Facial and Orbital Fractures

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Outline of Discussion

• Introduction to our patient
• Orbital anatomy
• Recommended imaging studies
• Presentation and radiological findings of various facial and orbital fractures
• Potential complications of orbital fractures
• Revisiting our patient
Patient Presentation – P.Q.

CC: Trauma patient, s/p fall from 70 feet.
HPI: brought to E.R. s/p fall from 70 feet with multiple injuries including facial and orbital fractures.
Defining the Orbital Walls

- **Medial Wall**: ethmoid bone (paper thin), lacrimal bone, body of sphenoid (posteriorly), frontal bone (superiorly), maxilla (inferiorly)
- **Lateral Wall**: zygomatic bone anteriorly, greater wing of sphenoid bone posteriorly.
- **Roof**: frontal bone, lesser wing of sphenoid bone containing optic canal
- **Floor**: maxilla and zygomatic bone anteriorly, palatine bone posteriorly
Bony Orbit

Bony Orbit – Medial Wall

Frontal

Lacrimal

Ethmoid

Sphenoid

Paranasal Sinuses

Plain Film

CT

Frontal
Ethmoid
Maxillary

### Extraocular Muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Primary Action</th>
<th>Secondary Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral Rectus</td>
<td>Abduction</td>
<td>None</td>
<td>CN VI</td>
</tr>
<tr>
<td>Medial Rectus</td>
<td>Adduction</td>
<td>None</td>
<td>CN III</td>
</tr>
<tr>
<td>Superior Rectus</td>
<td>Elevation</td>
<td>Adduction Intorsion</td>
<td>CN III</td>
</tr>
<tr>
<td>Inferior Rectus</td>
<td>Depression</td>
<td>Adduction Extorsion</td>
<td>CN III</td>
</tr>
<tr>
<td>Superior Oblique</td>
<td>Intorsion</td>
<td>Depression Abduction</td>
<td>CN IV</td>
</tr>
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</tr>
</tbody>
</table>
Extraocular Muscles

www.eyeplastics.com/orbital_anatomy.htm
Extraocular Muscles

Orbital **Arteries** and **Veins**

**Arteries**

Ophthalmic Artery is the first intracranial branch of internal carotid Artery. Accompanies optic nerve through optic canal and branches into:

1) Retinal Artery
2) Lacrimal Artery
3) Muscular Branches
4) Long and Short Posterior Ciliary Arteries
5) Medial Palpebral Arteries
6) Supraorbital and Supratrochlear Arteries

**Veins**

Vortex veins, anterior ciliary veins, and central retinal vein drain into superior and inferior ophthalmic veins

**Superior ophthalmic vein** passes through superior orbital fissure and communicates with cavernous sinus

**Inferior ophthalmic vein** passes through inferior orbital fissure to communicate with pterygoid plexus
Nerves of the Orbit

**Oculomotor Nerve (CN III):** enters via superior orbital fissure
- Superior Division: levator palpebrae, superior rectus muscle
- Inferior Division: medial and inferior recti, inferior oblique muscles, parasympathetic fibers to ciliary ganglion

**Trochlear Nerve (CN IV):** enters via superior orbital fissure
- innervates superior oblique muscle

**Abducent Nerve (CN VI):** enters via the superior orbital fissure
- Innervates lateral rectus muscle.
Nerves of the Orbit

**Trigeminal Nerve (CN V):**

- **Ophthalmic Branch:** enters via superior orbital fissure
  1) *lacrimal nerve:* provides sensory innervation to lacrimal gland
  2) *frontal nerve:* divides into supraorbital and supratrochlear nerves and provides sensation to brow and forehead
  3) *nasociliary nerve:* sensation to cornea, iris, and ciliary body
- **Maxillary Branch:** enters via inferior orbital fissure becomes the *infraorbital nerve* and exits via the infraorbital foramen provide sensory innervation to lower lid and cheek
Nerves of the Orbit

Optic Nerve (CN II):
• contains axons of ~1 million retinal ganglion cells.
• 80% is composed of visual fibers that travel to the visual cortex via the lateral geniculate body.
• 20% is composed of pupillary fibers that terminate in the pretectal area.
• Exits via the optic canal.

The optic nerve is ensheathed with fibrous wrappings which are continuous with the outer layers of the eye and the meninges.
The Orbital Apex

Entry point of
• Nerves
• Blood vessels

Site of origin of all EOM, except inferior oblique

The Anterior Orbit

Orbital Contents

Putting It All Together

Causes of Orbital Trauma

- Motor vehicle accidents
- High acceleration injuries
- Violent crime
- Athletic accidents
- Industrial accidents
Imaging Studies

• **Plain Films** in patients who show no neurological abnormalities or in patients who have suspected foreign body. Use Caldwell and Waters views.

• **High resolution axial CT** is primary imaging modality using both axial and coronal views.

• **CT angiogography** if there is concern for vascular injury such as carotid cavernous fistula.

• **MR** useful for evaluating vascular injuries and pseudoaneurysms, lacrimal drainage injury, motility disorders, and for surgical planning. Contraindicated until metallic foreign body ruled out.

• **US** can detect intraocular foreign bodies, globe rupture, suprachoroidal hemorrhage, and retinal detachment.
Types of Orbital Fractures

Orbital fractures are often associated with optic nerve injuries, paranasal sinus injuries, and/or intracranial injuries.

Types of orbital fractures include:

• Le Fort Fractures
• Medial Orbital Fractures
• Orbital Floor Fractures
• Orbital Roof Fractures
• Lateral (Zygomatic, Tripod) Fractures
• Naso-Ethmoidal Orbital Fractures
• Orbital Apex Fractures
Definitions

• **Blow-out Fracture:**
  - outward fracture of involved orbital bones.
  - Usually involves medial wall and floor.
  - Results in increased intraorbital volume and enophthalmos.

• **Blow-in Fracture:**
  - fracture of orbital bones inward into the orbital space.
  - Results in decreased orbital volume and proptosis.
Le Fort’s Fractures

Le Fort’s fractures are horizontal fractures that involve the maxilla bilaterally.

- **Le Fort I**: no orbital involvement.
- **Le Fort II**: medial orbital wall affected. Fracture of nasal, lacrimal, and maxillary walls. May involve nasolacrimal duct.
- **Le Fort III**: medial and lateral walls and floor affected. Craniofacial dysjunction. May involve optic canal.

Medial Wall Fractures

- Involves maxilla, lacrimal, and ethmoid bones.
- Associated with orbital floor fracture, depressed nasal bridge, traumatic telecanthus.
- Can get blow-out and prolapse of tissues into ethmoid and sphenoid sinuses.

Medial Wall Fracture

Signs and Complications

• Periorbital emphysema which develops when patient blows nose
• Defective motility: involving abduction and adduction because of medial rectus entrapment.
• Severe epistaxis if ethmoidal artery is damaged
• CSF rhinorrhea
• Lacrimal system injury

Medial Wall Fracture

Coronal CT
- Blow-out fracture of medial wall
- Blow-out fracture of orbital floor

Fracture of the Orbital Floor

- Caused by sudden increase in orbital pressure by small object.
- Floor fractures anteriorly through the maxillary bone and posteriorly along the thin bone covering the infraorbital canal.
- Orbital contents may prolapse and become entrapped in maxillary sinus.

Complications of Orbital Floor Fracture

- ecchymosis and edema
- Infraorbital nerve anesthesia: due to involvement of infraorbital canal
- Diplopia: caused by hemorrhage or edema, mechanical entrapment within the fracture, or direct injury to extraocular muscle
- Ocular damage
- Enophthalmos
- Globe ptosis
- Orbit and lid emphysema

Orbital Floor Fracture

CT scan demonstrates
- fracture of the orbital floor with displacement of inferior rectus muscle through the defect.

Arrowhead = optic nerve sheath hematoma
Open arrow = downward displacement of inferior rectus muscle

Roof Fractures

Pathogenesis: children have isolated minor trauma. Adults more likely to have complicated fractures from major trauma. May involve frontal sinus, cribiform plate, and brain.

Signs:
- Hematoma of the upper lids and periocular ecchymosis
- Inferior or axial globe displacement
- Pulsation of the globe may be seen in large fractures
- Supraorbital hypesthesia
- Ptosis
- Limited elevation and depression of the eye

Roof Fractures

Complications

- CSF rhinorrhea: localized by CT cisternography after intrathecal contrast administration
- Pneumocephalus: The frontal sinus dissipates the impact and is often fractured. Violation of posterior wall of frontal sinus require surgical repair.


fracture of posterior wall of frontal sinus

cerebral hemorrhage
Roof Fractures

Coronal CT of left orbital roof fracture demonstrating pneumo-orbit and pneumocephalus (arrow)

*Mauriello et al.* The Radiologic Clinics of North America, 1999, 37:1, page 244
Lateral Wall Fractures

- Bone is more solid
- Associated with extensive facial damage
- Fractures rarely occur alone
- Frequently part of a complex tripod or Le Fort III fracture.

Tripod Fractures
Involves fracture of three bones:
- Zygomaticofrontal suture superiorly
- Zygomatic arch laterally
- Zygomaticomaxillary suture inferomedially
Combined Fractures – Tripod Fracture

- A: coronal spiral CT shows separated frontozygomatic suture
- B: 3D reformatted spiral CT shows lateral displacement of lateral orbital wall
- C: 3D reformatted spiral CT shows downward displacement of trimalar complex.

Naso-Ethmoidal Orbital Fractures

- Often caused by MVA in which patient strikes the nose on the dashboard.
- Thick anterior bones cause telescoping of posterior thinner bones.
- Usually cause a blow-in fracture but occasionally cause blow-out into ethmoid sinus of medial wall.

www.erlanger.org/craniofacial/book/Trauma/Trauma_4.htm
Naso-Ethmoidal Orbital Fractures

Orbital Apex Fractures

- Usually in association with other facial fractures
- May involve optic canal and superior orbital fissure and cause injury to nerves in the area
- **Optic nerve** injury may be caused by mechanical tearing or laceration, stretching, torsion, contusion, compression, ischemia, hemorrhage, or thrombosis
- Must look for foreign bodies
- Complications:
  1) CSF leaks
  2) carotid-cavernous fistula
  3) loss of vision
Orbital Apex Fractures

- Intraocular hemorrhage from penetrating injury
- Intraocular air
- Intraocular blood

- Axial CT of fracture of ethmoid and medial wall of optic canal

- Axial CT of nerve sheath hematoma

Complications of Orbital Trauma

- Foreign bodies (Radiographs, US, CT, **NOT MRI**)
- Diplopia from muscle entrapment
- Globe rupture
- Suprachoroidal hemorrhage (US)
- Retinal detachment (US)
- Carotid cavernous fistula (CT, MRI, arteriography)
- Lens dislocation (US)
- enophthalmos
Foreign Bodies


BB at orbital apex


Plain radiograph (Waters view) showing left foreign body


B scan Ultrasound shows intraocular foreign body
Other Complications

Carotid Cavernous Fistula

Suprachoroidal Hemorrhage


Patient D.W.

Findings on CT: contiguous axial images from the foramen magnum through the cranial vertex

- Multiple comminuted fractures involving the bilateral maxillary sinuses and ethmoid air cells
- Fracture of lamina papyracea bilaterally
- Fracture of the left zygomatic arch
- Extensive blood and soft tissue density within maxillary, ethmoid, sphenoid, and frontal sinuses as well as mastoid air cells
- No gross abnormalities of the brain
Patient P.Q.

Fractures of maxilla

Blood in maxillary sinus

Courtesy of Beth Israel Deaconess Medical Center
Fracture of left zygomatic bone

Blood in sphenoid sinus

Blood in ethmoid sinus

Fracture of lamina papyracea

Patient P.Q.

Courtesy of Beth Israel Deaconess Medical Center
Patient P.Q.

Blood within frontal sinus

Courtesy of Beth Israel Deaconess Medical Center
References

- [www.erlanger.org/craniofacial/book/Trauma/Trauma_4.htm](http://www.erlanger.org/craniofacial/book/Trauma/Trauma_4.htm)
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