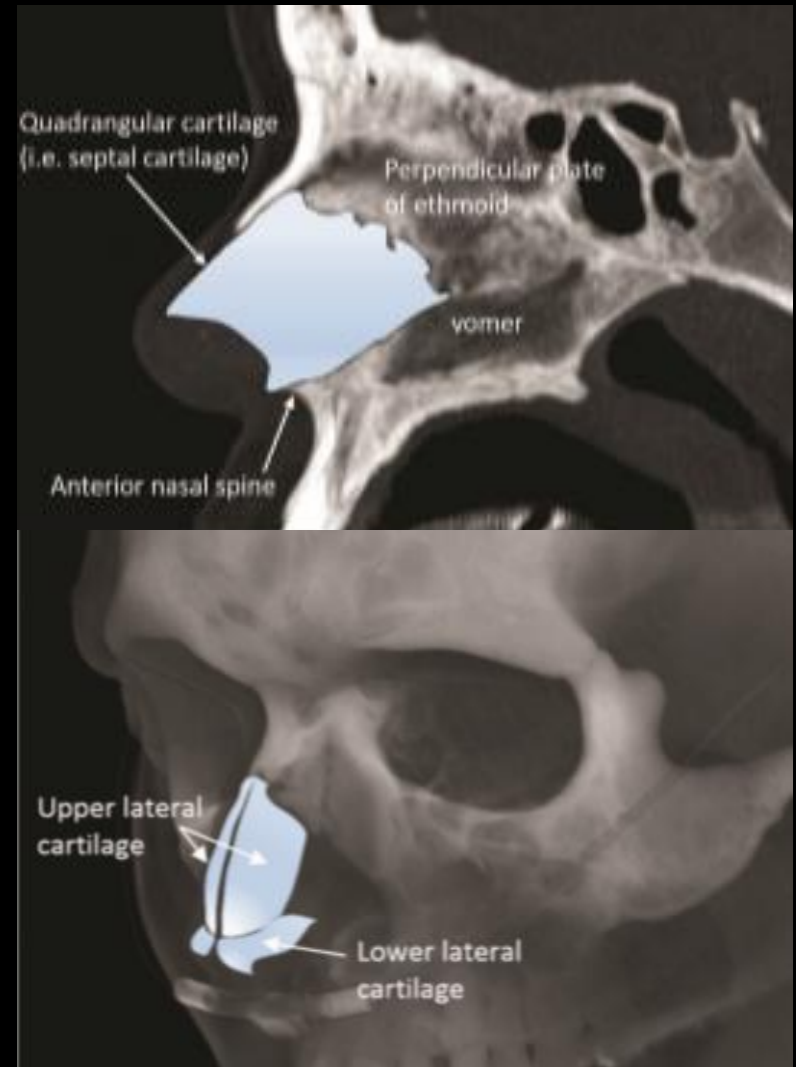
Nasoseptal Fractures

- Nose most frequently fractured facial subunit
 - Over 50% of all facial fractures
- Nasal bones articulate with the frontal bone and the frontal process of the maxilla



Nasoseptal Fractures

- Quadrangular (Septal) cartilage
 - More susceptible to fractures than bone
 - True injury severity less apparent on CT
 - Injury leads malalignment and malunion



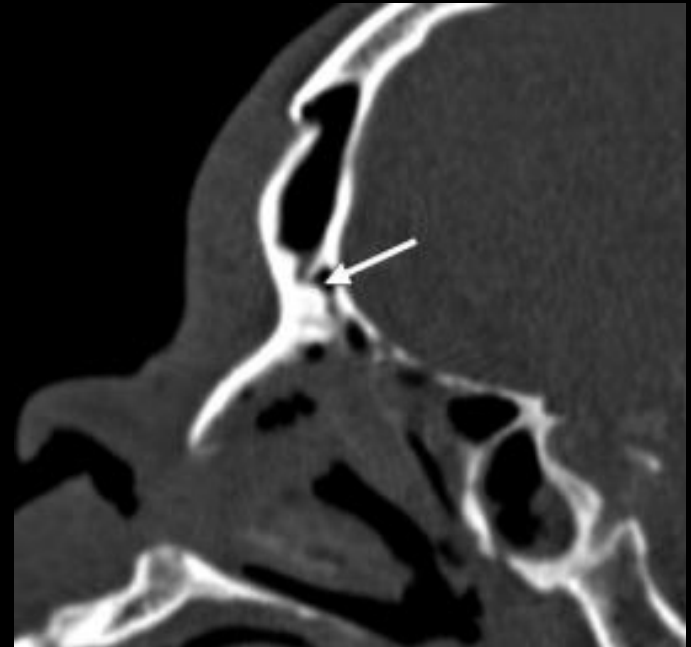
Nasoseptal Fractures

- Nasal septum maintains structure, symmetry, and airway patency
- Septal necrosis
 - collapse and saddle nose deformity



Nasoseptal Fractures

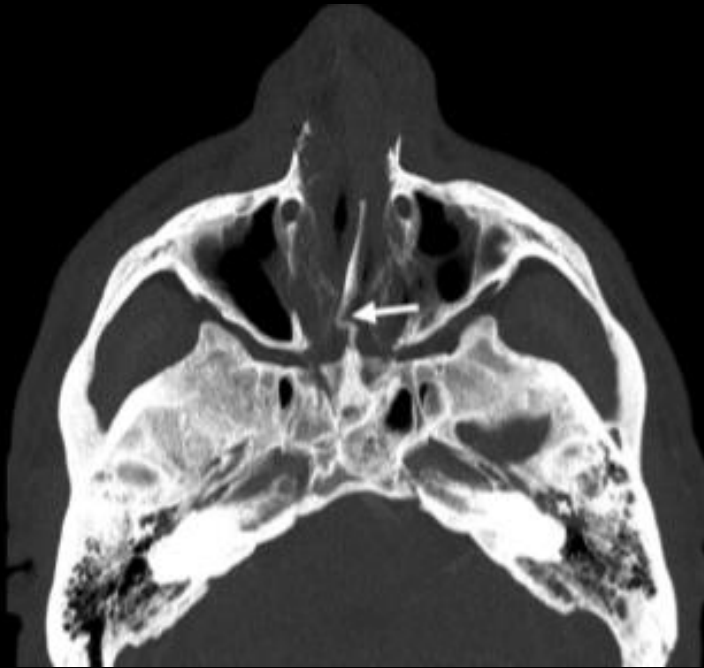
- Axial images miss 25% of nasal fractures
- Sagittal images 85%–99% sensitive nasal fractures
- CT-based grading systems underestimate the degree of cartilaginous injury



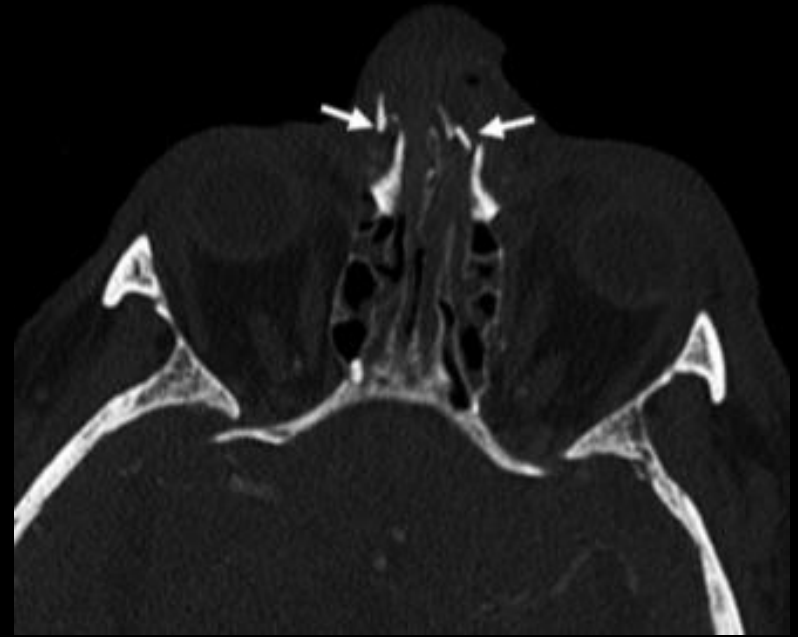
Nasoseptal Fractures

- Classification
 - Stranc
 - Grade 1: Unilateral nasal pyramid depression
 - Grade 2: Lateral displacement of the contralateral nasal bones
 - Grade 3: Displacement of both frontal maxillary processes
 - Rhee
 - Grade 0: Straight nasal septum
 - Grade 1: Deviated less than half the distance to the turbinates
 - Grade 2: Deviated more than half of this distance
 - Grade 3: Touching or almost touching the turbinates
- Rhee grade 2/3 or Stranc grade 3 fractures often require additional manipulation, straightening or splints.

Nasoseptal Fractures

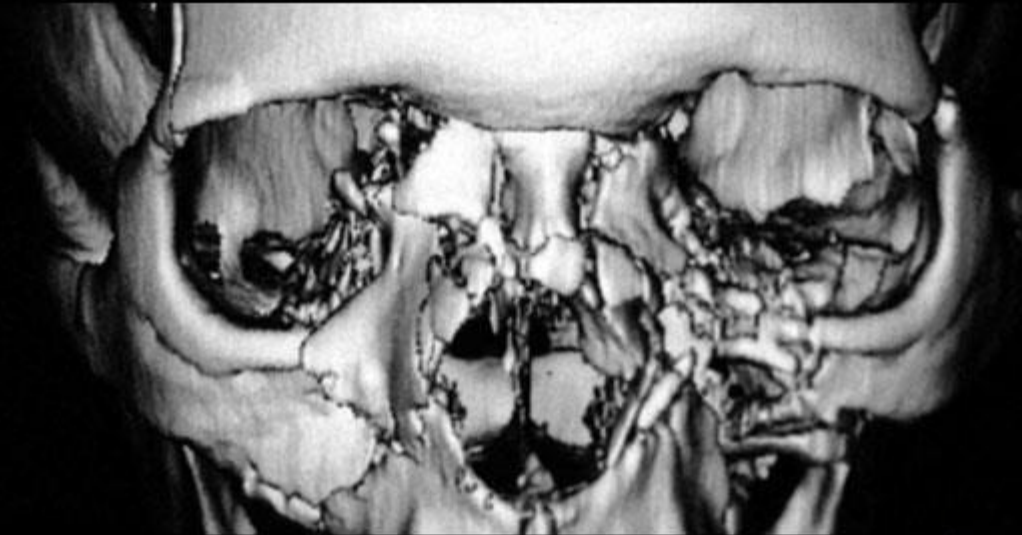


Rhee Grade 3



Stranc Grade 3

Naso-orbitoethmoid (NOE) fractures

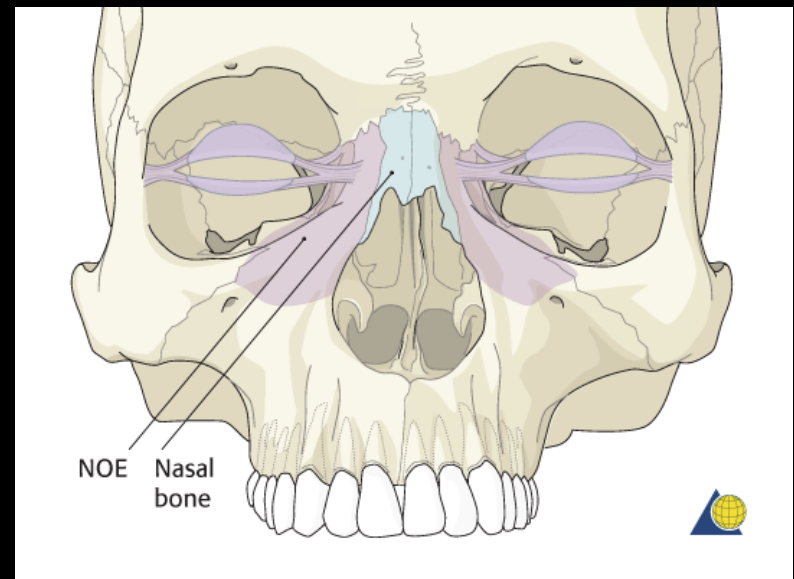


Retrieved from

https://www2.aofoundation.org/wps/portal/!ut/p/a0/04_Sj9CPykyssy0xPLMnMz0vMAFGjzOKN_AOM3D2DDbz9_UMMDRyDXQ3dw9wMDAx8jfULsh0VAdAsNSU!/?bone=CMF&segment=Midface&soloState=lyteframe&teaserTitle=&contentUrl=srg/92/01-Diagnosis/noe.jsp

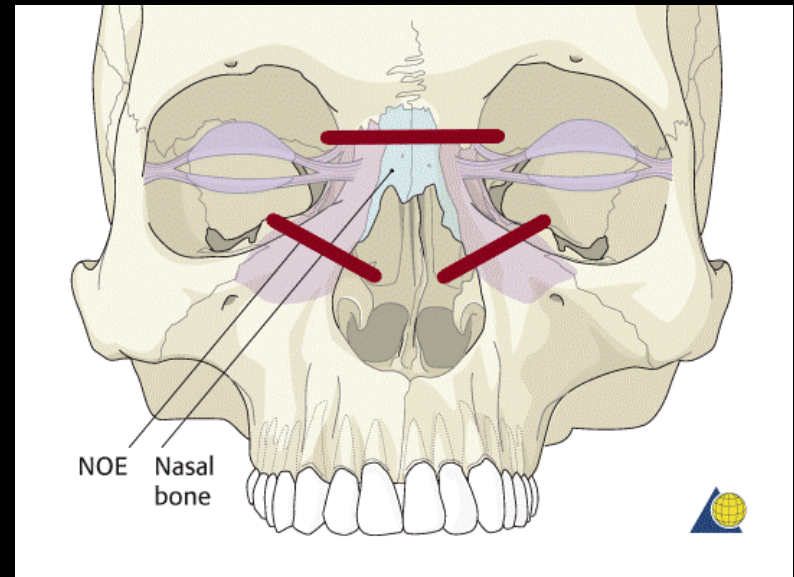
Naso-orbitoethmoid (NOE) fractures

- Central displaced fragment
- Involves at least 4 out of 5 cardinal tracts
 - Medial Orbital Wall
 - Inferior orbital rim and floor
 - Frontomaxillary suture
 - Nasomaxillary buttress
 - Lateral nose and piriform aperture



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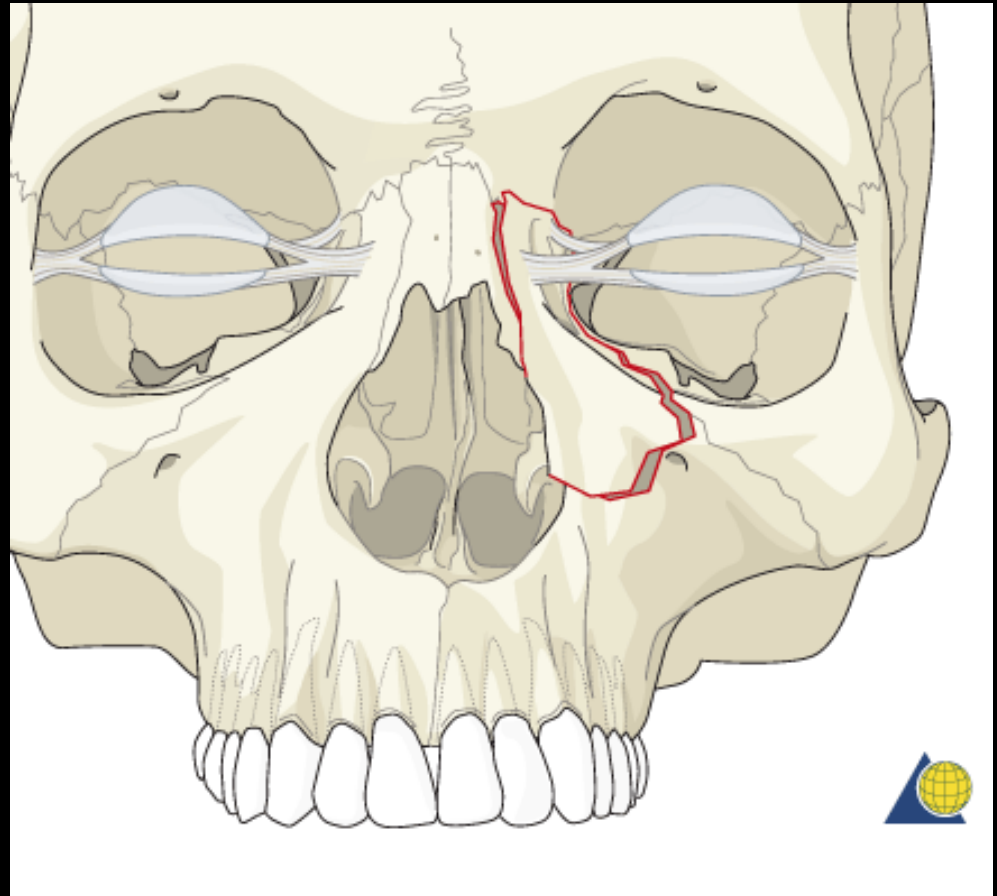
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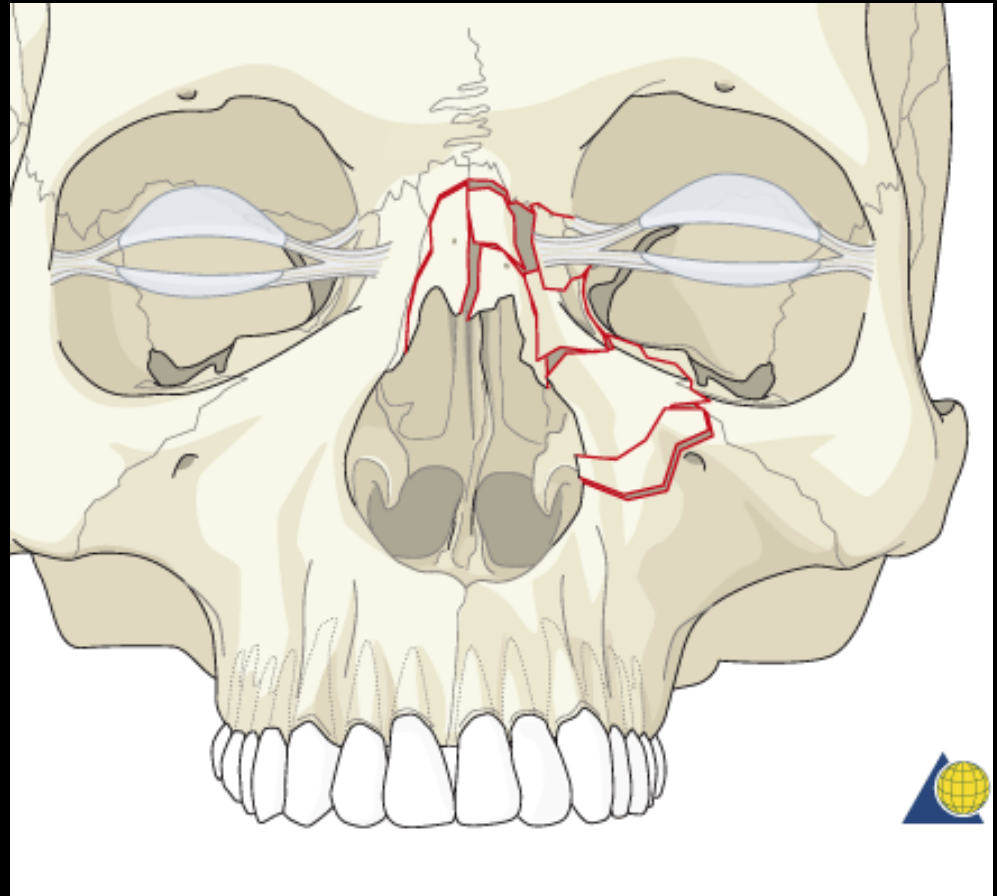
Naso-orbitoethmoid (NOE) Fracture

- Markowitz-Manson Classification
 - **Grade 1:**
 - **Single large fragment**
 - **Intact medial canthal tendon**
 - **Grade 2**
 - **Comminuted**
 - **Medial canthal tendon insertion intact**
 - **Grade 3**
 - **Severely comminuted**
 - **Medial canthal tendon rupture or tendon attached to a small fragment**



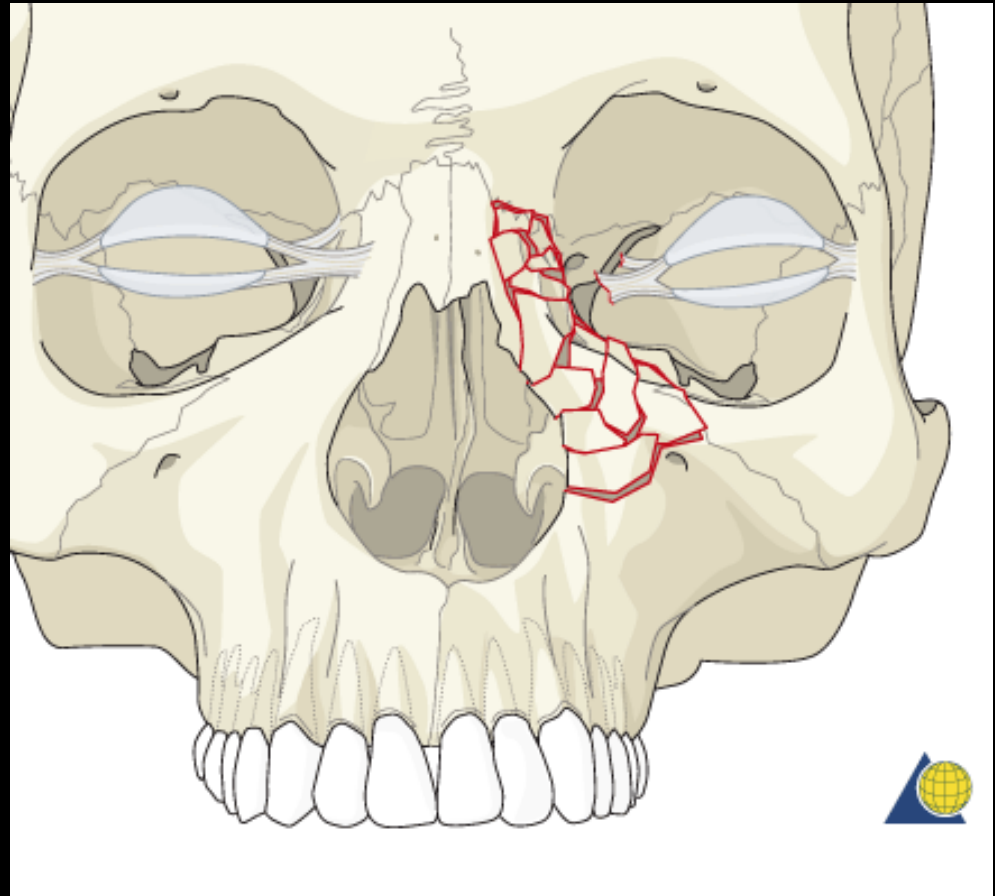
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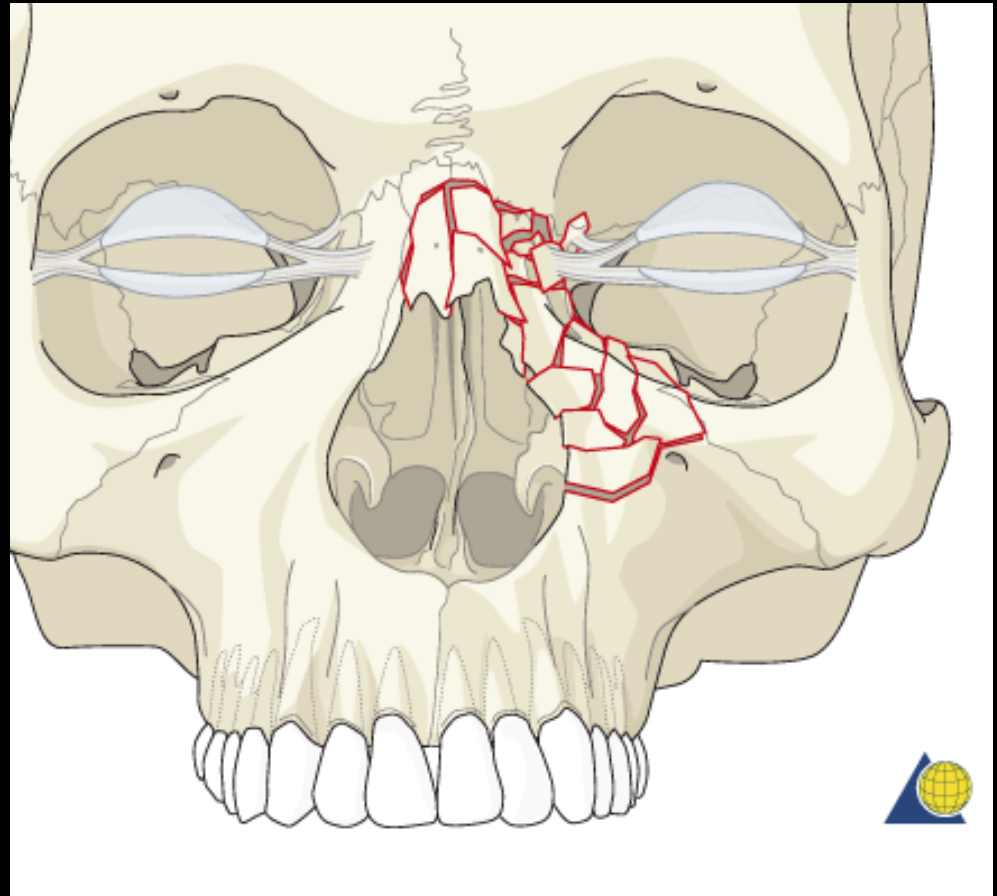
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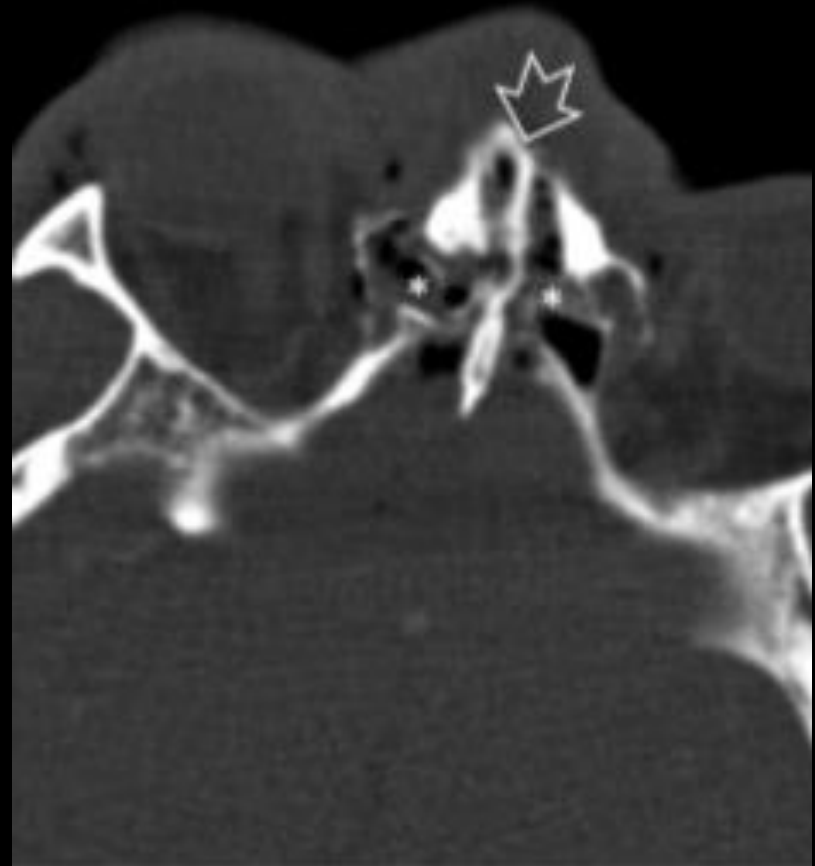
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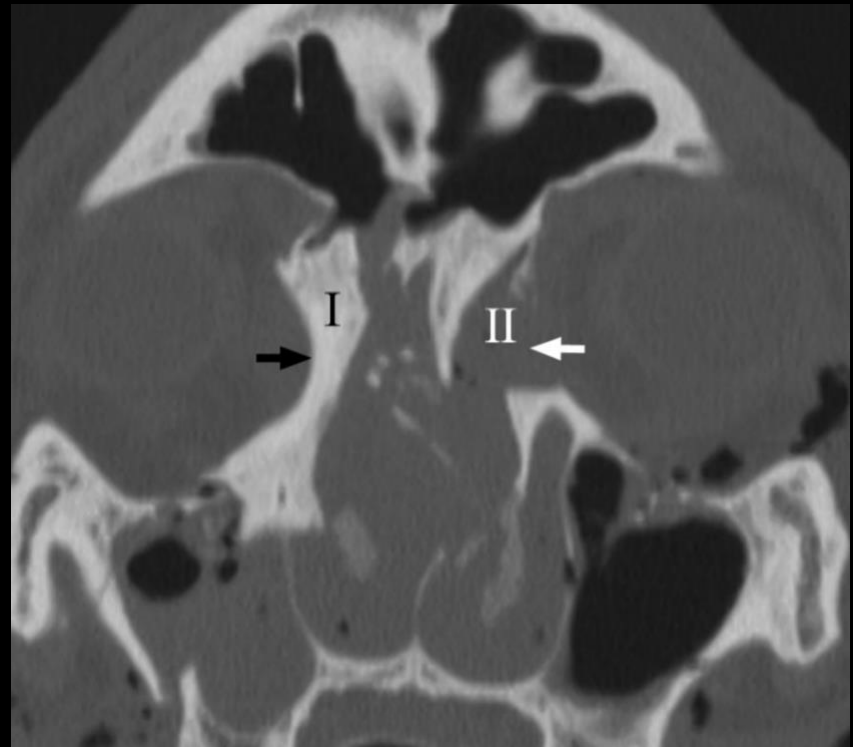
Naso-orbitoethmoid (NOE) Fracture

- Very difficult to distinguish between a type II and a type III NOE fracture by imaging
- Avulsion medial canthal tendon often has to be determined intraoperatively
- Describe the degree of comminution of the region of the lacrimal fossa (medial canthus attachment)
- Distance between the two lacrimal fossae in the coronal plane can also be important



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Naso-orbitoethmoid (NOE) Fracture

Frequently involve

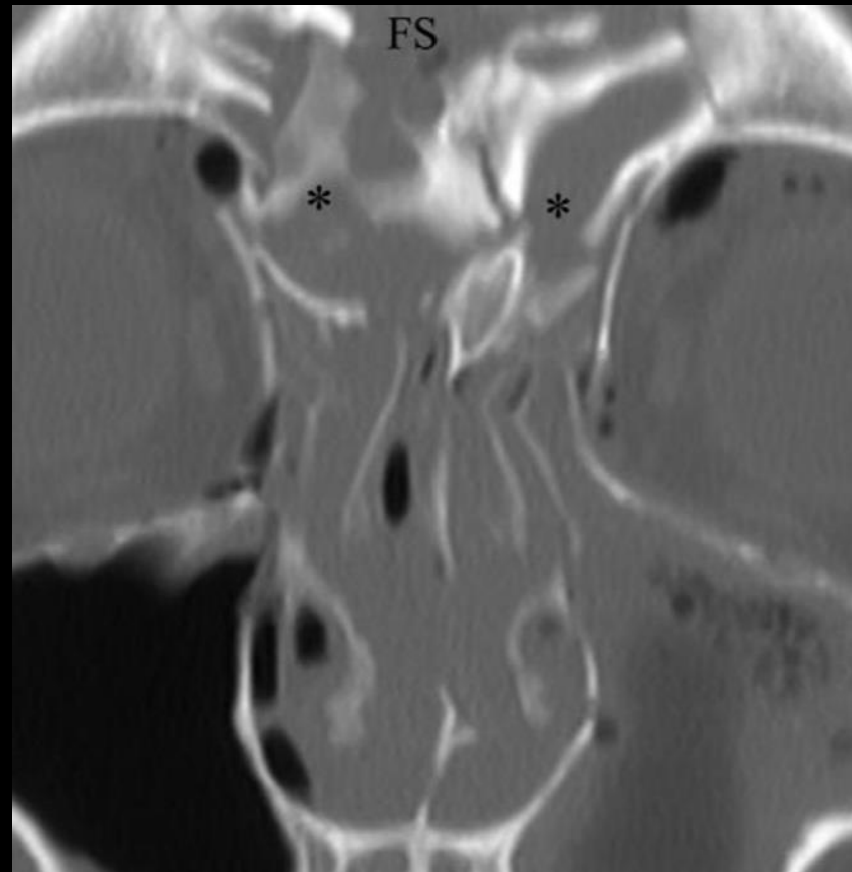
- **Nasolacrimal ducts**
 - Impairs tear and mucociliary drainage
 - Functional obstruction is clinical diagnosis
 - CT have poor diagnostic value
- Frontonasal duct injury
 - best on sagittal images
- Frontal sinuses injury
 - best on axial images



Naso-orbitoethmoid (NOE) Fracture

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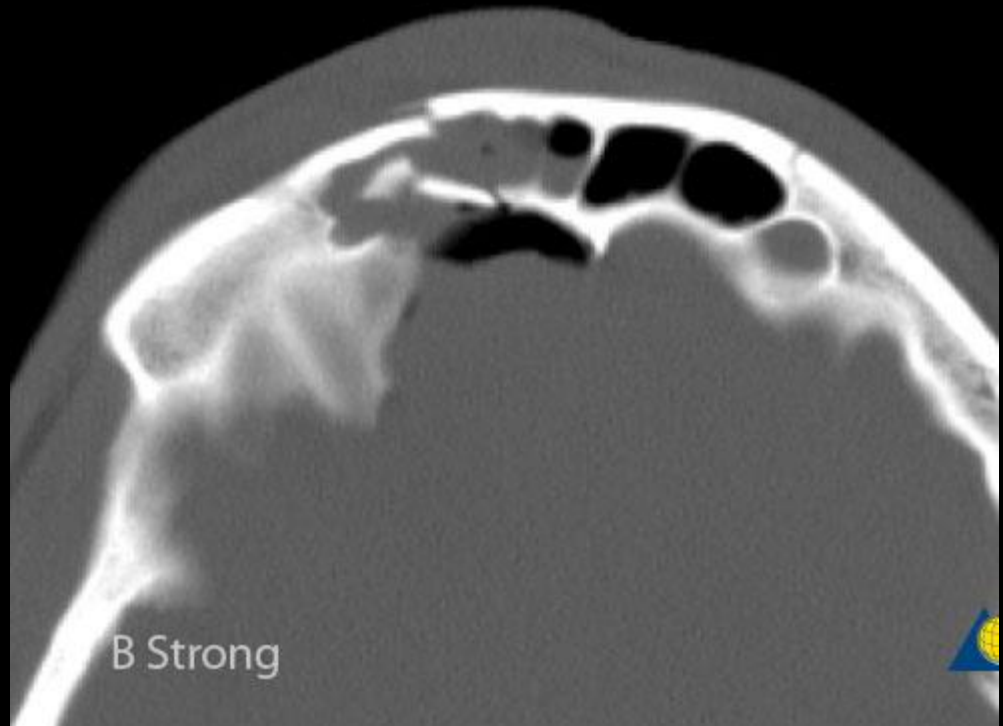
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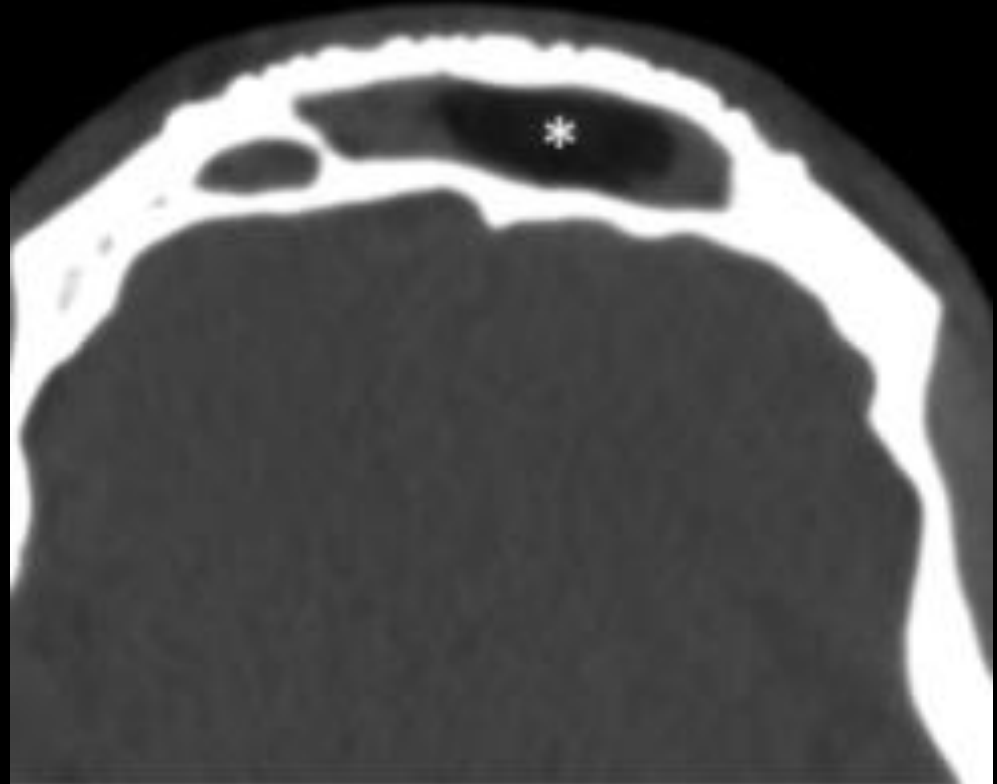
Frequently involve

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 - Impairs tear and mucociliary drainage
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 - best on sagittal images
- **Frontal sinuses injury**
 - best on axial images



Naso-orbitoethmoid (NOE) Fracture

- **Frontal Sinus and Frontonasal Duct Obstruction**
 - Mucopyoceles
 - Osteomyelitis
 - Hardware Infection
 - Meningitis
 - Brain Abscess
- Treatment involves frontal sinus obliteration.
 - Non-functioning safe sinus
 - Surgically seal frontonasal duct



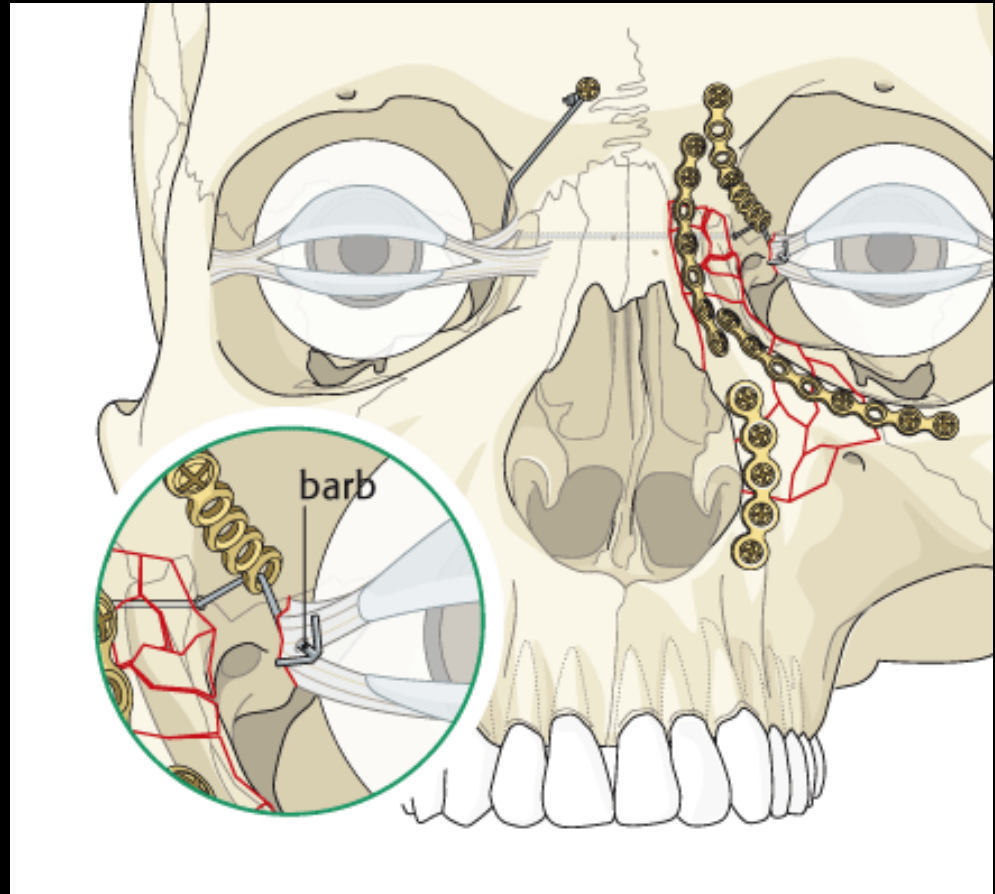
Naso-orbitoethmoid (NOE) Fracture

- Surgical fixation
- ORIF performed along three common fixation points:
 - Medial Maxillary Buttress
 - Superior Transverse Maxillary Buttress
- Grade 3 injuries require canthopexy



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- Grade 3 injuries require canthopexy



Orbital Fractures



Orbital Fractures

- CT important for diagnosis, prognosis, and surgical planning
- Not clinically apparent in unconscious patients
- Commonly occurs in combination with NOE, ZMC and Le Fort fractures

Orbital Fractures

Pure: limited to the internal orbit

- >80% of pure orbital fractures are blow-out type fractures

Impure: orbital rim involvement

- Realignment before reconstruction of the internal orbit

Orbital Fractures

Anatomy

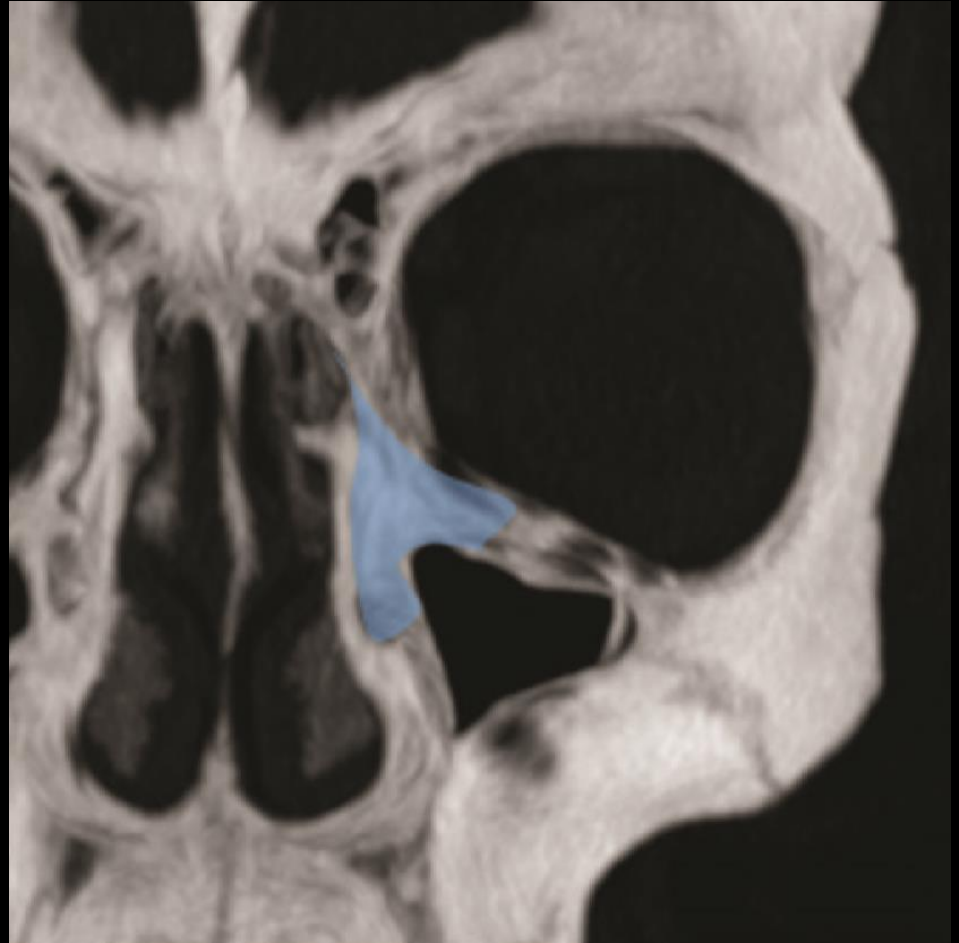
- Maxilla – floor
- Ethmoid and lacrimal – medial wall
- Frontal – roof
- Zygoma and sphenoid - lateral rim and wall



Orbital Fractures

Internal orbital buttress

- Confluence
 - medial wall of the maxillary sinus
 - medial wall of the orbit
 - orbital floor



Orbital Fractures

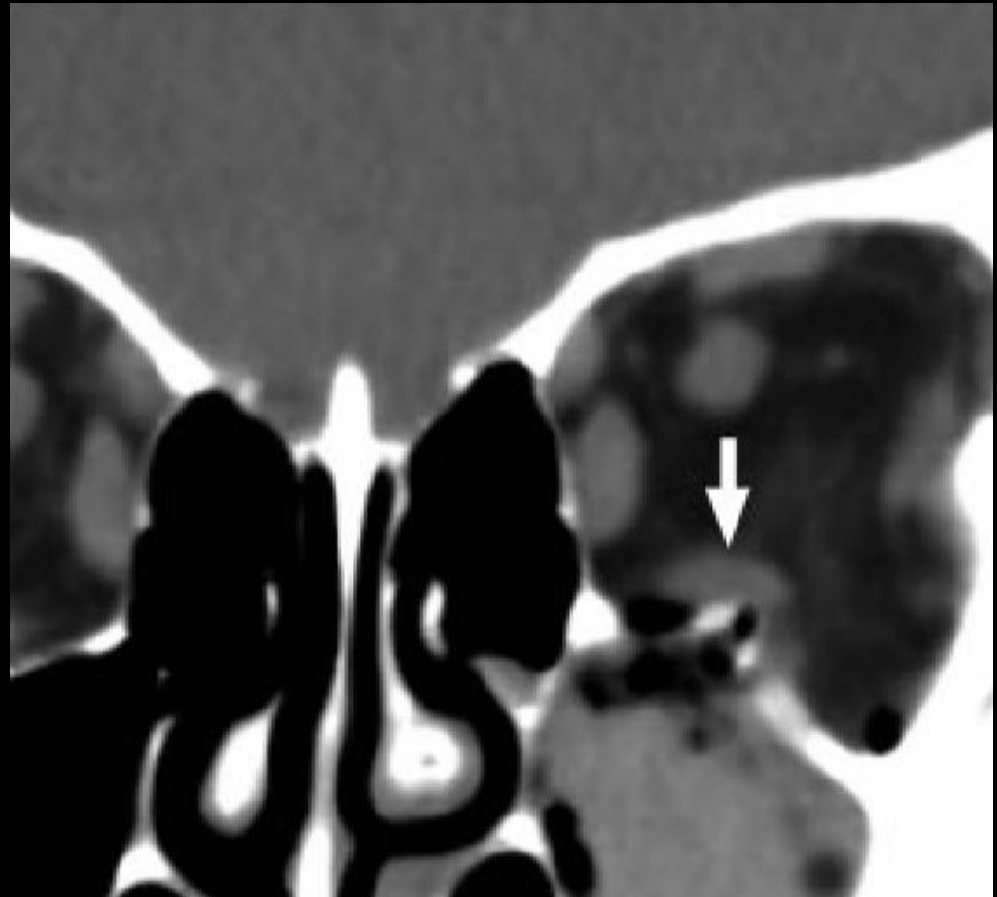
- CT reduced rate surgical exploration
 - Orbital exploration decreased from 90% in 1985 to 30% in 1989
 - Iatrogenic injury to ocular globe, muscles and nerves
- Surgical exploration mainly to prevent
 - Enophthalmos
 - Diplopia
 - Motility restriction



Orbital Blow-out Fractures

Orbital Floor Fractures

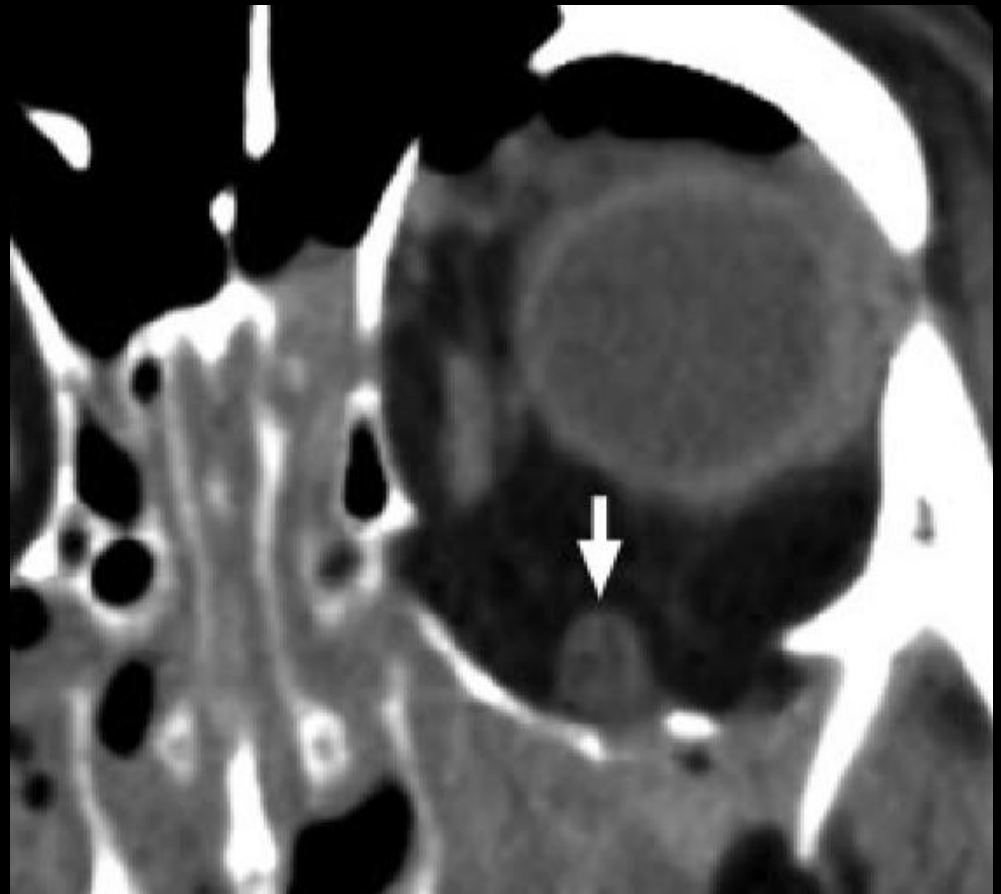
- Close attention to floor defect and adjacent muscle
- Coronal plane best for assessment
- Inferior rectus muscle – integrity of fascial sling
 - Shape
 - Round
 - Flat
 - Location
 - Displacement



Orbital Blow-out Fractures

Orbital Floor Fractures

- Close attention to floor defect and adjacent muscle
- Coronal plane best for assessment
- Inferior rectus muscle – integrity of fascial sling
 - Shape
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 - Flat
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 - Displacement



Orbital Blow-out Fractures

Medial orbital wall fractures

- Types
 - Blow-in
 - Blow-out
- Strong association with diplopia and enophthalmos in both types

Orbital Blow-out Fractures



Blow-in

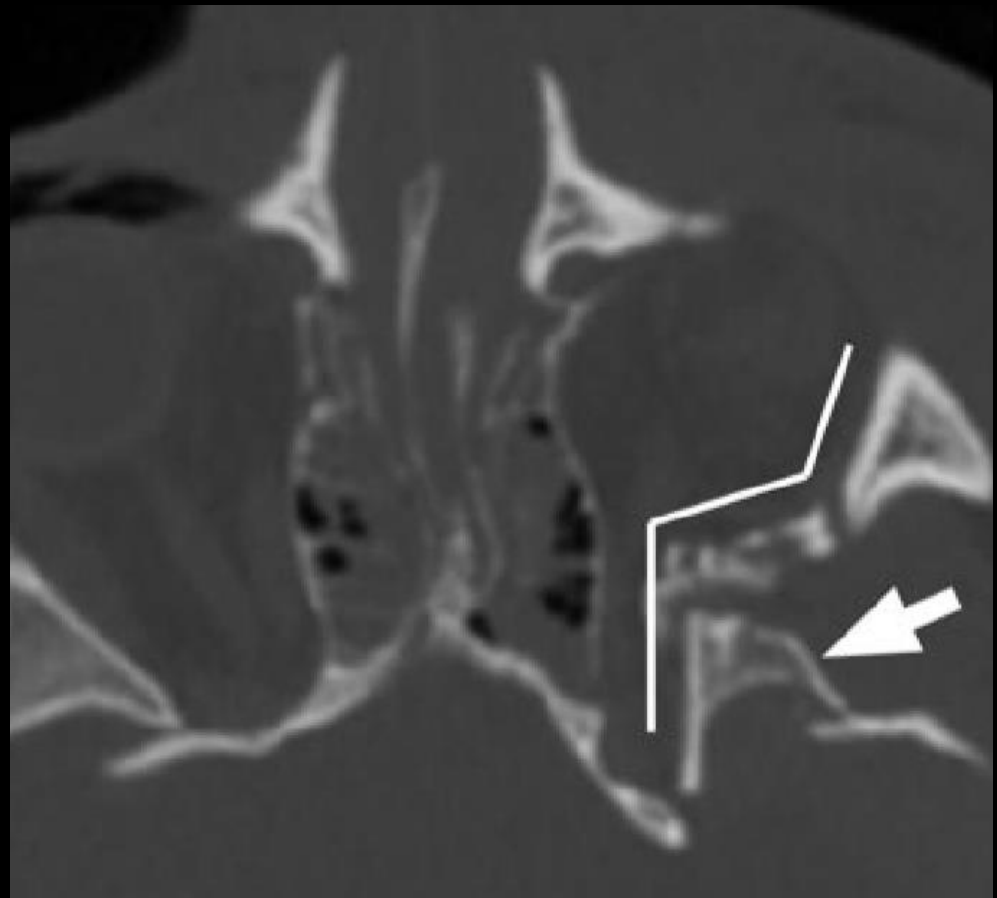


Blow-out

Orbital Blow-out Fractures

Orbital Apex fractures

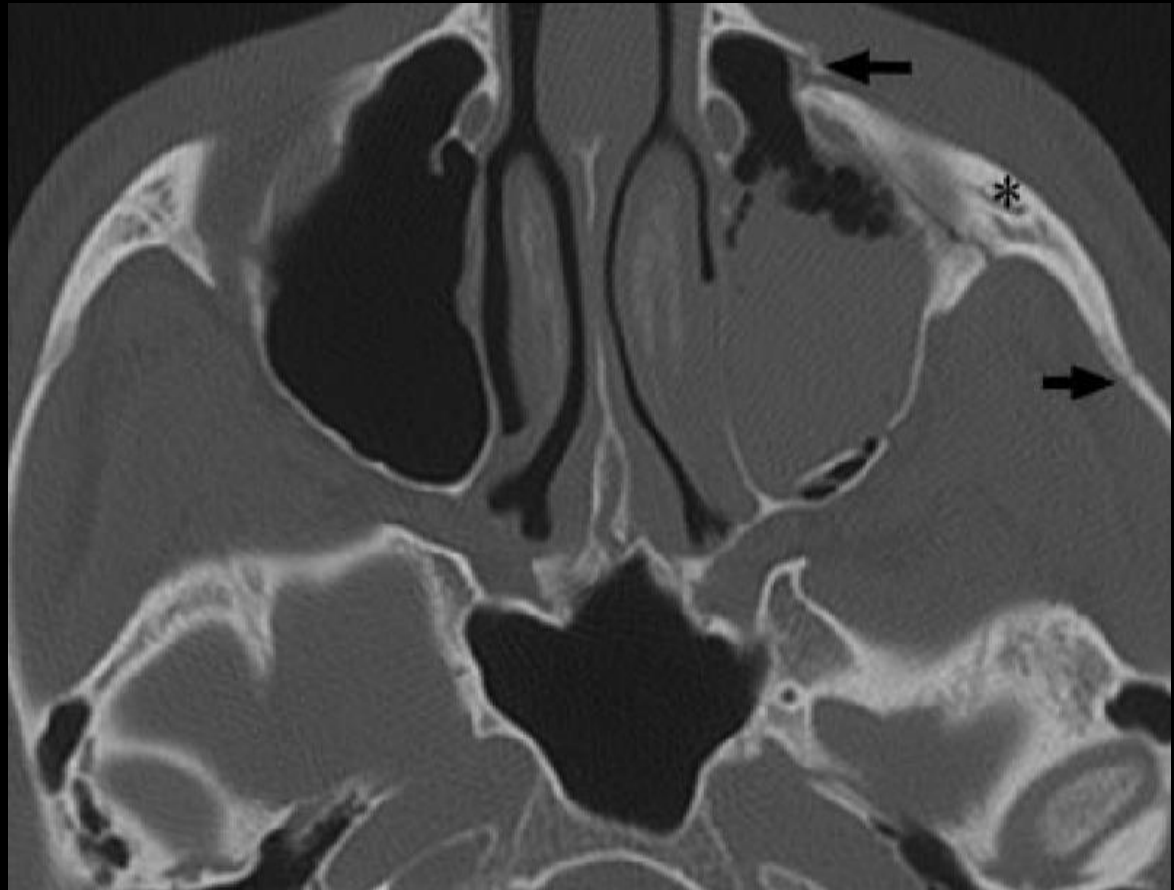
- Rare
- Optic nerve impingement
 - Hematoma
 - Bone Fragment
 - Displacement
- Emergent surgery if any finding of injury to globe or optic nerve
 - Communicate results



Orbital Blow-out Fractures

Pitfalls

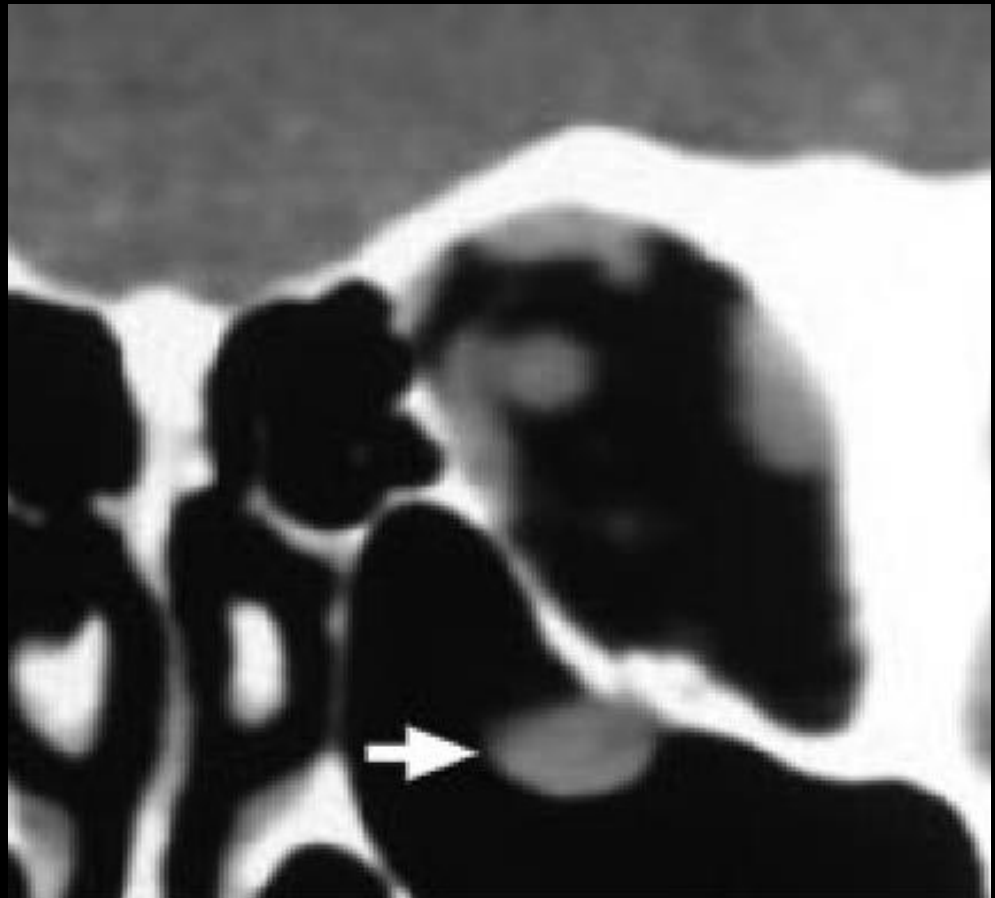
- Orbital defect underestimate in severe impacted fractures
- Defect can appear minimal in severe ZMC
- Look at zygoma relative to anatomic position to appreciate true size of defect/bone loss



Orbital Blow-out Fractures

Pitfalls

- Pediatric trapdoor fracture
- Fracture is non-displaced as bones are flexible and “springs” back in position
- CT looks normal except for prolapsed/entrapped muscle
- Urgent surgical intervention in 24-72 hours to prevent necrosis



Orbital Fractures Complications

Enophthalmos

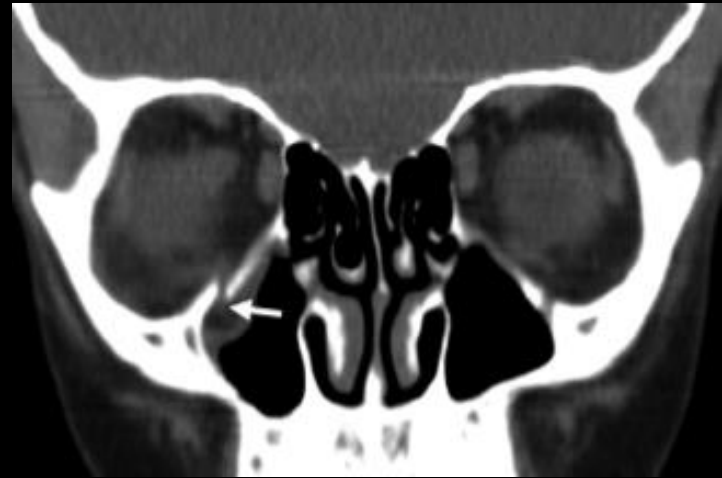
- Difficult to detect acutely clinically
 - May be normal from edema
- Linear relationship between the volume of displaced contents on CT and degree enophthalmos
- Risk factors
 - CT include defect surface area greater than 2 cm²
 - Greater than 25%–50% orbital floor or medial wall involvement
 - Collapse of the junctional bulge and internal orbital buttress
 - Soft-tissue herniation greater than 1.5 mL in volume



Orbital Fractures Complications

Diplopia and mobility issues

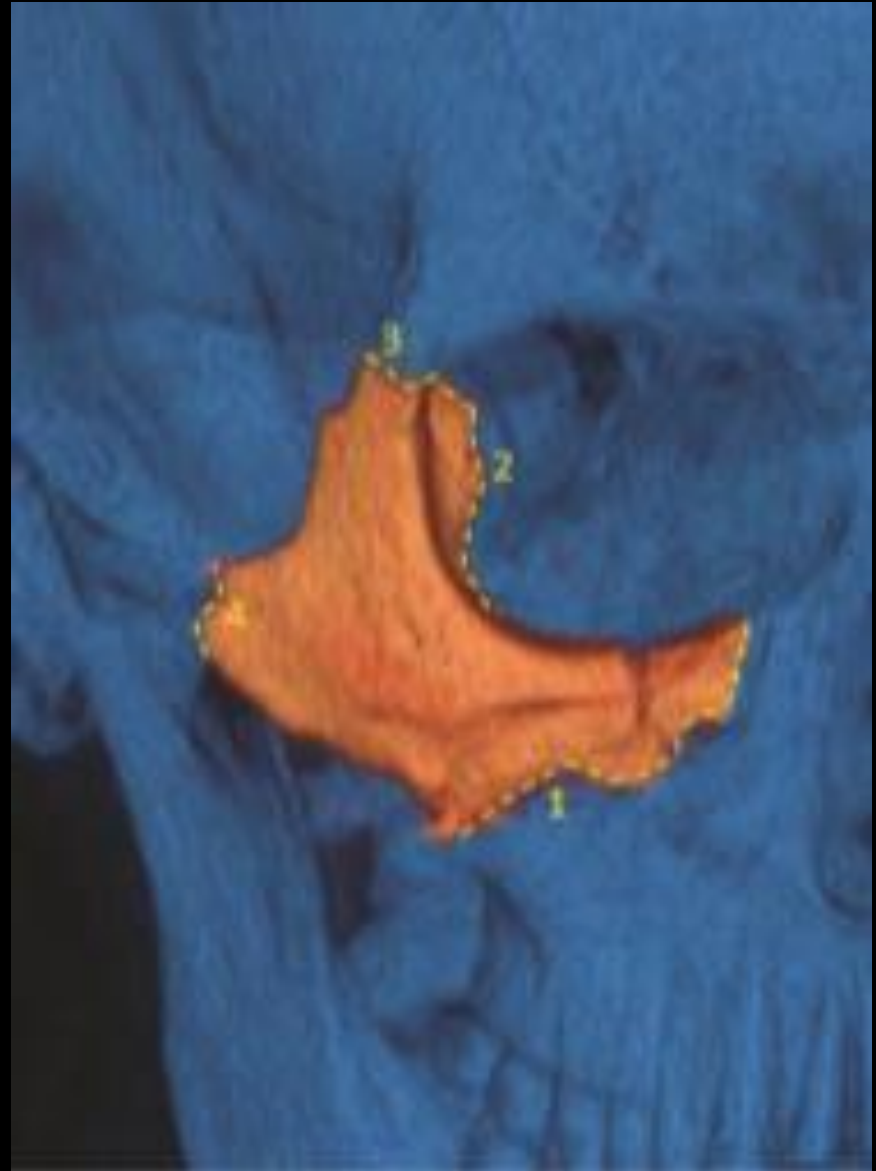
- Restricted mobility often result from fibrofatty tissue entrapment in fracture or catching on ledge of defect
- CT must correlate with physical exam
- Often self-limited related to temporary muscle paresis and contusion
- Tethering may resolve as edema improves
 - Serial CT examination important



Zygomaxillary complex (ZMC) Fractures

Tetrapod-shaped fragment displaced at four major points:

- (1) Zygomaxillary suture
- (2) Zygomaticosphenoid suture
- (3) Zygomaticofrontal suture
- (4) Zygomaticotemporal suture



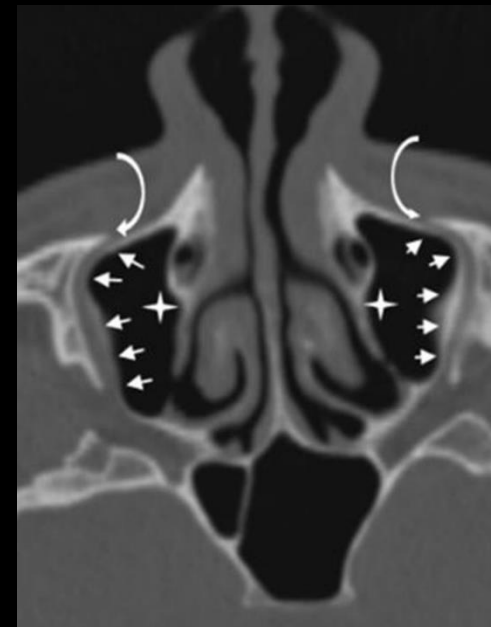
Zygomaxillary complex (ZMC) Fractures

- Disrupt alignment of lateral orbital wall
- Poor alignment or residual rotation associated with increased orbital volume and enophthalmos
- Fracture of inferior orbital rim can involve the infraorbital nerve foramen
 - Nerve injury may lead to permanent anesthesia of the cheek and a portion of the upper lip.



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Zygomaticomaxillary complex (ZMC) Fractures

Grading – Zingg Classification

- Zingg Type A – Isolated or Incomplete Fractures
 - Type A1: Isolated zygomatic arch
 - Type A2: Lateral orbital wall fracture
 - Type A3: Infra-orbital rim fracture
- Type A amenable to close reduction or single point fixation

Zygomaxillary complex (ZMC) Fractures

Grading – Zingg Classification

- Zingg Type B
 - Minimal displacement fracture of the tetrapod articulations
 - Most are unstable and can be managed single point internal fixation
 - Some cases managed with closed reduction or percutaneous pinning
- Zingg Type C
 - Comminuted fracture of the zygoma
 - All require ORIF
 - Unrecognized concurrent NOE fracture can result in facial widening



Zygomaxillary complex (ZMC) Fractures

Complications

- Facial asymmetry: malar retrusion, facial widening
- Enophthalmos: Results from fracture defect of the orbital floor $> 2 \text{ cm}^2$
 - Fracture reduction can create or enlarge defect
 - Risk of expansion greater with $>1 \text{ cm}$ posterior malar displacement



Zygomaxillary complex (ZMC) Fractures

Important findings to describe

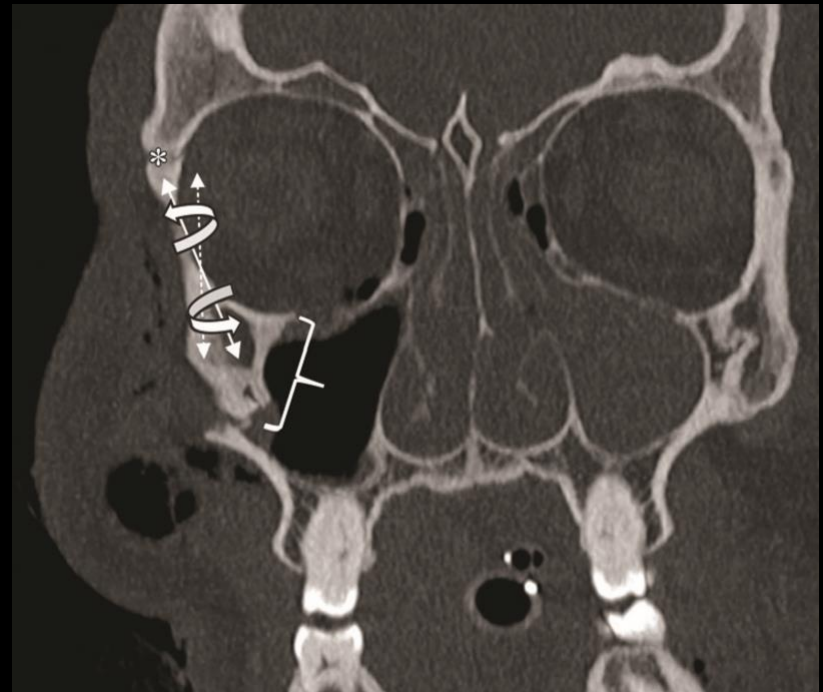
- Impaction/displacement of the zygoma
 - axial plane
- Degree of fragment rotation
- Facial symmetry depend on anatomic alignment of the malar prominence
- Orbital volume depend on alignment of lateral orbital wall



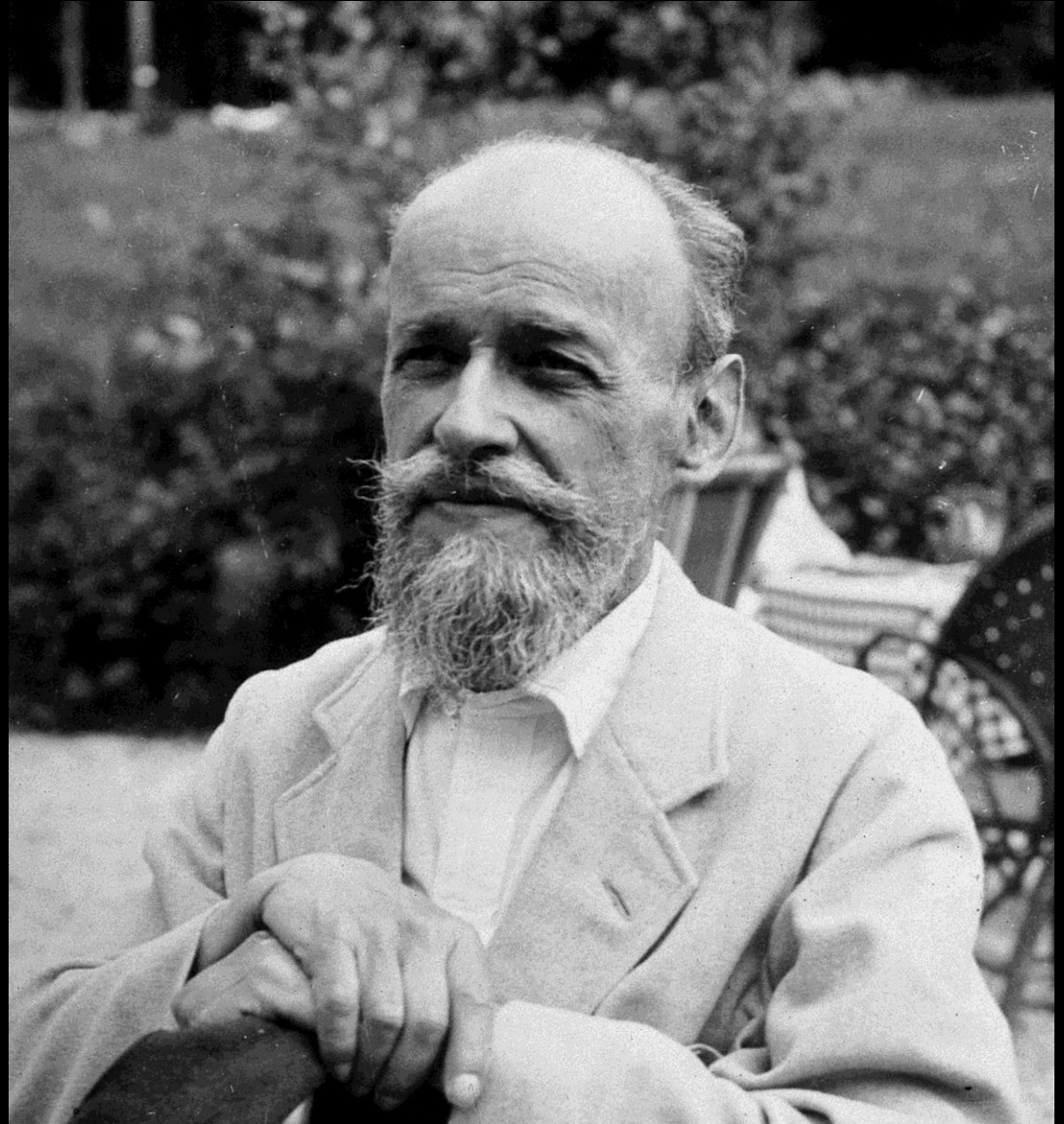
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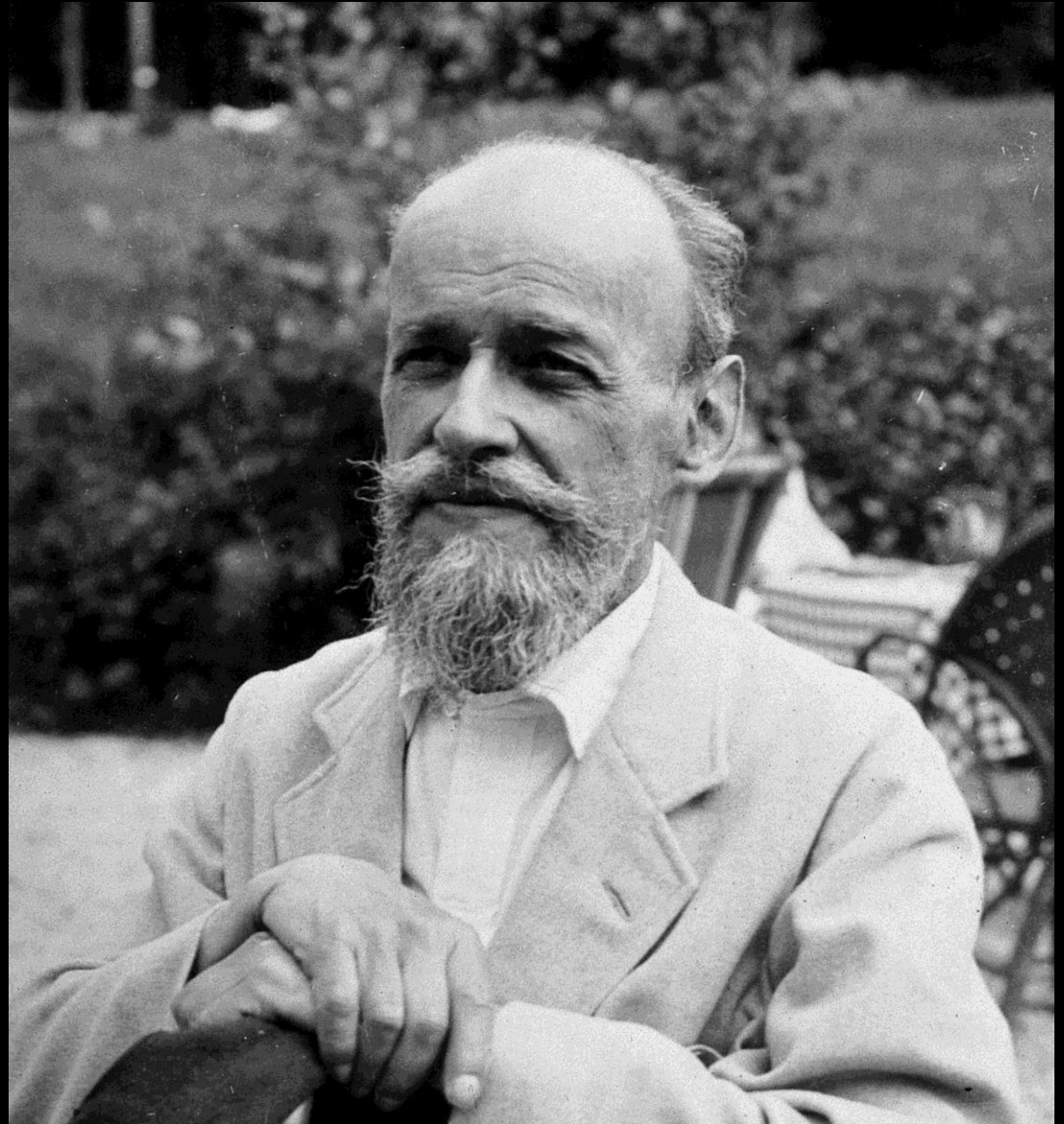


Le Fort Maxillary Fractures



Le Fort Maxillary Fractures

- French military surgeon born 1869
- 1901 *Étude expérimentale sur les fractures de la mâchoire supérieure*
- Created classification by traumatizing cadaver faces
- Anatomic lines of weakness



Le Fort Maxillary Fractures

- **Le Fort 1** “floating palate”: lateral and medial walls of the maxillary sinus
- **Le Fort 2** “floating maxilla”: frontonasal suture, inferior orbital rim and floor, maxillary sinuses
- **Le Fort 3** “craniofacial dissociation”: horizontal fracture from the frontonasal suture to the frontozygomatic suture and zygomatic arches

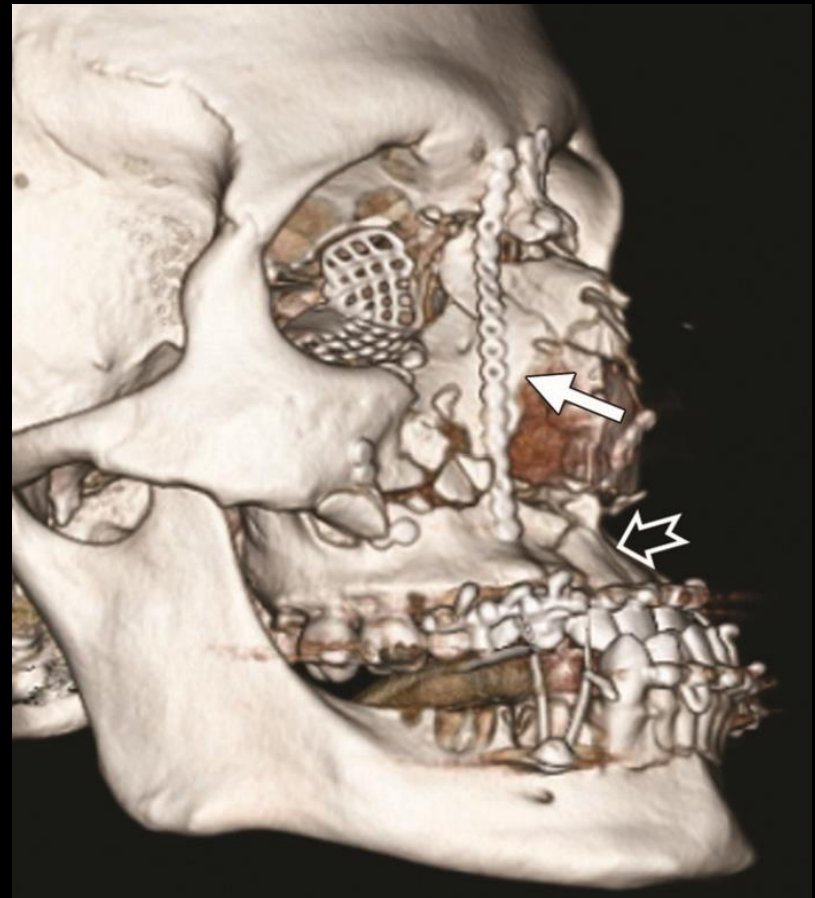


Le Fort Maxillary Fractures

- Upper level classification system outdated
- Better to describe fractures in subunits
- Commonly permutation of NOE, ZMC or Orbital fractures
- Lower level Le Fort associated with malocclusion

Le Fort Maxillary Fractures

- Occlusion-bearing fractures (lowest Le Fort level) can result in malocclusion
 - occurs in 8%–20% of Le Fort fractures
- 3D reconstructions can reveal gross malocclusions
 - Abnormal inclination
 - Open bite
 - Premature dental contact
 - Maxillary impaction
- Occlusion assessment primarily clinical



Le Fort Maxillary Fractures

Fracture Patterns most difficult to manage

- Incomplete
- Impacted
- Comminuted
- Palatal

Le Fort Maxillary Fractures

Incomplete Fractures

- Coronal CT plane best for subtle incomplete hairline fractures through maxillary walls and palatal vault
- Incomplete fractures can result in malocclusions
- Necessitate completion of nonreducible fractures by Le Fort 1 osteotomy
- High energy trauma can propagate fracture superiorly into skull base with resultant optic nerve injury and carotid-cavernous fistulas

Le Fort Maxillary Fractures

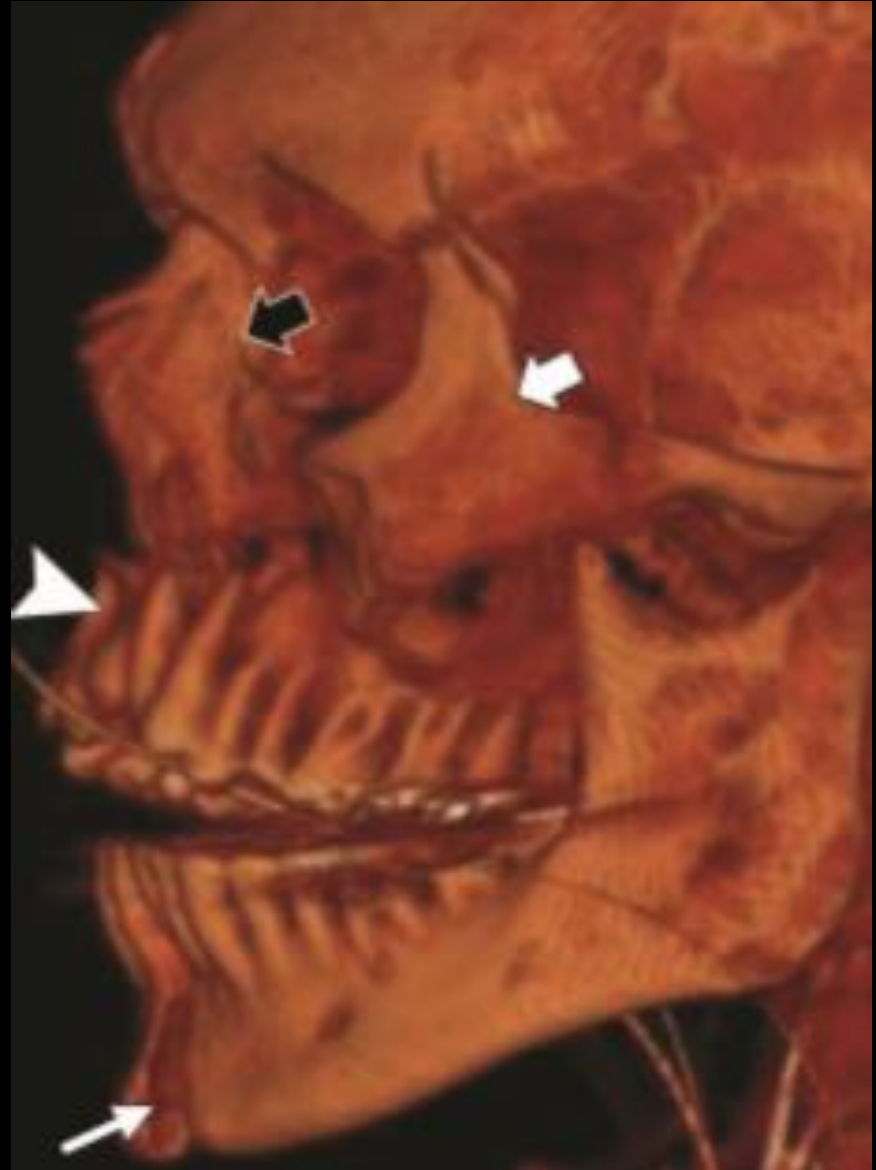
Impacted Fractures

- Retrusion and impaction of the bones of the thinned wall sinuses
- Reduction of impacted fractures require large amount of force with risk of iatrogenic injury

Le Fort Maxillary Fractures

Comminuted Fractures

- Easier to mobilize
- More difficult to stabilize with fixation hardware
- Pull by pterygoid result in anterior-superior inclination of the maxilla.



Le Fort Maxillary Fractures

Palatal Fractures

- Complications can result in palatal collapse and buccal flaring
- Three major patterns
 - Type 1 fractures (>90% of cases): Sagittally oriented
 - Type 2 fractures: Transverse orientation
 - Type 3 fractures: Complex and comminuted
 - High incidence of malocclusion and non-union
 - Long maxillomandibular fixation time
- High incidence of tooth loss




Le Fort Maxillary Fractures

- Incomplete, impacted, or severely comminuted maxillary fractures are the most difficult to manage
- Type 3 (comminuted) palatal fractures require long periods of maxillomandibular fixation
 - Comment comminution

Conclusion

- Radiologist should be familiar with fracture pattern and grade of injury
- Describing individual fractures not helpful
- Understand complications and clinical/intra-operative considerations for each midfacial subunit



Thank You!

References

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