

THE ORBIT

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I. ORBITAL ANATOMY

1. BASICS TO REMEMBER

Orbital dimensions

Volume = 30cc (one shot glass)

Height = 35mm

Width = 40mm

Orbital optic nerve = 25mm

Back of globe to apex = 18mm

Excess optic nerve = 7mm

Orbital volume	30cc
Globe volume	6.5cc
Width	45mm
Height	35mm
Maximum circumference	1cm behind rim
Length of medial orbital wall	40-45mm
Embryologic origin	Neural crest, except superotemporal orbit (mesoderm)

Table 1. ORBITAL MEASUREMENTS

2. BONY ANATOMY (Fig. 1)

- **ORBITAL BONES: ROOF**

Frontal bone: Lacrimal gland fossa, trochlea

Lesser wing of sphenoid

- **ORBITAL BONES: LATERAL**

Greater wing of sphenoid

Zygoma: Whitnall's tubercle, 50% of globe exposed

- **ORBITAL BONES: FLOOR**

Maxilla

Zygoma

Palatine bone

- **ORBITAL BONES: MEDIAL**

Maxilla

Lacrimal bone: lacrimal sac fossa

Ethmoid bone

Body of the sphenoid: contains optic canal

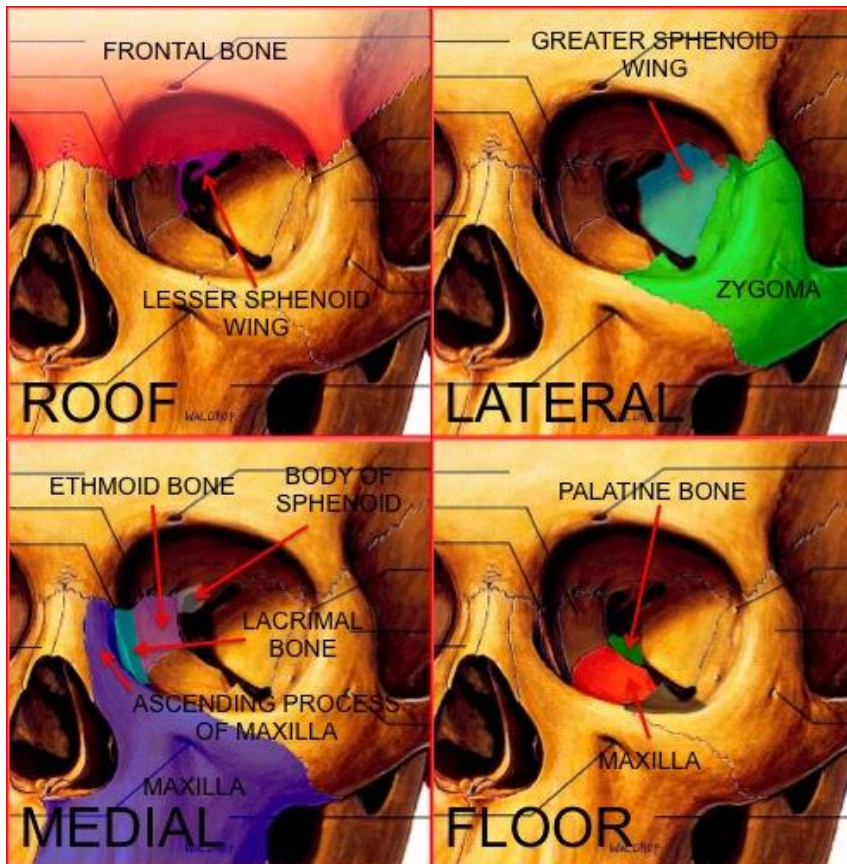


Figure 1.

ORBITAL WALL	BONES	BORDERS
Superior (roof)	Frontal, sphenoid (lesser wing)	Anterior cranial fossa, frontal sinus
Lateral	Zygoma, sphenoid (greater wing)	Temporal fossa, pterygopalatine fossa
Inferior (floor)	Maxilla (medial), zygoma (lateral), palatine (posterior)	Infraorbital canal, maxillary sinus
Medial	Maxilla, lacrimal, ethmoid, sphenoid (anterior to posterior)	Ethmoid and sphenoid sinuses, cribriform plate at frontoethmoidal suture

Table 2. ORBITAL WALLS

FLOOR	- Slopes upward anterior to posterior $\approx 20^\circ$. - Does not reach orbital apex (ends at pterygopalatine fossa). - Only wall without sphenoid bone contribution.
ROOF	Contains: - Trochlea (4mm behind orbital rim). - Lacrimal gland fossa (postseptal) - Supraorbital notch
MEDIAL	- Medial wall are parallel, 25mm apart. "Paper thin" – lamina papyracea - Lacrimal sac fossa (preseptal)
LATERAL	- Lateral walls are perpendicular to one another. - Strongest wall, but offers least protection to globe (because only 50% of globe is covered). - Contains lateral orbital tubercle (of Whitnall).

Table 3. ANATOMIC FINDINGS OF EACH ORBITAL WALL

- **OSTEOLOGY**

The supraorbital and infraorbital foramina usually lie in the same vertical plane.

Anterior ethmoidal and posterior ethmoidal foramina indicate the level of the cribriform plate.

The orbital floor tilts toward the apex 15-20 deg.

The inferior orbital fissure extends to within 1 cm of the inferior orbital rim.

ORBITAL OPENING	FEATURES
Supraorbital notch (foramen)	Frontal nerve (supraorbital nerve, V-1).
Anterior ethmoidal foramen	20-24 mm behind rim at fronto-ethmoidal suture (level of cribriform plate).
Posterior ethmoidal foramen	12mm posterior to anterior ethmoidal foramen, 5-8 mm anterior to optic foramen.
Zygomatic foramina	Zygomaticofacial and zygomaticotemporal neurovascular bundles.
Nasolacrimal duct	Beginning at the lacrimal fossa and opening intranasally in the inferior meatus (beneath inferior turbinate).
Infraorbital foramen	Exits 4-10 mm below orbital rim; infraorbital neurovascular bundle (V-2).
Optic foramen	Optic nerve, ophthalmic artery, sympathetic fibers. Diameter 6.5mm, length 10 mm.
Superior orbital fissure	Length: 22 mm Between greater & lesser wings of sphenoid Below and lateral to optic foramen Split in two portions by lateral rectus <u>Lateral</u> : lacrimal, frontal, trochlear nerves <u>Medial</u> : CN III (superior and inferior divisions), nasociliary, CN VI, superior ophthalmic vein, sympathetics/parasympathetics.
Inferior orbital fissure	Sphenoid, maxillary, & palatine bones; V-2, zygomatic nerve; inferior orbital vein
Frontosphenoid foramina	Fronto-sphenoidal suture of orbital roof: anastomosis of recurrent middle meningeal and lacrimal arteries (variable). Not always present.

Table 4. ORBITAL FISSURES AND OSTIA

- **PARANASAL SINUSES**

Ethmoid sinuses

- Present at birth.
 - Separated from frontal lobes by thin cribriform plate.
 - Separated from orbit by thin lamina papyracea. Strength of the medial wall is increased by septations within the ethmoids, imparting a “corrugated cardboard” effect.
- Most common source of orbital cellulitis, especially in children.
- Maxillary sinuses.

- Separated from the orbit by the orbital floor.
- Pneumatizes at 3-4 years of age.

Frontal sinuses

- Pneumatize at 7-15 years of age.
- Often involved in mucocele formation.

Sphenoid sinuses

- Pneumatize during teenage years into adulthood.
- Abut optic canals and cavernous sinuses.

- **ORBITAL APEX: IMAGING (See Imaging Handout for more details).**

To interpret CT/MRI correctly, you must understand the relationship between:

- The optic canal/nerve (upper tier).
- The cavernous sinus / superior orbital fissure (middle tier).
- The inferior orbital fissure and pterygopalatine fossa (lower tier).

The optic canal exits from the medial wall. On axial scans, the anterior clinoid process defines the location of the optic canal.

- **ORBITAL SEPTUM / PERIOSTEUM**

Begins at arcus marginalis

Extension of periosteum/periorbita

Discontinuous medially

NEVER suture!

Periosteum is loosely adherent to bone except at foramina:
potential space for abscess formation.

Avascular: poor penetration of antibiotics.

3. SOFT TISSUE ANATOMY

- **MOTOR & SENSORY NERVES**

MOTOR NERVES

- To extraocular muscles.
- Enter on inner aspect of EOM at junction of posterior 1/3 and anterior 2/3.
- All motor nerves enter within the annulus of Zinn EXCEPT trochlear nerve.

SENSORY NERVES

- All sensory nerves arise from the trigeminal nerve (CN V).
- The orbit is primarily supplied by the first branch of V.
- Major distal branches include the SUPRAORBITAL and SUPRATROCHLEAR.
- The second branch (V2) travels as the INFRAORBITAL nerve to supply the cheek, lower lid, and upper lid/teeth/gums – often damaged by blowout fractures. Two more minor branches – the ZYGOMATICOFACIAL and ZYGOMATICOTEMPORAL

supply the temple and lateral canthal region; often sacrificed during lateral orbital exploration.

Levator palpebrae superioris	• One nucleus of CN III supplies both levators (Edinger-Westphal nucleus also has bilateral output). • The lateral horn splits lacrimal gland into two lobes.
Lateral rectus muscle	• Only one muscular artery, but also receives partial blood supply from lacrimal artery.
Inferior rectus and inferior oblique muscles	• Partial blood supply from infraorbital artery
Inferior oblique muscle	• Has no tendon - bleeding is often encountered during surgical disinsertion. • Its nerve enters at the lateral border of the inferior rectus m. as they cross. • Inserts on the posterior aspect of the globe, in the region of the macula. • The condensation of the inferior rectus muscle sheath anterior to the inferior oblique muscle forms the suspensory ligament of Lockwood.
Superior oblique muscle	• Longest tendon (26mm). • Supplied by CONTRALATERAL CN IV.
Superior rectus muscle	• Inserts behind ora serrata - a full thickness bridle suture will perforate retina! • Supplied by the CONTRALATERAL CN III subnucleus.

Table 5. EXTRAOCULAR MUSCLE PEARLS

NERVE	FEATURES
Optic (II)	• Divided into three sections: - intraorbital: 24-25 mm long - canalicular: 8-10 mm long - intracranial: ~10mm long • Contains about 1.5 - 2 million fibers • Diameter: - 1.5 mm at optic nerve head - 3.0 mm posterior to globe (acquires dural sheath).
Oculomotor (III)	• Arises in midbrain. • Divides into a superior and inferior division, usually within the cavernous sinus: - superior division: levator, superior rectus - inferior division: medial, inferior, inferior oblique. - injury to the oculomotor nerve may result in miswiring between the divisions, manifesting as an "aberrant III regeneration syndrome". • Enters orbit through the SOF and the annulus of Zinn. • Carries the parasympathetic fibers to the globe (Edinger-Westphal nucleus).
Trochlear (IV)	• Arises in midbrain. • Has the longest intracranial course (~75mm). • Contains the fewest fibers (1500).

	• Commonly injured in closed head trauma. • Enters through SOF, but superolateral to annulus of Zinn. - usually not affected by retrobulbar anesthetic blocks.
Abducens (VI)	• Arises in pons. • Tethered by petrosphenoidal (Gruber's) ligament within Dorello's canal. - commonly injured in closed head trauma • The only CN not tethered to the lateral dural wall within the cavernous sinus. - partially tethered to the carotid siphon, but otherwise has an unpredictable central course through the sinus. • Most inferior nerve to pass through the SOF.
Facial (VII)	• The upper face has bilateral innervation. • The lower face has contralateral innervation. • Provides motor supply to the eyelid protractors (closes the eyelids) and one retractor: - orbicularis oculi - procerus - corrugator supercilii - frontalis (retractor) • Carries the parasympathetic fibers to the lacrimal gland (nervus intermedius). • Most commonly affected CN in sarcoidosis (optic nerve is #2) • Course over the face defines the locations of the Nadbath, O'Brien, and van Lindt blocks.

Table 6. CRANIAL NERVE FEATURES

- **AUTONOMIC NERVES**

PARASYMPATHETICS: Two separate sources supply orbital tissues, piggy-backing on two separate cranial nerves:

- To globe: III to CILIARY ganglion. Damage from PCOM aneurysm results in dilated pupil along with CN III palsy.
- To lacrimal gland: VII to SPHENOPALATINE ganglion. The lacrimal gland is simply a specialized salivary gland. Therefore, its nerve supply shadows that of the other salivary glands. The parasympathetics to the lacrimal gland follow a circuitous course from the facial nerve to synapse in the sphenopalatine ganglion, attach briefly to the infraorbital and zygomatic nerves (both V2 branches), then finally the lacrimal nerve (V1 branch) before entering the lacrimal gland. Damage to the facial nerve can result in miswiring of the parasympathetics of the lacrimal and salivary glands, resulting in "crocodile tearing".

SYMPATHETICS:

- See Neuro-Ophthalmology section for details on synapses.
- Sympathetics form a net around the carotid artery, following it intracranially into the cavernous sinus.
- From the cavernous sinus, one set enters the orbit through the superior orbital fissure.

- A second set travels into the orbit through the optic canal with the ophthalmic artery.
- Sympathetics supply the arteries, the iris dilator, smooth muscles of the upper (Müller) and lower eyelids, and the lacrimal gland.

- **VASCULAR SUPPLY**

- ARTERIES

- Watershed of ICA and ECA:
 - Eye/optic nerve without collateral supply
 - Medial: facial artery.
 - Superior/lateral: superficial temporal artery.
 - Inferior: Infraorbital artery (from internal maxillary artery).
 - Palpebral arcades anastomose medial and lateral supply.

- VEINS

- Major drainage: cavernous sinus via the superior orbital vein. Drainage into the pterygopalatine fossa is normally minor and takes over only under abnormal circumstances (CC fistula, etc.).
 - Orbital veins are valveless, predisposing to backflow in CC fistula and may facilitate spread of infection posteriorly into the cavernous sinus.

- **ORBITAL FASCIAL SYSTEM**

- The orbit is not simply a loose “bag of fat and muscle” (despite what the retina guys tell you!). A reproducible fascial system exists, separating the fat into discreet compartments and linking the extraocular muscles to each other. This explains why many patients with blowout fractures have diplopia even though the inferior rectus muscle is not directly entrapped. Two points to remember:

- The superior ophthalmic vein travels beneath the superior rectus/levator complex in a fascial sling. This relationship is frequently seen on coronal imaging.
 - The annulus of Zinn tethers the EOMS posteriorly around the optic canal and splits the superior orbital fissure (Fig. 2).

- Structures within the annulus of Zinn tend to stay intraconally. These include:

- Superior and inferior divisions of the oculomotor nerve.
 - The abducens nerve.
 - The nasociliary nerve.
 - The superior ophthalmic vein (SOV).

- Structures outside the annulus of Zinn:

- The trochlear nerve.
 - The lacrimal and frontal nerves.
 - The origins of the superior oblique and levator muscles.

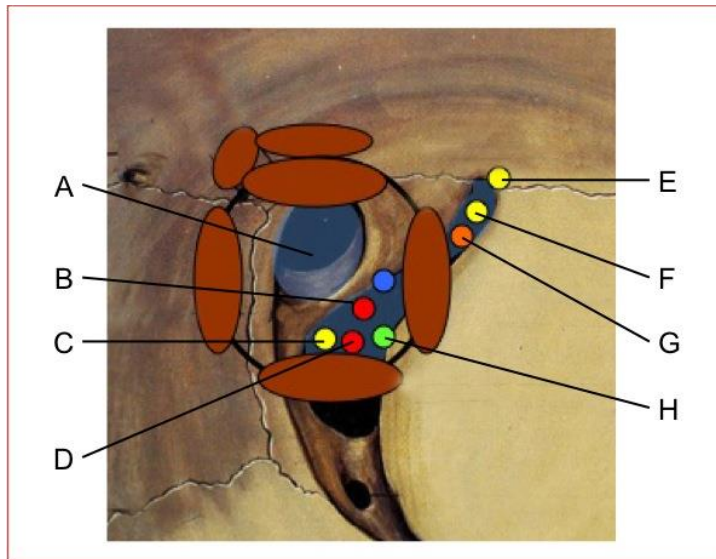


Figure 2. The orbital apex. The encapsulating fascia of the four rectus muscles fuses to form the annulus of Zinn. A. Optic canal. Structures within the annulus: B. Superior division of CN-III; C. Nasociliary nerve; D. Inferior division of CN-III. H. CN-VI. Note that the superior ophthalmic vein (blue) may be located either within or outside the annulus, depending on the atlas. Structures outside the annulus: E. Lacrimal nerve; F. Supraorbital nerve; G. CN-IV.

• CAVERNOUS SINUS (Fig. 3)

The cavernous sinus (CS) is located directly behind the superior orbital fissure. It is best described as a triangular structure with a bony roof and medial wall, and is draped laterally by dura. Several important features of the CS to remember:

- It is filled with a fenestrated venous plexus that drains the orbit via the superior ophthalmic vein and also communicated posteriorly with the central venous sinuses.
- The internal carotid artery travels through the CS in an S-shaped curve known as the carotid siphon. As soon as the ICA exits the CS, it gives off its first intracranial branch – the ophthalmic artery. The ICA is wrapped by a sympathetic plexus that also supplies the orbit.
- The lateral dural wall contains all of the cranial motor and sensory nerves supplying the orbit through the superior orbital fissure with one exception (see next). From superior to inferior: CN-III (sometimes as two divisions), CN-IV, CN-V1, and (depending on the atlas) CN-V2.
- CN-VI (abducens) travels loosely through the venous plexus close to the carotid siphon. Because of this lack of protection from the dural wall, CN-VI is the most frequently injured nerve in CS pathology.
- The medial wall of the CS also forms the lateral wall of the sphenoid sinus.
- The venous plexi of the two CSs communicate via the circular or intercavernous sinus.

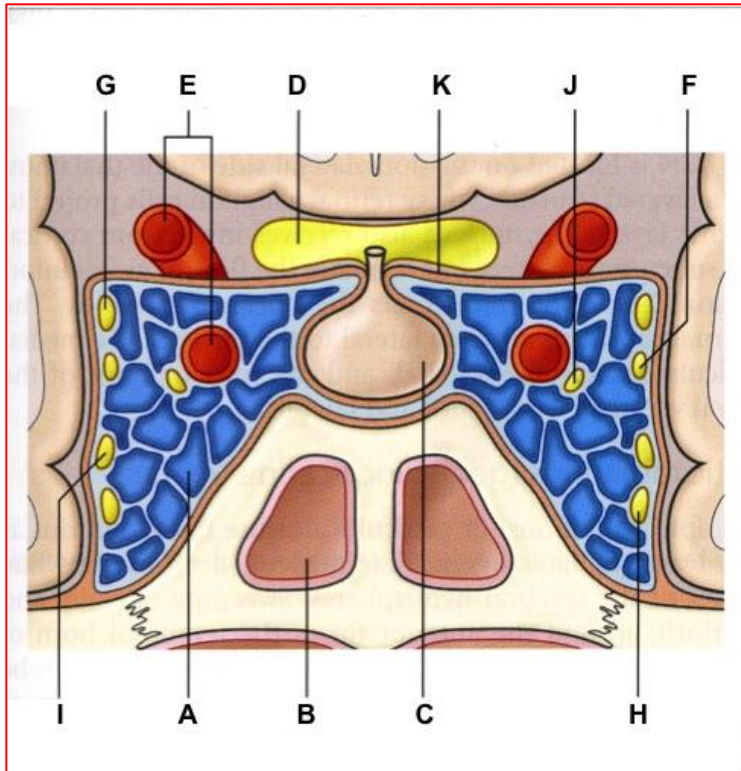


Figure 3. The cavernous sinuses (coronal view). A. The venous plexus; B. Sphenoid sinus; C. Pituitary gland. D. The optic chiasm; E. The internal carotid artery; Located within the lateral dural wall: F. Trochlear nerve; G. Oculomotor nerve. H. Infraorbital nerve (V2); I. Frontal nerve (V1); Located within the venous plexus: J. Abducens nerve; K. The circular sinus wraps around the stalk of the pituitary gland and joins the two cavernous sinuses.

IIA. A PRACTICAL APPROACH TO ORBITAL DISEASE

NOTE: Because of time constraints, only this general introductory section is reviewed during the course. However, a more detailed discussion of specific orbital tumors is also included. Additional information is also found in the Pathology and Oncology sections.

1. OVERVIEW: Orbital disease is frequently a manifestation of a systemic process. A complete history, including review of systems, should be performed on every patient.

Physical examination.

Complete eye exam (including fundus).

Periocular exam: facial abnormalities, paranasal sinuses, buccal / nasal mucosa.

Facial / cervical adenopathy.

Laboratory studies.

CLINICAL ENTITY	RECOMMENDED TESTS
Thyroid eye disease	T4, T3, TSH, ?TSI (thyroid stimulating immunoglobulin)
Sarcoidosis	Angiotensin converting antibody, chest X-ray, +/- gallium scan
Vasculitis (Wegener granulomatosis, polyarteritis nodosa)	c-ANCA, p-ANCA, proteinase-3
Metastatic disease Breast carcinoma Prostate carcinoma Lung carcinoma Colon carcinoma	Mammography Prostate specific antigen, urologic exam Chest X-ray or CT Colonoscopy, barium enema
Lymphoproliferative disease	CBC w/ differential, LDH, body imaging (CT, MRI, or PET/CT), ?bone marrow biopsy, ?HIV antibody
Myeloproliferative disease (multiple myeloma, myeloid dysplasia, etc)	Serum/urine protein electrophoresis, body imaging.

Table 7. RECOMMENDED WORK-UP FOR SPECIFIC ORBITAL LESIONS

Imaging studies: See separate handout on this subject.

2. THE SIX P's OF ORBITAL DISEASE

- **Proptosis.**
- **Progression.**
- **Palpation.**
- **Pulsation.**
- **Periorbital changes.**
- **PAIN**

Inflammation: orbital pseudotumor, leaking dermoid.

Infection: cellulitis, abscess, Mucor.

Orbital hemorrhage: trauma, lymphangioma, thrombocytopenia.

Malignant lacrimal gland lesions: adenoid cystic carcinoma.

Paranasal sinus disease.

Neoplasia: Paranasal sinus carcinoma, metastatic lesions.

- **PROPTOSIS / DISPLACEMENT**

AXIAL PROPTOSIS

- Graves' orbitopathy.
- Intraconal masses.
- Orbital cellulitis.
- Orbital pseudotumor.
- Unilateral myopia.

INFEROMEDIAL DISPLACEMENT

- Lacrimal gland masses.
- Dermoid cysts.
- Dacryops.

SUPERIOR DISPLACEMENT

- Maxillary sinus disease (usually neoplasia).

INFERIOR DISPLACEMENT

- Frontal lobe lesions (meningioma).
- Frontal sinus processes: abscess, mucocele, neoplasia.
- Orbital floor defect: blowout fracture, chronic sinus disease (silent sinus syndrome).

TERMINOLOGY	
Proptosis	Forward displacement or bulging (not necessarily the eyes).
Exophthalmos	Proptosis of the globe.
Exorbitism	>90° between lateral orbital walls.
Hypertelorism	Widening of the medial orbital walls (bone).
Telecanthus	Widening of the medial canthi (soft tissue).
Hyper/hypoglobus	Superior/inferior displacement of the globe.
DISPLACEMENT	
Axial	Thyroid eye disease, intraconal masses (cavernous hemangioma, fibrous histiocytoma, schwannoma, optic nerve meningioma or glioma), C-C fistula, cellulitis.
Superior	Maxillary sinus tumor.
Inferior/medial	Lacrimal gland, dermoid.
Inferior/lateral	Mucocele, abscess, osteoma.
Enophthalmos	Trauma, schirrous breast carcinoma, silent sinus syndrome.

Table 8. CLASSIFICATION OF PROPTOSIS AND OTHER DESCRIPTIVE TERMS**BILATERAL PROPTOSIS**

- Thyroid eye disease (Graves orbitopathy).
- Inflammation (sarcoidosis).
- Lymphoproliferative disease.
- Vasculitis (Wegener granulomatosis).
- Leukemia.
- C-C fistula.

ADULTS
Thyroid eye disease
Cavernous sinus thrombosis
Lymphoma / lymphoproliferative disease
Carotid cavernous fistula
Vasculitis (e.g. Wegener granulomatosis)
Inflammation (e.g., sarcoidosis)
IOIS (rarely)
CHILDREN
Neuroblastoma
IOIS
Leukemia

Table 9. CAUSES OF BILATERAL PROPTOSIS

Enlarged globe
Myopia
Asymmetric orbits
Extraocular muscle palsies (<2mm)
Asymmetric palpebral fissures
- Ipsilateral retraction
- Contralateral ptosis

Table 10. CAUSES OF PSEUDOPROPTOSIS

- PROGRESSION

Weeks to months:

- Graves' orbitopathy.
- Lymphoproliferative disease.
- Inflammation (sarcoidosis).
- Cavernous hemangioma, schwannoma, etc.
- Meningioma.
- Atypical inflammation (Aspergillosis).
- Mucocele.

Explosive:

- Idiopathic orbital inflammatory syndrome (IOIS, orbital pseudotumor).
- Infection (bacterial, Mucor).
- Rhabdomyosarcoma.
- Hemorrhage.
- Leukemia.
- Leaking dermoid.

- PULSATION

Vascular/arterial: Always check for bruit.

- Carotid cavernous fistula.
- Dural sinus fistula.
- Arteriovenous malformation.

Valsalva:

- Venous malformation, varix.

Orbital roof / apex bony defect:

- Encephalocele.
- Neurofibromatosis (Orphan Annie sign).
- Previous neurosurgery.
- Orbital roof fracture.

- PERIORBITAL CHANGES

Eyelids

Conjunctiva

Midface

Globe

Lymph node exam!

3. IMAGING: CT or MRI?

- Plain X-rays are usually useless, do not effectively rule out fracture, expose the patient to needless radiation, and cost money.
Exception: Rule out metallic foreign body for MRI.
- Basic rules for ordering CT or MRI:
When in doubt, call first!
Know the capabilities of your local hospital.
Never order MRI as the first study following trauma.
Include specifics in request form.
Remember managed care (1 pt = 1 study).
Include cavernous sinuses and paranasal sinuses in all studies.
Orbital CT (1-3mm cuts) does not equal brain CT (5mm cuts).
- **CT: INDICATIONS**
If bone is important:
 - Trauma.
 - Thyroid eye disease.
 - Lacrimal gland lesions.
 - Suspected orbital abscess.If an emergency scan is necessary:
 - Many hospitals do not run their MRI 24 hours/day.If patient is claustrophobic (open MRI not ideal for orbital studies).
If MRI is contraindicated: metallic foreign body or certain types of pacemakers.
- **MRI: INDICATIONS**
MRI of the orbit is tricky and often poorly performed.
Orbital apex / cavernous sinus.
Optic nerve lesions.
 - Neurogenic tumors (glioma, meningioma) strongly enhance with gadolinium.CNS studies.
Demyelinating disease (should be obtained in all cases of new onset optic neuritis – see ONTT section in Neuro-Ophthalmology notes).
Tissue specific signals: blood, mucus, lipid, melanin.
Fungal cellulitis.
Wooden foreign bodies.
- **MRI: TISSUE SPECIFIC**
The vast majority of lesions are DARK on T1 images and BRIGHT on T2.
Certain tissues are BRIGHT in T1:
 - Subacute hemorrhage.
 - Melanin (melanoma).

- Lipid (lipoma, liposarcoma).
- Mucus (dermoid, mucocele).

MRI is especially useful in the transition zone between the orbit and CNS:

- Orbital apex.
- Cavernous sinus.
- Pterygopalatine fossa.

- **MRI: CORRECT TECHNIQUE**

Fat is bright in T1.

Most orbital lesions enhance (become bright) with gadolinium.

ALWAYS use fat suppression with gadolinium.

Otherwise, lesions may “disappear” into orbital fat!

- **MRA:**

- Does NOT use gadolinium – safe to use in renal dysfunction.

- **MRI Minutiae (because you don’t already have enough to remember):**

- Nephrogenic fibrosis syndrome: Idiopathic, progressive scleroderma-like reaction affecting skin and viscera after gadolinium infusion, often fatal. Typically occurs in patients with poor renal function, liver disease, severe trauma, etc. Many MRI centers require precontrast BUN/creatinine/creatinine clearance.
- Gadolinium deposition syndrome: Usually seen in the CNS after multiple MRIs. Significance unknown – FDA is reviewing data.

4. CLASSIFICATION OF LESIONS

- **By appearance:**

Well-circumscribed.

Poorly circumscribed.

Variably circumscribed.

- **By location:**

Intraconal.

Extraconal.

Optic nerve.

- **By age.**

- **Bone vs. soft tissue.**

- **BY APPEARANCE**

Well-circumscribed:

- Cavernous hemangioma.
- Solitary fibrous tumor (fibrous histiocytoma, hemangiopericytoma)
- Schwannoma.
- Neurofibroma.
- Dermoid cyst.
- Pleomorphic adenoma (lacrimal gland).

- Lymphoma (50%).
- Poorly circumscribed
- IOIS.
- Lymphangioma.
- Hemorrhage.
- Cellulitis (bacterial or fungal).
- Sarcoidosis.
- Wegener granulomatosis.
- Variably circumscribed:
- Rhabdomyosarcoma.
- Metastatic lesions.
- Lymphoproliferative disease.
- Adenoid cystic carcinoma.
- Abscess.
- Leukemic infiltrate.
- **BY AGE**
- Children:
 - Cellulitis!
 - Dermoid cyst, capillary hemangioma, rhabdomyosarcoma.
- Adults:
 - Graves' orbitopathy.

CHILDHOOD (0-17yrs)	Dermoid/epidermoid cysts Capillary hemangioma Rhabdomyosarcoma Metastatic disease Histiocytosis X Lymphangioma Optic nerve glioma Varix Neuroblastoma Ewing's sarcoma
ADULT	Cavernous hemangioma Schwannoma Solitary fibrous tumor (fibrous histiocytoma, hemangiopericytoma) Sphenoid wing meningioma Optic nerve sheath meningioma Lacrimal gland tumors Lymphoid hyperplasia Inflammation (mucocele, sarcoidosis, Wegener, etc.) Lacrimal gland masses Vascular lesions (cavernous-carotid fistula, varix, arteriovenous malformation, etc.) Secondary (mucocele, etc.) and metastatic lesions Lymphoproliferative (esp. lymphoma) Metastatic lesions Primary orbital malignancies

	Vascular lesions (esp. dural-cavernous sinus fistula)
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Table 11. AGE-SPECIFIC INCIDENCE OF ORBITAL LESIONS

PART IIB. SPECIFIC ORBITAL TUMORS

Neurogenic Optic nerve glioma Optic nerve meningioma Secondary meningioma (e.g. sphenoid wing).	Mesenchymal Rhabdomyosarcoma Solitary fibrous tumor (fibrous histiocytoma, hemangiopericytoma) Fibrous dysplasia Osteoma Chondroma Chondrosarcoma Aneurysmal bone cyst Lipoma/dermolipoma Myxoma
Peripheral nerve sheath Schwannoma Neurofibroma	Lymphoproliferative Lymphoma Lymphoid hyperplasia Hodgkin disease Burkitt lymphoma
Vascular Capillary venous malformation Cavernous hemangioma Lymphangioma Hemangiopericytoma Varix Arteriovenous fistula/malformation	Leukemic/Histiocytic Leukemia (plasmacytoma) Multiple myeloma Reticulum cell sarcoma Histiocytosis X (eosinophilic granuloma, etc) Paget's disease
Cystic Dermoid/epidermoid Hematic	Inflammatory Idiopathic orbital inflammatory syndrome (IOIS) Sarcoidosis GPA (Wegener granulomatosis) eGPA (Churg Strauss syndrome) Histiocytoses (Rosai Dorfman disease, etc). Tolosa-Hunt syndrome (technically in cavernous sinus, not orbit)
Lacrimal Gland Pleomorphic adenoma Pleomorphic adenocarcinoma Adenoid cystic carcinoma Mucoepidermoid carcinoma Dacryoadenitis Dacryops	Metastatic Neuroblastoma Carcinoma (breast, lung, prostate, colon, kidney, etc.)
Other Primary orbital melanoma Primary orbital amyloid Teratoma Mucocele Encephalocele/meningocele	Secondary (eyelid, eyeball, paranasal sinus, etc.) Carcinoma (squamous cell, basal cell, sebaceous cell) Uveal melanoma Retinoblastoma Pituitary lesions Craniopharyngeoma

Table 12. ORBITAL LESIONS.

1. LACRIMAL GLAND LESIONS

Lesions of the lacrimal gland present a diagnostic and management dilemma for the clinician. Because lacrimal gland pathology is encountered with relative frequency, a basic discussion of management issues is warranted. Recall that anatomically, the lacrimal gland consists of a palpebral and orbital lobe, separated by the lateral horn of the levator aponeurosis. Neither lobe is palpable in the normal state, although the orbital portion may sometimes be palpable in shallow orbits. It is important to remember that in a general ophthalmic practice, processes of the lacrimal gland requiring biopsies account for less than 10% of all biopsied orbital lesions. Therefore, processes diagnosed presumptively (i.e. without biopsy) occur much more frequently. The “50-50 rule” is a convenient method for summarizing the incidence of epithelial lacrimal tumors, and is summarized in Table 13. However, remember that this rule applies to lacrimal gland lesions presenting in a referral (oculoplastic/orbital) practice!

- In a **referral** (Oculoplastic/Orbital) practice:
 - 50% of lesions inflammatory* or lymphoid
 - 50% of lesions are epithelial parenchymal proliferations
 - 50% of epithelial tumors are pleomorphic adenomas (i.e. 50% of epithelial tumors are benign)
 - 50% of epithelial tumors are malignant
 - 50% of malignant tumors are adenoid cystic carcinoma
 - 50% of adenoid cystic carcinomas are of the basaloid type
 - In a **NON-referral** (General Ophthalmology) practice:
 - Inflammatory and lymphoid lesions are at least 5 times more common than epithelial tumors.
- * inflammatory lesions include infectious and noninfectious

Table 13. THE “50-50” RULE OF LACRIMAL GLAND LESIONS

A. Evaluation of Lacrimal Gland Lesions

Conclusions as to etiology and appropriate management of lacrimal gland lesions are dependent on data obtained from three sources: history, examination, and CT imaging. All three are essential for correct management. Put simply, the greatest fear is an incomplete excision (incisional biopsy) of a pleomorphic adenoma (benign mixed tumor), which then allows for spillover spread into surrounding orbital fat, destructive infiltrative growth and inflammation, and the potential for malignant transformation. On the other hand, performing an excisional biopsy (i.e. complete removal of the mass) on all lacrimal gland masses is an untenable alternative, since this will result in unnecessary biopsy of common inflammatory and infectious lesions; furthermore, the procedure does carry a certain inherent morbidity.

Clues to a specific etiology include:

- **History: DURATION and PAIN**

Inflammatory lesions tend to be of short duration (days to weeks). Conversely, epithelial and lymphoid tumors have a duration of several months (sometimes up to a year).

Inflammatory tumors typically present with pain, although there are exceptions (sarcoid, Sjögren's). Lymphoid lesions are almost exclusively painless, while epithelial lesions may present with varying degrees of discomfort (see below).

- **Examination**

An enlarged and inflamed PALPEBRAL lobe with surrounding conjunctival injection points toward infectious (viral, bacterial) inflammation or idiopathic inflammatory pseudotumor (inflammatory dacryoadenitis).

Lymphoid lesions may or may not affect the palpebral lobe. If involved, the palpebral lobe demonstrates effacement of its normally irregularly contoured surface, a "salmon pink" color, has a rubbery texture, and is nontender to palpation.

Epithelial tumors (with rare exceptions) begin in the ORBITAL lobe and spare the palpebral lobe.

- **Imaging**

The gold standard for imaging lacrimal gland lesions is still COMPUTED TOMOGRAPHY (CT), since bony changes are of paramount importance in narrowing the differential diagnosis and in planning surgery.

Magnetic resonance imaging (MRI) is helpful to assess the extent of intracranial extension, but has poor resolution for defining bony changes.

There is no role for plain X-rays.

B. Differential Diagnosis of Lacrimal Lesions

- **INFLAMMATORY LESIONS**

Divided into INFECTIOUS and NONINFECTIOUS.

The majority of these lesions are non-infectious dacryoadenitis in the setting of idiopathic orbital inflammation (discussed later).

SARCOIDOSIS

- Usually presents as a bilateral, subacute or chronic, PAINLESS enlargement of the lacrimal glands.
- More common in American Blacks (rare in Africa), Scandinavians, and several other ethnic groups.

- Work-up is summarized in Table 7. Biopsy of the lacrimal gland is often necessary to confirm the diagnosis, although in many cases diagnostic tissue is obtained by bronchoscopy.
- Treatment is deferred to rheumatologists or immunologists. Ophthalmologists provide valuable input regarding intraocular inflammation and the potential mass effect from enlarged lacrimal glands.
- Although corticosteroids are still used in most cases, treatment with low doses of chemotherapeutic anti-metabolites is increasingly popular.

SJÖGREN SYNDROME

- Has an overwhelming female preponderance.
- Typically presents as bilateral, painless swelling with severe keratoconjunctivitis sicca and dry mouth. Conjunctival infiltration resembling lymphoma or symblepharon formation suggestive of possible a primary cicatrizing conjunctival disorder (i.e., ocular cicatricial pemphigoid) may also occur.
- Biopsy may require special staining for definitive diagnosis.
- A Sjögren's-like syndrome has been described recently in HIV-infected individuals; this association is most frequent in black males.

• **LYMPHOID LESIONS**

These fall into the rubrics of lymphoid hyperplasia and lymphoma and are covered in more detail later.

The typical finding on CT is a lesion involving both the palpebral and orbital lobes.

The lesion classically respects native anatomic planes, causing little or no distortion of the globe or lacrimal gland fossa, instead assuming the molded, so-called "pancake" appearance.

• **EPITHELIAL TUMORS**

Epithelial tumors of the lacrimal gland are defined as those arising from the substance of the gland itself, i.e. either the glandular or stromal elements, or both.

Specific entities include pleomorphic adenoma (benign mixed tumor), adenoid cystic carcinoma, pleomorphic adenocarcinoma (malignant mixed tumor), and mucoepidermoid carcinoma, among others; only the first two lesions will be discussed here.

PLEOMORPHIC ADENOMA (BENIGN MIXED TUMOR, BMT)

- BMT is the most common epithelial tumor of the lacrimal gland, typically presenting at 30-50 yrs of age (range 7-77 yrs), with a 60% male predominance. The tumor overwhelmingly

involves the orbital lobe of the lacrimal gland, although rare cases of palpebral lobe or accessory gland involvement have been reported. Table 14 lists the distinguishing characteristics of BMT. **Treatment is usually limited to surgery, requiring TOTAL EXCISION of the mass. If any tumor is left behind, it has a tendency to infiltrate into adjacent orbital fat,** making future excisions extremely difficult. Furthermore, **there is the potential for transformation into a malignant mixed tumor;** the frequently quoted figure from Font and Gamel is 10% per decade beginning at 20 yrs after excision. The role of fine-needle aspiration biopsy for orbital lesions is still controversial (the technique is more accepted in the diagnosis of salivary gland adenomas).

	PLEOMORPHIC ADENOMA	ADENOID CYSTIC CARCINOMA
DURATION	> 1 year	< 1 year
PAIN	RARE	COMMON
DIPLOPIA	UNCOMMON	COMMON
CT FINDINGS	NO bony destruction +/- fossa formation	Bony destruction COMMON
SURGERY	EXCISIONAL biopsy	INCISIONAL biopsy
	WHEN IN DOUBT, PERFORM TOTAL EXCISION OF THE MASS!	
POSTSURGICAL THERAPY	Clinical follow-up only	CONTROVERSIAL: Radiation (? type) ? Chemotherapy ? Radical excision

Table 14. CLINICAL CHARACTERISTICS OF LACRIMAL EPITHELIAL LESIONS

ADENOID CYSTIC CARCINOMA (ACC)

- ACC is the second most common epithelial tumor, accounting for 25% of all lacrimal gland epithelial tumors and 50% of malignant epithelial tumors.
- It usually presents at about 40 yrs of age (range 8-79 yrs) although a bimodal distribution has been reported recently.
- **PAIN is the hallmark of adenoid cystic carcinoma because of its propensity to grow along sensory nerves (i.e the lacrimal nerve).**
- The average duration of pain is 7.6 mos (range 0-33 mos). Therefore, these lesions may be mistaken for inflammatory lesions of the lacrimal gland.
- Other important signs and symptoms are listed in Table 14.

- Histologically, five patterns are described: cribriform (Swiss cheese), sclerosing, basaloid (solid), comedocarcinoma (basaloid units with central necrosis), and tubular (true duct formation).
- The term “adenoid” stems from the finding that the “holes” of the Swiss cheese pattern are not true ducts - hence the lesion is not “adeno”, but rather “adenoid”.
- Prognosis is most closely related to histology: **a distinctly worse prognosis is associated with the basaloid subtype** (50% of all adenoid cystic lesions):
 - Basaloid: 21% survival at 5 yrs, median survival 3 yrs.
 - Nonbasaloid: 71% survival at 5 yrs, median survival 8 yrs.
- Treatment is very controversial, running the spectrum from biopsy with radiation alone to radical cranio-orbital excision (“exenteration plus”) to intra-arterial chemotherapy. Trend at present is globe-sparing surgery with adjunctive radiation.
- Death usually due to intracranial spread, but lymphatic or distant metastases may occur.

OTHER LESIONS

- The lacrimal gland region can also play host to a variety of other conditions, which are mentioned here only for completeness: DACRYOPS, DERMOID CYST, METASTATIC LESIONS, EOSINOPHILIC GRANULOMA, CHOLESTEROL GRANULOMA, etc.

2. LYMPHOPROLIFERATIVE DISORDERS

• OVERVIEW

Although, with the exception of the lacrimal gland, the orbit does not contain a native, sedentary population of lymphocytes, lymphoproliferative tumors are among the most common tumors encountered in this area. Recent studies have identified primitive lymphatics within the orbits of lower primates. However, no lymphatic system has been identified to date in the human orbit.

It is more likely that a lymphocytic predilection for the orbit may have to do with specific “homing receptors” found on the surface of certain lymphocyte subpopulations. Support for this hypothesis comes from the finding that most orbital lymphoma is of the **MALT (mucosa-associated lymphoid tissue) type**. Although such **IgA producing** lymphocyte populations are commonly identified in various extranodal mucosal surfaces (Waldeyer’s ring in the nasopharynx, Peyer’s patches of the gut), their resultant lymphomatous proliferations are **most frequently found in two areas of the body devoid of native lymphocytes: the orbit and the stomach.**

Lymphoid lesions of the orbit constitute about 10% of all orbital tumors.

This number increases significantly with age (25%).

ALL orbital lymphoid lesions (both monoclonal and polyclonal) require a systemic work-up and close systemic surveillance over time.

Prognosis for extranodal lymphoma of the orbit is not readily inferred from data related to systemic nodal lymphoma!

- **CAVEATS**

Do NOT assume:

- **Polyclonal = benign = good**
- **Monoclonal = malignant = bad**

A significant minority of patients with “benign” or “reactive” lymphoid hyperplasia will develop systemic lymphoma.

- **CLASSIFICATION**

Much confusion exists in the literature regarding the classification of orbital lymphoproliferative disease.

NB: Idiopathic orbital inflammation (orbital pseudotumor) should NOT be considered a part of this disease spectrum.

- Biopsy-proven pseudotumor does NOT progress to lymphoma.
 - About 75% of ocular adnexal lymphomas are indolent (EMZL, CLL, grade I/II follicular) and about 50% are EMZL.
 - EMZL (extranodal marginal zone lymphoma) = MALT lymphoma = MALToma.
 -

SYSTEMIC LYMPHOMA (WHO DATA)	OCULAR ADNEXAL LYMPHOMA (OAL), n=353
<i>Diffuse large B-cell (30.6%)</i>	EMZL/MALT (52%)
Follicular cell (22.1%)	Follicular cell (23%)
EMZL/MALT (7.6%)	<i>Diffuse large B-cell (8%)</i>
CLL (6.7%)	<i>Mantle cell (5%)</i>
<i>Mantle cell (6.0%)</i>	CLL (4%)

Table 15. DISTRIBUTION OF SYSTEMIC AND OCULAR ADNEXAL LYMPHOMAS. AGGRESSIVE SUBTYPES ARE ITALICIZED. Data from Ferry JA, Am J Surg Pathol 2007. Aggressive subtypes are in italics.

- **DEMOGRAPHICS**

Age: Median of 60 yrs, usually between 50-70 yrs, but can occur at any age. Rare in children.

Sex: Minimally female > male.

No known racial/ethnic predilection.

More common and more aggressive in chronic immunosuppression (HIV/AIDS, severe rheumatoid arthritis, IgG4 sclerosing inflammation, etc.).

- **Vast majority are B-cell type.**

- **CLINICAL CHARACTERISTICS:**

Lymphoid lesions of the orbit are remarkably well-tolerated, usually presenting with only a paucity of symptoms, and rarely with advanced optic neuropathy.

Usually occur in older individual.

Indolent course.

Imaging shows a mass that molds to the native anatomy in ~ 50% and is well-circumscribed in ~ 50%.

- There is a predilection for the anterior and superior orbit, since the lacrimal gland is involved in about 30% of cases.

Bone destruction rare.

Rapid response to radiation therapy.

— The aforementioned characteristics hold for orbital lymphomas *overall*. Remember that aggressive subtypes (DLBCL, mantle cell, Burkitt) exhibit aggressive behavior (rapid growth, pain, optic neuropathy, bone destruction).

- **CLINICAL FINDINGS:**

“**Salmon patch**” lesion of the conjunctiva is common.

Check cul-de-sacs carefully!

Lacrimal gland enlargement.

Axial proptosis with good motility.

Rubbery lesion in eyelid fat pads.

- **RADIOLOGY**

CT or MRI of the orbits is recommended in all patients, even if only isolated conjunctival involvement is suspected.

Features:

- Intraconal fat infiltration.
- Lacrimal gland involvement.
- Extraocular muscle infiltration.
- **Molding or minimal distortion of normal anatomy in ~ 50% and is well-circumscribed in ~ 50%.**
- Bone erosion rare, but is seen in aggressive lesions (especially in HIV-related lymphoma).

- **ORBITAL CLASSIFICATION**

Lymphoid hyperplasia:

- The terms “benign” and “reactive” are misleading and should not be used.

- Despite polyclonality, may be a precursor for systemic lymphoma (25% over 5 yrs).
- Preponderance of T-cells (but small B-cell populations may show gene translocations that may progress to lymphoma).

Lymphoma.

As already mentioned, inflammatory orbital pseudotumor is NOT part of this disease spectrum.

- **HISTOPATHOLOGY**

Monotonous sheets of lymphocytes with varying degrees of cellular atypia are seen.

The degree of malignancy may be difficult to determine in most orbital lesions, since few are of the large cell subtype, although more recent studies have shown a good degree of correlation between histopathologic appearance (i.e. presence of Dutcher bodies) and clonality.

Lesions are characterized as polyclonal lymphoid hyperplasia or monoclonal lymphoma based on immunohistochemistry.

The vast majority of orbital lymphoma is of B-cell lineage, whereas in inflammatory lesions of the orbit, the majority of lymphocytes are of T-cells.

- **TREATMENT is dependent on specific subtype (immunohistochemistry and flow cytometry), as well as clinical stage.**

Indolent monoclonal proliferations (lymphoma) limited to the orbit are treated with doses of orbital radiation 30-34 Gy). However, recent studies suggest that MALT lymphoma responds equally well to lower ("anti-inflammatory) doses of radiotherapy.

Systemic lymphomas or particularly aggressive-appearing orbital lesions (DLBCL, mantle cell, Burkitt, HIV-related) require chemotherapy. If systemic chemotherapy is pursued, orbital irradiation may need to be deferred, because of the typically excellent response of the orbital lesions to systemic chemotherapy and the potentiating effect of the chemotherapy increases the likelihood of radiation-related complications (i.e., cataract, retinopathy). Biologics (e.g. rituximab) are playing a greater role in lymphoma therapy and for certain subtypes have markedly improved prognosis. Note that rituximab works for B-cell lymphomas only (cells must be CD20+). It will not work in T-cell lymphoma or plasma cell tumors (e.g. multiple myeloma).

AGGRESSIVE	INDOLENT
DLBCL Mantle cell Burkitt Grade III follicular	EMZL CLL Grade I/II follicular
Fatal if not cured Approach to cure	Incurable, indolent Chronic management

TABLE 16. TREATMENT PARADIGM FOR B-CELL LYMPHOMA SUBTYPES.

The treatment of lymphoid hyperplasia is more controversial, although most orbital specialists recommend treatment with at least “anti-inflammatory” doses of radiotherapy (1500-2000 cGy).

Routine surveillance for evidence of systemic disease is recommended **regardless of the histopathology** or immunohistochemistry, usually consisting of a complete blood cell profile with differential, serum LDH, and imaging of the brain, thorax, abdomen, and pelvis. **PET/CT is recommended in ALL patients with lymphoma for staging and to monitor response to therapy (more sensitive for staging than CT or MRI).**

- These studies should be repeated every six months for at least three years, followed by annual studies for an additional 2-3 years.

- Bone marrow biopsy is now recommended in all orbital lymphomas, even if PET/CT shows only stage IE disease.

Overall, patients who remain disease-free by one year of diagnosis have an 87% likelihood of remaining so. However, this is *highly dependent on specific subtype*.

SUBTYPE	MORTALITY*
Overall	20-25%
EMZL/MALT	10%
Follicular cell	20-25%
DLBCL	40-45%
Mantle cell, NK/T-cell	75-100%

TABLE 17. MORTALITY FOR OAL SUBTYPES. *DATA PREDATES THE USE OF BIOLOGICS (RITUXIMAB, ETC.)

- **PREDICTORS OF FUTURE DISEASE**

Controversy exists as to the pathologic predictors for systemic disease in cases of orbital lymphoproliferation.

Knowles and Jakobiec have found that ocular adnexal location, and not immunohistochemistry, is predictive of future systemic lymphoma (Table 11).

In contradistinction, Medeiros and Harris have concluded the opposite. However, the study by Medeiros and Harris also included cases of idiopathic orbital inflammatory syndrome (IOIS, inflammatory orbital pseudotumor) and had no eyelid lesions, which may have skewed the findings.

Recent data shows convincingly that patients presenting with bilateral adnexal (lid, conjunctiva, orbit) lymphoma and aggressive histopathology have a greater likelihood of associated systemic lymphoma than those with unilateral orbital involvement with indolent subtypes. Bilateral involvement, aggressive histopathology, high MIB-1, high LDH, presence of systemic

lymphoma at time of adnexal diagnosis, and lid location also increase mortality.

– In all likelihood, the best predictor for systemic involvement and overall prognosis is the *specific subtype* of the lymphoma. That said, some textbooks (and some test questions) still rely on the outdated data in Table 18.

	Knowles and Jakobiec	Jenkins et al
Eyelid	67%	50%
Deep orbit	35% (Unilateral = Bilateral)	24%
Lacrimal gland (anterior orbit)		38%
Conjunctiva	20%	21%

Table 18. RISK OF CONCURRENT OR FUTURE SYSTEMIC LYMPHOMA BASED ON LOCATION OF LESION

- **HIV-RELATED LYMPHOMA**

May progress rapidly.

Often involves paranasal sinuses.

Often clinically confused with infection (Aspergillosis).

CNS involvement common.

CT may show bone destruction.

? Relation to EBV reactivation.

3. VASCULAR LESIONS

This category subsumes vascular proliferations (capillary hemangioma, cavernous hemangioma, hemangiopericytoma), venous malformations (varix, lymphangioma), and arteriovenous malformations (typified by carotid- and dural-cavernous fistulas). Salient features of each will be noted briefly.

- **CAPILLARY HEMANGIOMA (HEMANGIOMA OF INFANCY)**

This benign proliferation of vascular elements is best described as a congenital lesion, invariably presenting within the first two years of life, usually within the first six months.

- A diagnosis in an older patient is always highly suspect.
- During its proliferative phase, capillary hemangioma may grow at an alarming rate, raising the specter of rhabdomyosarcoma (RMS).
- Note, however, that the peak age for RMS is 7 years of age.

- Furthermore, a careful review of previous photographs usually reveals that the proptosis with capillary hemangioma is in fact more long-standing than suspected by the child's parents.
 - In many cases, cutaneous hemangiomas ("strawberry patches", "stork bites", etc.) are found on examination.
 - Orbital capillary hemangioma should be treated only if there is evidence of amblyopia caused by refractive error (induced myopia or astigmatism) or ptosis.
 - Biopsy is reserved for those cases causing a diagnostic dilemma.
 - Previously, treatment usually began with either corticosteroid injections or systemic therapy; neither modality is completely without risk.
 - **The use of systemic or topical β -blockers (e.g. propranolol) has largely supplanted all other modalities, including corticosteroids and is now considered first line therapy.** Note that careful cardiovascular monitoring is essential when using this therapy in infants or young children.
 - Studies have shown that capillary hemangioma is very responsive to interferon alfa-2 therapy, but this modality has fallen out of favor because of potential neurologic complications.
 - Excision can also be performed, but expertise is required to minimize blood loss in an infant.
- **CAVERNOUS VENOUS MALFORMATION (CAVERNOUS HEMANGIOMA)**

Cavernous venous malformation (CVM) is the most common vascular orbital tumor in adults, typically presenting in the 4th and 5th decades.

The lesion is remarkably well-tolerated because of its slow growth; visual loss, if any, is insidious and limited to lesions of the orbital apex.

CVM is very well-circumscribed on imaging, as are fibrous histiocytoma, hemangiopericytoma, and schwannoma, among others.

Orbital ultrasound of these lesions typically demonstrate high internal reflectivity due to the presence of acoustic interface between the large vascular spaces (up to 1mm) and adjacent fibrous septae. MRI shows a distinctive contrast enhancement pattern that is relatively slow and heterogeneous, helping to distinguish from other orbital lesions.

CVM is NOT the adult equivalent of capillary hemangioma. Not only are the lesions distinct histopathologically, but CVM is a slowly proliferating entity, associated with very low vascular flow.

Excision is curative.

- **LYMPHANGIOMA**

Lymphangioma is one of the more frustrating vascular lesions of the orbit mainly because it is nearly impossible to totally excise.

This lesion is best considered as a static (i.e nonproliferating), benign, **congenital venous malformation**.

Note that unlike a varix, **lymphangioma is NOT in direct communication with the venous system**; therefore, a Valsalva maneuver will not cause increasing proptosis in patients with suspected lymphangioma.

The lesion becomes symptomatic presumably when a rapid growth of its lymphocytic elements (such as may occur during a cold) causes tearing of and bleeding into fragile lymphatic/venous channels.

- A typical presentation is that of a spontaneous orbital hemorrhage following an upper respiratory tract infection in children or teenagers.
- In the vast majority of cases, lymphangiomas first present by age 14 years, although recurrent symptoms are common throughout adulthood.

Anterior segment examination may reveal lymphangiectasis of the conjunctiva or small hemorrhagic vesicular lesions of the eyelid margin (lymphangioma circumscriptum).

On CT/MRI, the lesion typically presents in a more infiltrating pattern with indistinct margins. **MRI is especially helpful in diagnosis**, since it may show acute or subacute hemorrhage within cystic spaces (chocolate cysts).

Rarely these lesions may extend through the superior orbital fissure into the intracranial space and be associated with non-contiguous intracranial venous anomalies.

During surgical exploration, no distinct dissection plane is encountered, since lymphangioma typically grows in an **infiltrating, “crab grass” fashion**. This feature limits most surgery to exploration and debulking only. Sclerosing agents have become a popular treatment modality for scarring the cystic component of the lesion.

- **ORBITAL VENOUS MALFORMATION (VARIX)**

Considered a venous anomaly or malformation, controversy exists regarding whether or not most orbital lesions are congenital or acquired.

The lesions may become symptomatic after blunt head trauma or significant, repeated Valsalva maneuvers (e.g. during childbirth).

A typical complaint from patients is that the eye on the affected side “bulges” when bending over, lifting heavy objects, sneezing, etc.

Visual loss is rare unless acute hemorrhage from the lesion occurs. Because the lesion is static, insidious progressive visual loss is also quite uncommon.

CT imaging will show a spectrum from poorly circumscribed infiltration to distinct lesions; **calcification** may also be noted. MRI may show thrombus within the mass.

In most cases, the lesion is followed without biopsy, especially if it is causing minimal symptoms. Excision may prove difficult if the lesion has **widespread connections to the native venous system**.

- **CAVERNOUS SINUS FISTULAS**

Carotid- and dural-cavernous sinus fistulas are a subtype of arteriovenous malformation.

- C-C (high flow) fistulas are due to a direct connection between the arterial column of the internal carotid artery and the venous plexus of the cavernous sinus (Barrow Type A).
- D-S (low flow) fistulas are caused by a communication between the much lower caliber pial feeder vessels of the lateral dural wall of the cavernous sinus and its venous plexus. The feeder can be from the internal carotid (Type B), the external carotid (Type C), or from both ICA and ECA (Type D).
- Distinguishing features of high vs low are listed in Table 16.
- Symptoms are highly variable. Clinical signs may be quite subtle, especially in low-flow lesions - many patients are misdiagnosed as having a unilateral “chronic conjunctivitis”.
- Arteriolized, “corkscrew” conjunctival vessels that extend to the limbus are an important clue.
- In cases of optic neuropathy or ocular ischemia, treatment requires invasive neuroradiologic techniques.
- A technique of embolization through the superior ophthalmic vein has been described for cases in which the more conventional internal carotid approach has failed.

	HIGH FLOW (Barrow Type A)	LOW FLOW (Barrow Type B, C, D)
Communication	Direct (Carotid siphon and venous plexus of cavernous sinus).	Indirect (Small feeder vessels from ICA/ECA and venous plexus of cavernous sinus).
Most common etiology	Trauma	Spontaneous + vasculopathic risk factors
Patient age	<50 yrs	> 50 yrs
Clinical findings	Proptosis, high intraocular pressure, optic neuropathy, ocular ischemia.	Variable, but usually to lesser degree than C-C fistula.
Spontaneous closure rate	Low	High
Treatment	Closure (embolization) by transarterial or transvenous neuroradiologic approaches. Higher morbidity and mortality than Barrow B, C, D.	Observation vs closure dependent on clinical findings. Rule out posterior cortical venous outflow.

Table 19. FEATURES OF CAROTID-CAVERNOUS (C-C) AND DURAL-SINUS (D-S) FISTULAS.

4. MESENCHYMAL LESIONS

Mesenchymal tumors constitute between 4 and 7% of all orbital lesions. This category includes a vast array of specific neoplasms, most of which are quite rare, even in a tertiary referral practice. Therefore, only three of the most common entities will be discussed: solitary fibrous tumor, rhabdomyosarcoma, and fibrous dysplasia.

- **SOLITARY FIBROUS TUMOR**

- SLT used to be strange mesenchymal entity relegated to the dark, dusty corners of histopathology. More recent data has shown that SLT is in fact fairly common, and now subsumes the previously separate categories of hemangiopericytoma and fibrous histiocytoma. Note that both of these lesions are now considered to be SFTs – however, many textbooks still describe them as separate lesions. The clinical behavior of SFTs is difficult to predict histopathologically. Some lesions behave in an indolent fashion, and a minority can metastasize systemically. Complete excision of orbital lesions is difficult because of the vascular nature of SFTs as well as the lack of clearly definable dissection planes intraoperatively; recurrences are common and patients need to be followed long term.

- **HEMANGIOPERICYTOMA**

Hemangiopericytoma is a proliferation of the pericytes found in the walls of arteries.

This lesion, like cavernous venous malformation, presents as a well-circumscribed mass on imaging studies, although at times an edge of infiltration into surrounding tissue may be noted.

Unlike the other commonly encountered encapsulated tumors (cavernous venous malformation, schwannoma, and neurofibroma), patients with hemangiopericytoma are more likely to present with orbital congestive findings.

A strange feature of hemangiopericytoma is that **histopathologic appearance has little correlation with clinical behavior**. In other words, a histologically benign lesion may behave aggressively and recur after excision, while a tumor with aggressive features on microscopic examination may never recur.

Accordingly, complete excision is advised.

- **FIBROUS HISTIOCYTOMA**

Fibrous histiocytoma (FHC) is by far the **most common orbital mesenchymal tumor in adults**.

Note, however, that overall, **rhabdomyosarcoma remains the most common orbital mesenchymal lesion**.

Clinically and on imaging studies, FHC is indistinguishable from other indolent orbital lesions, including cavernous hemangioma and schwannoma. A well-circumscribed, uniform mass is noted on CT and MRI.

Excision is curative in the vast majority of cases.

Histopathologically, FHS falls under the category of “spindle cell tumors”, exhibiting storiform pattern fibroblasts.

Malignant FHC has been reported, but is rare.

- **RHABDOMYOSARCOMA**

Orbital rhabdomyosarcoma (RMS) is typically a disease of childhood (**average age = 7 yrs**), although lesions have been reported in all age groups.

Patients usually present with a **rapidly progressive proptosis**. Secondary inflammatory signs may mimic orbital cellulitis, the most common cause of proptosis in children.

Prompt imaging is essential to rule out infectious etiology. RMS may present with either a well-circumscribed or infiltrative pattern on CT. At times, confusion with capillary hemangioma may arise.

If RMS is suspected, urgent exploration and biopsy are critical, since the lesion may grow explosively over days.

- Once RMS is confirmed by frozen section control, lumbar puncture and bone marrow biopsy should be performed for staging; it is therefore essential that a pediatric oncologist be available during the initial orbitotomy in an effort to minimize delay in treatment and to spare the patient a second anesthesia.

RMS is thought to arise from pleuripotential mesenchymal tissue within the orbit, and **not from extraocular muscle**.

- While features of skeletal muscle differentiation are typical in RMS, they do not correspond to a malignant transformation of existing extraocular muscles.

Orbital RMS is histologically divided into three groups: **embryonal**, **alveolar**, and **pleomorphic**. The embryonal group is further subdivided into classic, **botryoid**, spindle cell, and anaplastic.

- **The embryonal form is the most common histology in children, while the pleomorphic form has a predilection for older adults.**

- The botryoid subtype is defined as an embryonal RMS abutting a mucosal surface, e.g. conjunctiva.

- **The alveolar form appears to affect the inferior orbit most frequently and carries the worst prognosis.** Fortunately, recent findings by the Intergroup Rhabdomyosarcoma Study (IRS) indicate that with more aggressive therapy, the prognosis for alveolar RMS approaches the embryonal form.

Treatment for RMS is truly one of the triumphs of modern medicine. This once lethal diagnosis now carries a cure rate approaching 95%.

Much of what is known about the treatment of orbital rhabdomyosarcoma comes from the four Intergroup Rhabdomyosarcoma Studies (IRS). Noteworthy findings include:

- Orbital and genitourinary RMS carry the best prognosis for unclear reasons.
- However, local spread out of the orbit does decrease survival.
- Treatment of orbital RMS consists of a combination of chemotherapy and radiation therapy. Radiation therapy in doses of 4000-6000 cGy definitely carries significant morbidity for the globe, but the IRS-III concluded that this high dose is still necessary for adequate treatment. Lower doses of radiation are currently being studied.
- Anecdotal reports of successful chemotherapy alone for orbital lesions are intriguing, but far from conclusive.

- **FIBROUS DYSPLASIA**

Fibrous dysplasia is a relatively common finding around the orbit and midface, and is typically a disease of childhood.

It represents an arrest and confusion of bone maturation. **Immature woven bone is noted histopathologically.**

The membranous bones of the face are involved, including the maxilla, the sphenoid, and the frontal bone.

In many cases, fibrous dysplasia is not clinically symptomatic, but is simply noted on plain film or CT studies of the orbit performed for other reasons.

CT shows the classic “**ground-glass**” **appearance** characteristic of fibrous dysplasia. In other cases, abnormality and asymmetry of the face may be noted.

Optic neuropathy from encroachment on the optic canals is rare, but reported; therefore, all patients with lesions of the sphenoid bone should be followed at regular intervals to rule out optic nerve compression. Should this occur, optic canal decompression may be indicated.

5. NEUROGENIC TUMORS

- **SCHWANNOMA**

Schwannoma is a tumor of the Schwann cells, which form the lining of peripheral nerves.

Within the orbit, most schwannomas arise from **sensory nerve sheaths**, which may explain the predilection of these tumors for the superior orbit.

Schwannomas of the orbit are usually isolated findings, although an association with **neurofibromatosis type II (“schwannomatosis”)** is seen occasionally.

The typical paucity of symptoms associated with other benign, well-circumscribed orbital tumors is also characteristic of schwannoma. CT/MRI usually cannot distinguish between these lesions.

Excision in symptomatic cases is usually curative, although reports of recurrence do exist.

The Antoni A and B patterns are the classic histologic findings in schwannoma.

- The A pattern is characterized by abundant, tightly packed spindle cells.
- The B pattern exhibits fewer cells within a myxoid matrix.

Rare reports of malignant degeneration of a benign schwannoma have been reported. Most cases of malignant schwannoma appear to have arisen *de novo*, although an unsuspected benign precursor cannot always be ruled out.

- **NEUROFIBROMA**

Neurofibroma represents a benign proliferation of the peripheral nerves coursing through the orbit.

The plexiform subtype is pathognomonic of von Recklinghausen’s disease (neurofibromatosis type I).

Neurofibromas grow insidiously and tend to infiltrate local structures, making complete excision difficult, if not impossible. In addition, these tumors are endowed with a rich vascular supply, further complicating attempted excision; CO₂ laser may be helpful in this regard.

Eyelid infiltration results in an enlarged, rubbery lid with an **S-shape**.

In some case, dysplasia of the sphenoid wings in association with neurofibromatosis may result in a **pulsatile exophthalmos (“Orphan Annie” sign)**.

- **OPTIC NERVE GLIOMA**

Gliomas of the optic nerve arise from **prechiasmal oligodendroglia and astrocytes**.

These lesions are usually found in childhood, with a peak incidence between 2 and 6 years of age.

There is an association with **neurofibromatosis, especially type I** for orbital and prechiasmal lesions.

Orbital gliomas usually present as a painless, axial proptosis. Depending on the child’s age, visual loss may be difficult to document. Strabismus is a common association, either because of mechanical interference of EOM function due to the size of the lesion or from sensory amblyopia.

The growth pattern of optic nerve gliomas is difficult to predict, making optimal imaging to rule out extension toward the chiasm of paramount importance.

- To this end, **MRI with gadolinium enhancement** is significantly more sensitive than CT.

Usually, optic nerve gliomas are followed conservatively unless extension toward the chiasm becomes evident. On occasion, confirmatory biopsy is needed for initial diagnosis if confusion with other lesions is present, especially optic nerve sheath meningiomas. Once the lesion begins to track toward the chiasm, complete surgical excision through a combined orbital and neurosurgical approach is warranted to minimize the risk of extension to the contralateral optic nerve, raised intracranial pressure, and pituitary/hypothalamic dysfunction.

Malignant optic nerve gliomas are rare and usually arise in adults.

- **OPTIC NERVE SHEATH MENINGIOMA**

The optic nerve is essentially an extension of the central nervous system, surrounded by meninges and bathed in cerebrospinal fluid.

The meninges consist of oligodendroglia, not Schwann cells; thus, **lesions of the nerve sheath of the optic nerve are classified as meningiomas, not schwannomas.**

Histologically, proliferations of meningotheial cells, typically from the arachnoid, group themselves into densely cellular whorls. Calcifications known as **psammoma bodies** may be present. Although there is an association with neurofibromatosis, **most optic nerve sheath meningiomas are an isolated finding, classically presenting as a painless, axial proptosis in middle-aged women.**

Visual loss usually occurs slowly, over years to decades. In most cases, optic nerve sheath meningiomas are followed conservatively.

Surgical excision was recommended in the past for lesions extending toward the chiasm, but had a high rate of iatrogenic visual loss in the affected eye.

In classic cases of ONSM, stereotactic, fractionated (not just conventional! Not radiosurgery!!) radiotherapy is effective in preserving vision and slowing or arresting growth in lesions causing progressive optic neuropathy, and empiric SFR is now considered the TREATMENT OF CHOICE for ONSM. That said, many ONSMs causing no or minimal visual loss may be followed by observation with serial examinations and imaging, reserving SFR for progressive lesions.

As with gliomas, high quality serial MRI with gadolinium infusion is essential for proper follow-up.

Optic nerve sheath meningiomas in the young have a high association with neurofibromatosis, multiple intracranial foci, and aggressive behavior. Thus, surgical intervention tends to occur earlier for orbital meningiomas in this age group (less than 30 yrs old).

- **SPHENOID WING MENINGIOMA**

Secondary meningiomas may invade the orbit from the intracranial space or alternatively cause visual loss by encroachment on the optic chiasm or canal. Lesions arising in the region of the **greater sphenoid wing and parasellar area** are the most frequent perpetrators of this type of visual dysfunction.

Once orbital invasion occurs, proptosis becomes clinically apparent. However, intracranial lesions sometimes cause diagnostic dilemmas because of subtle visual loss and a paucity of associated clinical signs; an improper diagnosis of retrobulbar optic neuritis or Graves' orbitopathy may be made.

- In such cases, MRI is invaluable in making the definitive diagnosis. **On CT, hyperostosis is the classic finding**, although bony erosion may also occur with meningiomas.

Secondary meningiomas causing minimal visual and neurologic symptoms are followed conservatively. Surgical intervention in cases causing significant progressive visual loss usually requires some combination of orbital and intracranial surgery. Lesions may recur, since complete initial excision may not be feasible. Recurrent lesions may respond to radiotherapy.

6. DERMOID CYST

- Dermoids cysts are relegated to their own category here, since other congenital lesions are included elsewhere.
- These cysts form as **two waves of neural crest tissue meet in the superior periorbital area and pinch off a nest of epidermis**. Thus, the most common locations for these lesions are the **frontozygomatic suture (superolateral) and the frontoethmoidal suture (superomedial)**, in that order.
- They are by far the most common lesions excised from pediatric orbits, accounting for 30-50% of the total. Lesions that span two compartments (i.e., orbit and intracranial or orbit and temporal fossa) separated by an intraosseous bony isthmus are termed complex, compound, or **dumbbell dermoids**.
- Dermoids contain various adnexal structures, including hair follicles and glandular elements.
- Dermoid cysts usually present as a well-tolerated, stable or slowly enlarging lesion in infants or young children. The masses are non-tender to palpation and usually cause no overlying skin changes.

On occasion, spontaneous or traumatic rupture of a dermoid cyst may incite an acute inflammatory reaction **mimicking orbital cellulitis**.
- Deeper lesions typically do not manifest clinically until late childhood or even adulthood.

- On CT, a cystic appearance is almost invariable. Adjacent bone may show pressure changes (“fossa formation”). On MRI, the mucus content of the lesion may result in a **hyperintense signal on T-1 images**.

Because the differential diagnosis of a cystic lesion in the superior orbit of a child includes meningocele (herniated meninges only) or meningoencephalocele (herniated meninges and brain tissue), adequate preoperative imaging should be obtained in all cases to rule out these possibilities.

Surgical management of both meningoceles and meningoencephaloceles is obviously quite different than that of dermoid cysts; a misdiagnosis and excision could have disastrous results.

- Most dermoid cysts can be followed conservatively unless they are causing functional or cosmetic problems, or there is a diagnostic dilemma.

If excision is warranted, **the entire tumor should be removed** without rupture since, as already mentioned, any leakage into adjacent tissue may cause significant postoperative inflammation.

7. SECONDARY TUMORS

- Secondary tumors of the orbit are defined as **lesions extending from any adjacent structures**: the globe, eyelids, paranasal sinuses, and intracranial compartment.

Eyelid lesions are discussed in in the previous section.

Ocular lesions are most commonly extrascleral extensions of retinoblastoma (children) and choroidal melanoma (adults).

Intracranial masses are by far most commonly meningiomas, described in a previous section.

Paranasal sinus lesions include infection (bacterial or fungal), inflammation (sarcoidosis, Wegener’s granulomatosis), structural (mucocoele), and various adenomas and carcinomas. Regardless of their etiology, paranasal sinus lesions extending into the orbit have a tendency to cause bony erosion, even if benign.

- **MUCOCELES** are especially common, presenting in the context of chronic sinusitis and perennial allergies.

A history of sinus polyps and multiple sinus surgeries may be obtained.

On CT, mucocoeles present as cystic lesions arising out of the frontal/ethmoidal sinuses; maxillary sinus mucocoeles are notably less common.

On MRI, the protein content and viscosity of the mucus may result in a **hyperintense signal on T-1 images**, which is helpful diagnostically.

Management by endoscopic sinus surgery performed by an otolaryngologist usually suffices; on occasion, an orbital approach for more complete excision and drainage or orbital wall reconstruction is needed.

- **PARANASAL SINUS CARCINOMA**

Note that paranasal sinus carcinomas may present as mucoceles due to obstruction of outflow.

In all cases, any tissue excised should be sent for careful histopathologic review.

Also remember that if paranasal sinus carcinoma with orbital involvement is suspected clinically, **a transcutaneous orbitotomy for biopsy should not be performed**, as this may violate otherwise intact anatomic planes and facilitate subsequent tumor spread. The most appropriate management is a diagnostic biopsy using the least invasive technique, namely a transnasal endoscopic approach.

8. METASTATIC TUMORS

- The incidence of specific metastatic lesions to the orbit is dependent on two factors: age and sex.

In children, the most common lesions are various forms of sarcoma, including neuroblastoma, medulloblastoma, Ewing's sarcoma, and Wilms' tumor.

In adults, carcinomas dominate, including **breast and lung carcinoma in women and prostate, lung, gut, and kidney carcinoma in men**.

- In children, aggressive sarcomas, including neuroblastoma and Ewing's sarcoma, present with a rapidly progressive proptosis associated with periocular ecchymosis.

Note that about 90% of patients with orbital involvement by neuroblastoma already have a known diagnosis; thus, an initial diagnosis of neuroblastoma based on orbital signs is the exception rather than the rule.

- In the adult population, **uveal metastases far outnumber orbital lesions by a ratio of 10:1**. Usually, patients are between 50 and 70 yrs old with a known history of cancer. However, orbital involvement may be the initial manifestation of an as yet undiagnosed carcinoma elsewhere. In addition, metastases may occur years or decades after "definitive" treatment of the carcinoma.
- **Metastatic orbital lesions in adults typically cause more symptoms than most primary orbital tumors.**

Pain, extraocular muscle restriction, ptosis, and visual loss are all common findings. A shorter duration of complaints along with rapid progression are also ominous findings.

Several specific carcinomas may present with curious signs.

- **Scirrhou breast carcinoma may produce enophthalmos** because of its associated fibroblastic response. Of note, about 20% of metastatic breast carcinoma to the orbits is bilateral. We do not know why.
- **Renal cell and thyroid carcinoma tends to be highly vascular**, producing pulsatile exophthalmos.
- Some tumors, most notably **prostate carcinoma and multiple myeloma, have a predilection for bone invasion, especially the greater sphenoid wing. Both of these tumors may present with spontaneous orbital hemorrhage.**
- Others, including breast, oat cell, and renal cell carcinoma may lodge in an **extraocular muscle**.
- Diagnosis is usually based on imaging findings and tissue biopsy.
 - On CT and MRI, metastatic lesions run the spectrum from well-encapsulated to infiltrating masses.
 - Extraocular muscles harboring carcinoma may exhibit a “knobby” enlargement.
 - Bone involvement may manifest as osteolysis or hyperostosis.
- Once diagnosis is confirmed by orbital exploration and biopsy, the patient should be referred without delay to an oncologist for further therapy. If there is no previous history of carcinoma, then an extensive systemic work-up is warranted, but is usually deferred to the oncologist.
- Prognosis for vision is guarded due to infiltration of the metastatic lesion as well as subsequent chemo/radiotherapeutic damage to native orbital structures.

PART III. INFLAMMATION

Orbital inflammatory processes are divided into INFECTIOUS and NON-INFECTIOUS etiologies.

A. INFECTION

1. OVERVIEW

- Before the antibiotic era, orbital cellulitis carried a significant morbidity:
 - 17% mortality.
 - 20% blindness.
- For periocular / orbital infection, there are three routes of inoculation:
 - DIRECT (25%): Trauma, foreign body, surgery.
 - SPREAD FROM AN ADJACENT STRUCTURE (50-80%): Paranasal sinusitis, endophthalmitis, meningitis.

HEMATOGENOUS DISSEMINATION (<10%): Sepsis, abscess elsewhere, endocarditis.

- **“STAGES” OF INFECTION**

Chandler (Laryngoscope 1970; 80:1414) described five stages of orbital infectious inflammation, with each stage progressing to the next.

VERY artificial!

STAGE 1: Inflammatory edema (phlegmon).

STAGE 2: Orbital cellulitis

STAGE 3: Subperiosteal abscess.

STAGE 4: Orbital (intraconal) abscess.

STAGE 5: Cavernous sinus thrombosis.

- **ORGANISMS OF INFECTION**

BACTERIA:

- In adults: Streptococci, Staphylococci, anaerobes.

- In children: +/- *Hemophilus influenzae*. H. flu is becoming much less common in children thanks to an effective vaccination program.

FUNGUS:

- Mucor.

- Aspergillus.

- Cryptococcus

PARASITIC:

- Rare in North America: Echinococcus, *Taenia solium*.

VIRAL

- Primary *Herpes simplex*.

- *Herpes zoster*.

- Mumps, EBV

- **ANATOMIC PEARLS**

Only the ethmoid sinuses are pneumatized at birth.

Maxillary sinuses aerated at 3-4 yrs.

Frontal sinuses by age 7 to 15 yrs.

Sphenoid sinuses are last to pneumatize.

The lamina papyracea (medial orbital wall) is very thin and perforate, facilitating infectious spread from the ethmoid sinuses.

Orbital veins are VALVELESS, facilitating infectious spread from the orbit into the cavernous sinus.

Subperiosteal space is poorly vascularized, not allowing good antibiotic penetration.

The lacrimal gland is a postseptal structure: dacryoadenitis is by definition a form of orbital cellulitis.

The lacrimal sac is a preseptal structure: isolated dacryocystitis is by definition a form of preseptal cellulitis.

- **INFECTION IN CHILDREN**

Orbital cellulitis (OC) is the most common cause of proptosis in children!

In children 1-5 years old with OC, an associated bacteremia may be found:

- Neonates are protected by maternal antibodies.
- Young children have an immature immune system (poor opsonization and clearance by spleen) and an immunologic naivete.

No clear seasonal predilection (may be increased in winter, due to increased incidence of URI).

REMEMBER to cover *H. influenzae*!! (even though the incidence is rapidly decreasing).

2. CLASSIFICATION of INFECTION

Periocular infection is divided clinically into two large categories: preseptal and orbital cellulitis. It is important to remember that the distinction between the two is sometimes difficult to determine and significant overlap exists. Furthermore, periocular infection should never be managed in a “cookbook” fashion. The management options listed below are guidelines only, and each patient’s treatment should be tailored individually. Table 17 also provides a summary.

• PRESEPTAL CELLULITIS

SYMPTOMS:

- Tenderness over area.
- May have history of antecedent URI, trauma, chalazion, etc.

SIGNS:

- Usually afebrile or “low grade” fever.
- Tenderness and erythema of eyelid skin.
- Normal vision, pupils, and extraocular motility.
- No proptosis or trigeminal hypesthesia.
- May have conjunctival chemosis.

WORK-UP is usually limited:

- In clear-cut cases, CT not necessary.
- CBC (if obtained) may show leukocytosis .

TREATMENT:

- Always suspect occult foreign body in traumatic cases, especially in recurrent cellulitis.

○ IN ADULTS:

Oral antibiotics for 7-10 days

Keflex® 250-500 mg QID

Augmentin® 250-500 mg TID

Bactrim DS® BID

N.B. Augmentin is much more expensive than Keflex or Bactrim in most pharmacies!

Warm compresses 6x per day: this is extremely important and often overlooked!

Decongestants if sinusitis is suspected.

- IN CHILDREN: Remember that children may fool you with signs and symptoms!

Younger than 5 years old: ADMIT for IV antibiotics.

Older than 5 years: oral antibiotics with daily follow-up.

If there is ANY question of compliance or follow-up, admit the patient!

Warm compresses and decongestants.

Always admit children to the Pediatrics Service, not to the Ophthalmology Service!

Always have a low threshold for obtaining a CT in children!

- **ORBITAL CELLULITIS**

SYMPTOMS:

- Fever, malaise, decreased vision, eyelid swelling, diplopia/pain with eye movement, nausea/vomiting.
- PMHx: diabetes, immunosuppression.

SIGNS:

- Fever, eyelid erythema and tenderness.
- Decreased vision or pupillary abnormalities.
- Motility restriction, proptosis.
- Papilledema, retinal venous engorgement, choroidal folds.
- Nuchal signs are ominous.

WORK-UP:

- CBC with differential: leukocytosis with left shift.
- Blood cultures x 2 (+ in 42% of pediatric cases!).
- Usually nothing to culture locally:
Eyelid cultures in absence of purulent drainage are useless and misleading: lid flora may not be pathogen!
If sinus drainage observed on nasal exam, culture is useful.
- CT scan **WITH contrast**: include paranasal sinuses, direct axial and coronal scans, 3 mm cuts
Plain films are not helpful in the diagnosis of orbital cellulitis!
- Lumbar puncture if CNS signs present.

TREATMENT

- ADULTS and CHILDREN:
Admit for IV antibiotics
 - ☐ Unasyn® (Ampicillin/Sulbactam) or
 - ☐ Nafcillin with ceftazidime or ceftriaxone (3rd generation cephalosporins)

□ Vancomycin should not be used empirically except in patients with suspected MRSA or at high risk for MRSA infection.

Warm compresses/decongestants.

Frequent re-evaluation to r/o progression (improvement may not be seen for 24-36 hours).

Consider Otolaryngology consult if sinus disease present.

Infectious Disease consult in difficult or atypical cases.

If sinuses are clear and no evidence of exogenous cause, systemic work-up for endogenous nidus.

	PRESEPTAL CELLULITIS	ORBITAL CELLULITIS
Symptoms	• History of recent URI, trauma, sinusitis • Mild malaise, low-grade fever • NO complaints of diplopia or decreased vision	• History of recent URI, trauma, sinusitis • Failure to improve on oral antibiotics • Malaise, fever, nausea/vomiting • Diplopia • Possibly decreased vision
Signs	• Erythematous, tender eyelid swelling • Normal pupillary exam and extraocular motility • No proptosis	• Tense eyelid swelling with erythema and tenderness • Decreased extraocular motility • Proptosis • Possible optic neuropathy (afferent pupillary defect, color vision deficit)
Imaging Studies (CT with IV contrast)	• Preseptal soft tissue swelling • Orbital tissue without abnormality • Paranasal sinus opacification • Rule out foreign body	• Preseptal soft tissue swelling • Orbital fat will show varying degrees of ill-defined opacification • Paranasal sinus opacification • Rule out foreign body
Ancillary Tests	In adults and older children: • None indicated In younger children: • CBC w/ diff may show leukocytosis with left shift	In all patients: • CBC w/ diff may show leukocytosis with left shift In younger children: • Obtain blood cultures
Antibiotic Therapy*	In adults and older children (choose only one option): • Augmentin® 500 mg TID or 825 mg BID • Keflex® 500 mg QID • Bactrim DS® BID • Dicloxacillin 500 mg QID In younger children: • Admit for IV therapy (see adjacent box)	In adults and older children: • Unasyn® 1.5-3 gm q 6^o In younger children: • Adjust dosage to weight.

Table 20: SUMMARY OF PERIOCCULAR CELLULITIS. NOTE: Additional coverage may be needed in difficult cases. See text for details.

- **SUBPERIOSTEAL ABSCESS**

SIGNS and SYMPTOMS are similar to orbital cellulitis, although they may be magnified in scale.

Suspect an abscess if the patient fails to improve after 48-72 hours of IV antibiotics or if clinical picture deteriorates on IV antibiotics.

- Must re-image all patients who do not improve after 48-72 hours of IV therapy.

- Obtain CT **WITH CONTRAST!!** (allows for easier identification and extent of abscess).

If optic neuropathy is present and abscess is noted on CT, emergent drainage is required.

Usually managed as a combined approach by ENT and Orbital Surgery.

Leave a drain in ALL patients for 24-48 hours.

Dramatic and rapid improvement is the rule after adequate drainage.

Unless patient is deteriorating postoperatively, do NOT reimage. Imaging usually lags behind clinical response by 48-72 hrs.

- **AGE and SUBPERIOSTEAL ABSCESS**

Harris GJ, *Ophthalmology* 1994;101:585 and Garcia GH, Harris GJ. *Ophthalmology* 2000;107:1454 - highly recommended reading!

Microbes involved in subperiosteal abscess formation are related to the age of the patient and this influences response to IV antibiotics.

- <9 years old: respond to IV antibiotics.

Drainage revealed either a sterile collection (phlegmon) or mono-organismal infection.

Anaerobic organisms RARE.

- 9-14 years old: drainage revealed more complex infections.

- >15 years old: polymicrobial infections common.

Anaerobic organisms are the rule.

AGE	CULTURE RESULTS	NEED TO DRAIN
< 9 years	Sterile (58%) or single aerobe	No in 93%
9-14 years	Mixed aerobes and anaerobes	+/-
> 14 years	Mixed, anaerobes in all.	Yes

Table 21. AGE AND SUBPERIOSTEAL ABSCESS

N.B. These are GUIDELINES only, and should not be considered iron-clad rules! (See Harris GJ follow-up letter to the editor, *Am J Ophthalmol*, 1995.). **Any patient with optic neuropathy should be drained urgently, regardless of age!**

- **INTRAORBITAL ABSCESS and CAVERNOUS SINUS THROMBOSIS**

- **INTRAORBITAL ABSCESS**

- Rare, because periosteum is an excellent barrier to intraorbital spread.
 - May be seen following trauma, previous surgery, with foreign body, extrascleral extension of endophthalmitis, or from endogenous seeding.
 - TREATMENT: drainage and IV antibiotics. Drainage may be difficult because of several isolated loculations.

- **CAVERNOUS SINUS THROMBOSIS**

- Rare in era of antibiotics - most commonly seen today with Mucor.
 - In bacterial cases, the patient is usually septic and may be obtunded and hemodynamically unstable (DIC).
 - Guarded prognosis:
 - Mortality approximately 30% (range 14-79%)
 - Morbidity: Visual loss in 7-22%.
 - Management:
 - Hemodynamic support (usually in an intensive care unit).
 - Broad spectrum antibiotics.
 - If an infectious nidus is identified (paranasal sinuses, orbit, etc), it should be drained immediately.
 - Anticoagulation is usually recommended. Studies of cerebral venous thrombosis from a variety of causes have concluded that systemic anticoagulation reduces both morbidity and mortality and does not increase the risk of hemorrhagic stroke.

3. ATYPICAL INFECTION

- **FUNGAL INFECTION**

Fungal infection to the orbit is typically secondary to spread from an adjacent paranasal sinus. Table 20 provides some distinguishing characteristics between *Aspergillus* and *Mucor*, the two most frequently encountered organisms. Conversely, *Cryptococcal* infection usually spreads into the orbit from the CNS along the optic nerve sheaths, is rare in the orbit, and is typically limited to patients with severe immunosuppression.

	ASPERGILLUS	MUCORMYCOSIS
Organism(s)	• <i>Aspergillus</i> sp.	• <i>Rhizopus</i> , <i>Absidia</i> , <i>Mucor</i> sp.
Nidus	• Found normally in the respiratory tract.	• Found normally in the respiratory tract in a noninvasive form.
Demographics	• Most patients with the allergic form have no predisposing factors	• Seen almost exclusively in patients with underlying

	and are otherwise healthy. • May have allergic (noninvasive) or invasive form. • More common in moist, humid climates. • May be seen in AIDS.	immunosuppression. • Ketoacidosis is also a common predisposing factor. Suspect this organism in patients with diabetes, leukemia, s/p chemotherapy, extensive burns. • Uncommon in AIDS.
Clinical Presentation	• Symptoms are usually chronic and indolent. • Slowly progressive (over weeks) proptosis, diplopia, nasal congestion. • Pain is variably present, but is often absent. • A history of allergies, asthma, and chronic sinusitis may be present. • Clinical course may resemble Mucor in immunocompromised individuals.	• Pain is the hallmark of mucormycosis, due to tissue infarction. A fulminant clinical course is common. • Orbital signs are variable, including evidence of orbital apex syndrome or orbital infarction. Ophthalmic or central retinal artery infarction may be seen • A black eschar on nasal or oral exam is a LATE finding. Its absence does NOT rule out the possibility of Mucor!
Radiographic Features	• Difficult to distinguish from bacterial orbital cellulitis. Sinus opacification with a variable degree of orbital involvement. Pseudocalcification within the mass is a highly diagnostic finding. • One clue for this etiology is the presence of dramatic, extensive radiographic involvement with minimal or mild clinical signs. Bone destruction may be present on CT. • Ring enhancement is seen in allergic "aspergilloma".	• Radiologic findings run the gamut from minimal paranasal sinus opacification to extensive paranasal sinus and orbital involvement. • MRI may be helpful in visualizing cavernous sinus involvement. Orbital infarction may also be seen on MRI as an asymmetry in overall signal between the orbits.
Treatment	• Allergic aspergillosis does not invade the orbit and is treated differently than the invasive form. Usually all that is required is debridement of the paranasal sinuses and possibly systemic corticosteroids. Amphotericin therapy is not indicated. For invasive aspergillosis, tissue biopsy for diagnosis (usually by transnasal endoscopy). Surgical debridement of the paranasal sinuses with intravenous amphotericin is indicated. • In immunocompromised patients, treatment similar to that of Mucor may be necessary. • Despite aggressive therapy, mortality is high with the invasive form.	• Urgent surgical debridement or the paranasal sinuses and necrotic orbital tissue ("limited exenteration"). • Placement of an intraorbital catheter* for local irrigation with amphotericin along with systemic therapy has been advocated recently. • Surgical management must be aggressive (including complete exenteration, if necessary) to improve prognosis, although recent data has shown that globe-sparing surgery may be as effective as exenteration. • Systemic ketoacidosis must be reversed rapidly, since the organism thrives in an acidotic environment. • ? Use of hyperbaric oxygen.
Histopathology	• Septate hyphae seen with fungal	• Nonseptate, branching hyphae

	staining and on H&E. • Granulomatous inflammation, possible caseation.	on fungal staining and H&E; polymorphonuclear infiltrate. • Evidence of necrotizing vascular invasion is common.
Prognosis	• Favorable in immunocompetent patients.	• Poor (high mortality)

* 7 French single lumen central line catheter. Amphotericin 1-4 mg in 1-2 cc sterile water (not saline!) one to two times per day.

Table 22. COMPARISON OF FUNGAL INFECTIONS OF THE ORBIT

• MUCORMYCOSIS

Organism is a common bread mold normally found in respiratory tract in noninvasive form.

Invasion is almost exclusively seen in patients with underlying immunosuppression:

- Diabetes (DKA), leukemia, chemotherapy, extensive burns, etc.
- Uncommon in AIDS (? role of humoral immunity).
- Rare, but may occur in healthy individuals.
- Ketoacidosis may be necessary for invasion.

CLINICAL PICTURE:

- **PAIN is the hallmark**, and is due to ischemic damage to tissue ("orbital angina").
- Profound, rapid visual loss is common.
- Varied orbital signs, including orbital apex syndrome and orbital infarction.
- BLACK ESCHAR on palate or intranasally is helpful, but only seen late in the disease!!

TREATMENT:

- Systemic IV Amphotericin.
- Debridement, with placement of Amphotericin catheter, possibly exenteration.
- **RAPID REVERSAL OF KETOACIDOSIS IS IMPORTANT!**

Prognosis: Fair to poor

• ASPERGILLOSIS

Normally found in respiratory tract.

Invasive disease is mostly seen in immunosuppressed individuals, while the allergic variant is seen in immunocompetent individuals, sometimes with a history of atopy or nasal polyposis.

Symptoms are usually chronic and indolent.

Most patients live in warm, humid climates.

Treatment: surgical debridement and systemic antifungal agents (po or IV) for the invasive form.

Mortality is significant with CNS spread.

N.B.: In immunocompromised hosts, disease course is fulminant, resembling mucormycosis!

N.B.: Invasive aspergillosis is not equivalent to allergic aspergillosis prognostically!!

- **HIV / AIDS**

Sinusitis / orbital cellulitis more common than in general population.
Always suspect atypical infectious organisms, including fungus.

- Aspergillus much more common than Mucor.

Consider noninfectious causes, especially HIV-related lymphoma.

HZO IN HIV

- Especially severe.
- May be presenting sign of HIV infection.

Be suspicious of HIV in patients presenting with HZO younger than < 45 yrs.

- May occur over several dermatomes.
- High incidence of cicatrix.

- **NECROTIZING FASCIITIS**

Deep soft tissue infection.

Most often due to Group A β -hemolytic Streptococcus.

High mortality from pulmonary / renal failure, despite aggressive therapy.

Exotoxin production varies among subtypes and greatly influences survival.

CLINICAL CHARACTERISTICS

- Rapid progression is highly suspicious.
- Eschar formation.
- Sepsis.
- Rapid systemic deterioration.

TREATMENT

- ICU admission, antibiotics, aggressive debridement of deeper fascial layers, sparing the skin and orbicularis if possible.
- Overall mortality 50 - 75%.

? Lower for isolated periocular involvement.

- **METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS (MRSA) INFECTION**

Incidence is rising.

Two types:

- Hospital-associated (HA-MRSA): Susceptible to vancomycin only. Usually seen in hospitalized or institutionalized (nursing homes, prisons) individuals.
- Community-associated (CA-MRSA): Susceptible to vancomycin + tetracycline, trimethoprim-sulfa (Bactrim), and clindamycin (although resistance to clinda is rising). May occur with trivial trauma in healthy patients.

TREATMENT

- Clinical suspicion. If patient fails to improve on penicillin or cephalosporin medications and CA-MRSA suspected, begin doxycycline or Bactrim. In some large metropolitan areas (including Philadelphia), incidence is so high that some physicians begin doxycycline or Bactrim as first line therapy.
- For HA-MRSA, IV vancomycin is necessary. May progress rapidly and require debridement.

B. NONINFECTIOUS INFLAMMATION

1. IDIOPATHIC ORBITAL INFLAMMATION SYNDROME (IOIS)

- **DEFINITION**

IOIS (previously called inflammatory orbital pseudotumor) is an acute, nonspecific inflammation affecting any tissue within the orbit.

- **ETIOLOGY**

The etiology is unknown. In the vast majority of cases, there is no associated systemic disease.

On occasion, patients with other autoimmune or inflammatory conditions (lupus, ulcerative colitis) may present with orbital inflammation.

IOIS has no clear predilection for a certain age, sex, or race.

No clear seasonal pattern has been proven.

- **HISTOPATHOLOGY**

A mixed hypocellular, inflammatory response is the rule, including:

- Neutrophils
- Lymphocytes
- Monocytes

In some cases (especially children), a preponderance of eosinophils may be seen.

- **CLINICAL CHARACTERISTICS**

Symptoms:

- Classically the presentation is acute, with a sudden onset of:
 - Pain.
 - Swelling.
 - Double vision.
- A painless, more indolent presentation may occur, but is ATYPICAL and should prompt a search for other etiologies!

Signs: IOIS can affect any or all soft tissue components within the orbit and may manifest signs of:

- Dacryoadenitis: Red, painful enlargement of the lacrimal gland, often misdiagnosed as infectious dacryoadenitis.
- Myositis: Painful external ophthalmoplegia, often accompanied by inflammation ("beefiness") of the EOM insertion.

- Optic neuritis: Important to distinguish from demyelinating disease, since work-up and treatment are different! See Neuro-Ophth section.
- Tenonitis: Diffuse conjunctival chemosis and injection. Orbital imaging is usually very helpful.
- Posterior scleritis: May present with visual loss, vitritis/choroiditis, optic neuritis, chemosis. Often requires IV steroids to control. May affect other eye sequentially in up to 40% of cases.
- Orbital apex syndrome when the disease affects the posterior orbit. May present with multiple cranial neuropathy and visual compromise (N.B. NOT equivalent to Tolosa-Hunt syndrome!).
- **PEDIATRIC SIGNS**
 - In children, IOIS may present with systemic symptoms, including fever, and is more often bilateral (simultaneously or sequentially) than in adults.**
 - “Pseudocellulitis”
 - Must rule out infection first!
- **IMAGING**
 - CT or MRI imaging should be obtained in all patients with suspected IOIS.
 - IV contrast should be used with all CT studies.
 - Gadolinium and fat suppression should be used in all MRI studies.
 - A poorly circumscribed, infiltrating enhancement of orbital tissue. May be limited to specific tissue (muscle, lacrimal gland).
 - Bone destruction is very atypical and necessitates tissue biopsy.
 - On occasion, B-scan ultrasonography is helpful in cases of posterior scleritis, which may not be visible on CT or MRI.
- **SYSTEMIC WORK-UP**
 - Rarely helpful and is usually not indicated.
 - In patients where differentiation from infection is difficult, a CBC may be obtained.
 - An elevated white count and left shift may be seen in both infectious and noninfectious orbital inflammation.
 - Bacterial infection will usually result in a neutrophilia with left shift, while in some cases of IOI, an eosinophilia may be present.
- **? BIOPSY**
 - Orbital biopsy is performed in atypical cases, after several recurrences, or with treatment failure. Recent studies have also recommended biopsy in all cases when tissue is accessible (ie, much easier to biopsy lacrimal gland than orbital apex) – from the practical standpoint, this usually refers to cases of dacryoadenitis.

CAVEATS

- **IF** atypical:
 - By presentation: Subacute/chronic, bilaterally in adults, significant systemic complaints, **history of cancer**.
 - By treatment response: Responds poorly to corticosteroid treatment (recalcitrant or recurrent cases).
 - By imaging: Bone destruction.

THEN a lower threshold for a complete systemic work-up and **TISSUE BIOPSY** in search of another cause should be aggressively pursued.
- As noted above, in Europe, the current recommendation from many orbital centers is to biopsy all patients. This may be due at least in part to referral patterns in Europe, where most typical cases are managed locally and orbital centers see a plethora of more atypical cases.
- Note that treatment with systemic corticosteroids will likely affect any subsequent biopsy results. Biopsy should be performed prior to corticosteroid therapy or after a washout period of at least 2 weeks.
- **TREATMENT**
 - Corticosteroids:**
 - In adults, prednisone 80-100 mg daily usually results in rapid and dramatic clinical improvement, often after only one dose. Lower doses may not be effective and should not be initiated.
 - Pediatric doses should be calculated based on body weight.
 - Relapses are common and are usually related to a rapid taper of corticosteroids.
 - Non-steroidal anti-inflammatory medications (NSAIDs):**
 - Primary therapy: Common in Europe.
 - Secondary therapy: In patients who are intolerant of corticosteroids, the initial corticosteroid dose may be tapered more rapidly while a steady dose of NSAIDs is maintained, followed by a slow NSAID taper.
 - Radiation therapy:**
 - A course of low-dose (2000 cGy total) orbital radiotherapy may be considered.
 - Many experts mandate tissue biopsy before proceeding with radiotherapy.
- **DIFFERENTIAL DIAGNOSIS: IS IT CELLULITIS?**

If any doubt is present between IOI and orbital cellulitis (especially in children):

 - If the paranasal sinuses are clear on imaging studies and there is no history of penetrating trauma, then IOI is more likely than cellulitis. However, many (? most) patients often have at least

some opacification of the paranasal sinuses as a routine finding on imaging.

- Prudent to first begin a trial of intravenous antibiotics with close clinical follow-up.
- If symptoms fail to improve after 48 hours, then a “test dose” of corticosteroids may be given while still maintaining antibiotic coverage.
- A rapid response to corticosteroids is indicative of a noninfectious inflammation.
- **Remember rhabdomyosarcoma!**

2. GRANULOMATOSIS WITH POLYANGIITIS (GPA, WEGENER GRANULOMATOSIS)

- A necrotizing vasculitis that may present in either an indolent or explosive fashion.
 - Most patients are male and between 20 to 40 years old.
 - Ocular involvement occurs in 50% of patients, including conjunctivitis, scleritis, restrictive strabismus, epiphora (NLD obstruction is very common), intraocular inflammation, optic neuritis/papillitis, and orbital inflammatory signs.
- Two variants are seen:
 - Generalized**, with involvement of the lungs and kidneys.
 - These patients present with significant, fulminant systemic complaints, including fever, weight loss, etc.
 - **A positive c-ANCA serology is the rule and is diagnostic.**
 - Rapid diagnosis and treatment are essential to minimize organ failure (pulmonary, renal, etc.).
 - Localized**, with involvement limited to the paranasal sinuses and orbit.
 - Symptoms are reminiscent of chronic sinusitis.
 - Bone destruction on CT is the rule.
 - **Biopsy is necessary for definitive diagnosis, since c-ANCA serology is negative in a significant percentage of patients (68%).**
- Management:
 - Tissue biopsy to confirm diagnosis.
 - Chemotherapy.

3. SARCOIDOSIS

- Periocular or intraocular sarcoidosis may present in either an indolent or fulminant fashion.
- Involvement of the lacrimal glands is common.

- History may reveal constitutional symptoms as well as complaints of shortness of breath or a misdiagnosis of asthma.
- Ocular exam may reveal eyelid and conjunctival nodules, evidence of previous uveitis (keratic precipitates), iris nodules, vitreous debris, and cotton-wool spots. Optic neuritis may occur.
- **Angiotensin converting enzyme (ACE) and chest X-ray may be helpful, but can prove negative in a localized variant known as “orbital sarcoid” (Jakobiec).**
- Definitive diagnosis necessitates a tissue biopsy.

4. IDIOPATHIC ORBITAL FIBROSIS (SCLEROSING PSEUDOTUMOR)

- Rare variant of orbital inflammation or a separate disease more closely associated with other forms of systemic fibrosis?
- More chronic and causes significant tissue destruction from secondary fibrosis.
- Poorly responsive to corticosteroid therapy and may require more drastic measures, including:
 - Chemotherapeutic agents.
 - Repeated surgical debulking.
 - Exenteration.
- The clinical and histopathologic picture is so atypical of classic orbital pseudotumor that some experts have appropriately questioned whether this diagnosis even belongs within the rubric of orbital inflammation (Rootman). A more appropriate term may be **idiopathic orbital fibrosis**.

5. IgG4-Related Orbitopathy

- A recently described inflammatory syndrome that can affect any organ system in the body, but seems to have a predilection for the orbit (especially the lacrimal gland).
- Usually indolent, painless presentation.
- Typified by a fibroinflammatory histopathology with IgG4+ plasma cells.
- Note that there is an overlap with other inflammatory conditions, including GPA.
- Some cases of IgG4-related orbitopathy have progressed to B-cell lymphoma (usually EMZL). This seems to be more common in East Asia.

5. TOLOSA HUNT SYNDROME

- NOT equivalent to orbital apical pseudotumor.
- Histologically, a **granulomatous inflammation of the carotid siphon**.
- A diagnosis of exclusion! Patient needs long term follow-up to rule out other etiologies.
 - DDx: Meningioma, aneurysm, infection, lymphoma, metastasis.

- Pain responds to corticosteroids rapidly, but external ophthalmoplegia may take weeks to improve.
- Appears to have a tendency to recur and sometimes affect contralateral side.

6. THYROID EYE DISEASE (TED, THYROID-RELATED ORBITOPATHY, GRAVES DISEASE)

- **BACKGROUND**

Most common cause of unilateral and bilateral proptosis in adults is TED.

Described by Perry (1825) and Graves (1835).

Europe: Basedow syndrome.

- **ORBITOPATHY**

GRAVES DISEASE

- Describes the triad of:

Goiter.

Tachycardia (sometimes pretibial myxedema).

Exophthalmos.

- Patients usually are initially **HYPERthyroid (80-90%)**.

HYPOthyroid: 1-3%

Euthyroid: 5-10%

Hashimoto's thyroiditis: 3%

- Of euthyroid patients, risk of thyroid disease is:

25% in 1 year.

50% in 5 years.

Hyperthyroidism

- Incidence of about 2% in general population.
- **Female:male = 6:1.**
- Family history common (50%).
- Always ask about other autoimmune disease (MG seen in ~2%).
- Orbitopathy seen in 30-70% of hyperthyroid patients.

Female:male narrows to 4:1.

10-25% of undiagnosed hyperthyroid patients present initially to the ophthalmologist.

- **CLINICAL PRESENTATION**

Usually gradual.

Early symptoms are nonspecific: photophobia, tearing, FBS, eyelid puffiness, conjunctival injection, intermittent diplopia.

UPPER EYELID RETRACTION IS A HIGHLY SPECIFIC FINDING!

DDX: previous lid surgery, anxiety, being a Maori dancer.

NOSPECS CLASSIFICATIONS: ? PRACTICAL USE

- No signs or symptoms.
- Only signs.

- Soft tissue involvement.
- Proptosis (60%).
- Extraocular muscle involvement (40%).
- Corneal involvement.
- **Sight loss / optic neuropathy (6%).**

HISTORY

- Ocular complaints.
- Systemic complaints.
- Thyroid treatment.
- **I-131 and prednisone use.**
- **SMOKING**
- Patient expectations.

SMOKING AND TED

- Several independent studies have confirmed that thyroid disease and smoking are a bad mix. In patients with thyroid disease, smokers have:

A higher incidence of TED.

A more severe, progressive orbitopathy.

- All smokers with TED should be counseled in depth about these findings, and the conversation clearly documented in the medical record at each visit.

I-131 AND TED

- This remains a controversial topic.
One study from Italy concluded that I-131 therapy increases the risk for progressive orbitopathy, and the use of corticosteroid therapy at the time of I-131 is protective.
These findings were subsequently refuted by a Mayo clinic study, which found no such correlation.
- Personal opinion: The endocrinologist should provide appropriate care of the thyroid dysfunction, including I-131 if necessary.

In young, healthy patients, a course of oral corticosteroids during and after I-131 therapy can be offered.

- **HYPOTHYROIDISM AND TED**

- Regardless of therapy (I-131, thyroidectomy, etc), the single greatest risk for progression of TED appears to be acute and profound post-treatment hypothyroidism. It is therefore imperative that any patient undergoing thyroid ablation (medical or surgical) be followed closely and treated aggressively immediately following therapy for any iatrogenically induced hypothyroidism.

EXAMINATION

- Full ophthalmic exam, including:
Color plates, pupils.

IOP in primary and upgaze.

Prism bar testing as indicated.

Resistance to retropulsion, exophthalmometry.

Dilated fundus exam.

- **EYELID SIGNS**

- **UPPER EYELID RETRACTION.**

- “Lateral flare”

Lower lid retraction much less specific.

Lid lag (von Graefe’s sign): upper lid lags or “hangs up” in attempted downgaze.

Lagophthalmos: Inability to close the lids completely.

Edema or boggiess: Often misdiagnosed as “allergies”.

Ptosis: Less common. Should prompt an investigation for myasthenia gravis and thymoma, both of which can be seen in association with Graves’ disease.

- **OCULAR SIGNS**

Conjunctiva: Injection, chemosis.

Cornea: Exposure keratopathy, ulceration.

Intraocular pressure: Elevation in primary gaze, increase of >4mm Hg in upgaze.

Optic nerve: Visual field defect, optic neuropathy, disc swelling, pallor.

Retina: Chorioretinal folds, venous congestion.

- **EXTRAOCULAR MUSCLES**

Diplopia: May be both vertical and horizontal.

Usually worse on lateral and upgaze.

- Noncomitant esotropias common.
- Vertical deviations common.

Quantification

- Ductions.
- Diplopia fields.
- Prism bars, red filters, Maddox rods.
- ? Forced ductions.

IMAGING: CT

- Not indicated in all patients.

- CT without contrast is preferable to MRI for bony anatomy (in case decompression is needed).

- Indications for CT:

Unilateral Graves’ disease: to rule out other etiologies.

Optic neuropathy.

Severe congestive orbitopathy with restrictive strabismus.

Atypical presentation.

- **MRI**

May help predict inflammatory phase of disease.

Advantages: No radiation, better soft tissue detail.

Disadvantage: Poor bone detail.

CLINICAL COURSE

- Highly variable.
- Rundle's curve:
 - Inflammatory phase.
 - Quiescent phase.
- If possible, avoid surgical intervention during inflammatory phase.

Exceptions: unmanageable optic neuropathy, corneal ulceration, dangerously high IOP.

"SUBTYPES" OF TED

- TED is sometimes divided into a **MYOGENIC** and **LIPOGENIC** subtype (Table 23).

Note that this is an artificial and somewhat arbitrary separation, since most patients, with Graves' disease present somewhere in-between.

- ****N.B. Severe proptosis does NOT correlate with a high risk of compressive optic neuropathy. Optic neuropathy occurs in patients with little or no proptosis, significant restriction to retropulsion, and restrictive strabismus. Such patients should be followed much more frequently than patients who have proptosis and exposure keratopathy, but little or no strabismus.****

FINDINGS	MYOGENIC	LIPOGENIC
Proptosis	Minimal	Significant
EOMotility	Restricted	Full or nearly full
Keratopathy	Mild	Severe
Restriction to retropulsion	Markedly increased	Normal or mild
Optic neuropathy	Common	Rare
CT/MRI	Markedly enlarged EOMs, apical crowding.	Normal or minimally enlarged EOMs

Table 22. SUBTYPES OF GRAVES' ORBITOPATHY

• **MANAGEMENT: SUPPORTIVE**

Exposure keratopathy

- Lubrication: Artificial tears q 2hrs, ointment q hs.
- Sunglasses, moisture chambers.
- Bedtime taping, Saran wrap.

Diplopia

- Prisms: Try Fresnel first!
- Occlusion.

Periorbital edema

- ? Raise head of bed.
- Cold compresses, especially in AM.
- Avoid diuretics.
- High IOP
 - Topical medications usually ineffective.
- **MANAGEMENT: STEROIDS**

Corticosteroids are a temporizing measure ONLY!!

Effective in inflammatory phase.

Indications:

 - Optic neuropathy.
 - Peri-operative.
 - With XRT.
 - ? With I-131
 - Severe flare-ups of inflammation.

Dosage:

 - Prednisone 40-100 mg q day, tapered over 4-6 weeks.

○ A recent study from Europe noted long term control of inflammatory TED signs with initial high dose IV pulse steroids over 12 weeks, which have a better safety profile than oral corticosteroids..The long term efficacy of this modality is not yet known and there have been rare cases of death from higher doses.
- **MANAGEMENT: RADIATION**

Should only be used in INFLAMMATORY phase.

CONTROVERSIAL!

Mayo clinic study concluded it is ineffective in TED.

 - Study excluded patients with optic neuropathy!
 - Gorman CA, et al. Ophthalmology (2001) 108:1523-34.

Comment: Feldon S, 1521-2.

 - Study results have been hotly debated.

Dose: 1800-2500 cGY divided over 10-14 treatments.

Cover flare-ups with Medrol dose pack.

Complications are rare.

 - Radiation retinopathy / optic neuropathy has been reported.

Avoid in vasculopathies (diabetics, etc.)

Never repeat treatment.
- **MANAGEMENT: ADJUNCTIVE**
 - SELENIUM: Recent data have shown that the use of antioxidant therapy (selenium supplementation for 6 months) may decrease the severity and progression of TED.
 - VITAMIN D: Vitamin D deficiency appears to cause progression of TED. Vitamin D supplementation is often recommended in active TED.
- **MANAGEMENT: MONOCLONAL ANTIBODIES**

- Rituximab: The data is a bit conflicted with TED. Some studies found efficacy and others did not.
- Tocilizumab, an IL-6 receptor blocker now used in the treatment of giant cell arteritis, has shown to be effective in TED in a limited number of small studies.
- **Teprotumumab is a blocking antibody of the insulin-like growth factor-1 (IGF-1R)**
 - It binds to the IGF-1R/TSHR signaling complex, blocking the ability of thyroid autoantibodies (thyroid stimulating immunoglobulin (TSI) and thyroid peroxidase (TPO)) to bind and stimulate this complex to induce fibroblast proliferation.
 - Teprotumumab is the first FDA-approved targeted therapy for TED as of January 2020.
 - Efficacy over a the broad spectrum of TED is as yet unknown, but promising results have been found in the initial patient cohort.
- **MANAGEMENT: SURGICAL**
 - ORBITAL SURGERY
 - Bony decompression.
 - Soft tissue (fat) decompression.
 - Combination.
 - STRABISMUS SURGERY
 - EYELID RETRACTION SURGERY
 - COSMETIC CONSIDERATIONS
 - N.B. Sequence of surgery is VERY important.**
- **ORBITAL DECOMPRESSION**
 - Indications:
 - Optic neuropathy.
 - Exposure keratopathy.
 - High IOP.
 - Globe luxation.
 - Cosmetic considerations (proptosis).
 - Complications
 - Common:
 - Inadequate decompression: usually due to soft tissue fibrosis.
 - Diplopia: may increase in 15-40% of patients postoperatively.
 - Increased lid retraction.
 - Overcorrection (globe ptosis).
 - Sinus disease.
 - Infraorbital hypesthesia.
 - Uncommon:

- CSF leak.
- Lacrimal obstruction.
- Blindness.
- Carotid injury or intracranial bleeding.
- Death.
- **STRABISMUS**
 - Challenging to manage.
 - Restrictive myopathy.
 - Noncomitant deviations.
 - Goals:
 - Maximize single binocular field of vision.
 - Concentrate on functional gazes: primary and downgaze.
 - Surgery
 - Recessions: MRM, IRM. **AVOID RESECTIONS!**
 - Adjustable sutures.
- **EYELID MALPOSITIONS**
 - Tarsorrhaphy.
 - Upper eyelid recession.
 - Mullerectomy.
 - Levator myotomy, recession.
 - Lower eyelid recession.
 - Excision of LL retractors.
 - Spacer grafts.
 - Lateral canthoplasty.

PART IV. ANOPHTHALMOS

1. OVERVIEW

- Removal of the eye is a major event in any patient's life and has several nonophthalmic and ophthalmic implications:
 - Psychologic:
 - The patient may be profoundly depressed by loss of the eye, especially in acute trauma situations. Family support is essential and, on occasion, psychiatric consultation is needed.
 - The patient needs to be counseled about the anticipated final cosmetic result. In general, it is best to be conservative with any predictions about cosmesis and motility.
 - In cases of ocular or orbital malignancy, fear of metastasis and death may be overwhelming for the patient and need to be addressed.
 - Systemic: In cases of malignancy, systemic work-up and surveillance need to be set-up with an oncologist.
 - Ocular:

- In cases of acute visual loss, depth perception is often very poor for several months, until the brain learns to use other cues. The patient needs to be counseled about potential pitfalls in activities of daily living.
- POLYCARBONATE SAFETY GLASSES must be prescribed to all patients and their use must be discussed with the patient! The initial conversation and subsequent reminders should be documented in the patient's record. If patients refuse to wear glasses, they must understand the potential consequences and their refusal should also be documented.
- The contralateral eye needs to be monitored routinely for any pathology that may affect visual function.

2. DEFINITIONS:

- **ENUCLEATION:** Removal of the eye, including the cornea, sclera, and intraocular contents along with a portion of the optic nerve.
- **EVISCERATION:** Removal of the intraocular contents with preservation of the sclera and (depending on surgical technique) the cornea.
- **EXENTERATION:** Removal of the orbital tissues and globe down to the bone. An ANTERIOR EXENTERATION refers to preservation of orbital apical soft tissue. On occasion, orbital bones also need to be removed.

3. ENUCLEATION

- INDICATIONS:
 - Blind, painful eye not responsive to topical therapy (and ? intraorbital alcohol injection).
 - B-scan ultrasonography may be performed preoperatively in cases with a poor view of the fundus to rule-out extrascleral extension of an unsuspected intraocular malignancy.
 - Intraocular malignancy not amenable to other forms of therapy.
 - Cosmetically deformed or phthisical eye. A trial of a cosmetic scleral shell or contact lens may be tried first.
 - Severely traumatized eye or irreparably ruptured globe.
 - In most cases, enucleation is performed within 10-14 days of the initial trauma to minimize the risk of sympathetic ophthalmia.
 - Primary enucleation following trauma is not commonly performed to allow the patient to psychologically adjust to the situation, assure the patient that all other alternatives have been exhausted, and to allow soft tissue swelling to settle down.
 - Primary enucleations may be necessary in cases of severe trauma, especially gun shot wounds to the orbit.
 - It is imperative that possible enucleation be listed on the informed consent in ALL cases of ruptured globe.

- Even in obviously unsalvageable eyes, an intraoperative exploration by a cornea or retina specialist is advisable before proceeding with primary enucleation.
- GOALS:
 - Replace the lost volume with an appropriately sized orbital implant and prosthesis.
 - Provide good anterior coverage of the orbital implant to minimize the risk of postoperative exposure, extrusion, or infection.
 - Maintain conjunctival fornices to support the prosthesis.
 - Provide some motility transfer from the implant to the prosthesis.
 - In very young children, orbital growth is dependent on the presence of an eye. Therefore, if enucleation is indicated, a large sphere should be used to promote growth of orbital bones.
 - Soft tissue expanders are being investigated, but their role may be limited because of the potential for extrusion.
 - Dermis fat grafts should also be considered in children: recent studies have documented growth the the fat graft along with the orbit.
- IMPLANTS:
 - The type of orbital implant used is a decision made between the patient and surgeon. **NO IDEAL IMPLANT EXISTS!**
 - Shape: spherical vs. conical.
 - Type: dermis fat vs inert material.
 - Type: porous (porous polyethylene, hydroxyapatite) vs smooth (acrylic, silicone).
 - Technique: wrapped or unwrapped; muscle attached or not attached; implant coupling (“pegging”) to the prosthesis.
 - Prosthesis fitting is usually performed 4-8 weeks following enucleation.
- COMPLICATIONS / PROBLEMS:
 - Removal of wrong eye:
 - In ALL patients, check your office notes, the consent, ask the patient to tell you and point to the eye for removal, mark the site personally, and have the nursing staff confirm all of these steps. In cases of “quiet eyes” (i.e. not traumatized, nonphthisical), such as those harboring melanoma, indirect ophthalmoscopy is indicated intraoperatively.
 - Incomplete removal of the eye: Usually due to an overzealous rotation of the enucleation scissors during attempted cutting of the optic nerve. The orbit should be explored and any remaining globe removed.
 - Lid malpositions and motility dysfunction: common in traumatized eyes because of soft tissue injury.

Late ptosis, superior sulcus deformity, and lower lid laxity: Due to soft tissue stretching from the weight of the prosthesis as well as intraorbital implant migration.

Chronic papillary reaction: The patient often complains of “pus” or mucous discharge. Usually due to protein build-up on the prosthesis. Managed with topical antihistamines and prosthesis polishing.

Extrusion or conjunctival breakdown: Seen more often in porous implants. Meticulous closure of Tenon capsule is essential. Unclear if wrapping the implant (sclera, dura, polyglactin mesh, etc.) decreases the incidence (there is some evidence that wrapping may increase extrusion rates).

4. EVISCERATION

- Advantages over enucleation:
 - Less orbital soft tissue manipulation / destruction.
 - Better prosthetic motility.
 - ? better treatment for acute enophthalmitis: The sclera may act as an effective barrier against orbital spread of infection. This has never been definitively proven.
 - Technically simpler: May be safer from an anesthesia risk standpoint in older patients or medically unstable patients.
- Disadvantages:
 - May allow for egress of unsuspected intraocular malignancy.
 - ALL PATIENTS MUST UNDERGO A DETAILED PREOPERATIVE FUNDUS EXAM. IF THIS IS NOT POSSIBLE BECAUSE OF OPAQUE MEDIA, B-SCAN ULTRASONOGRAPHY MUST BE OBTAINED!
 - May increase the risk of sympathetic ophthalmia:
 - Based on available anecdotal data, this is at best a theoretical risk. There is no definitive study that supports or refutes this supposition.

5. EXENTERATION

- Indications:
 - Intraorbital malignancy from primary source, secondary spread (eye, brain, paranasal sinuses, skin), and ? metastasis.
 - Consider alternative therapies (chemotherapy, radiation): may be as or more effective for survival.
 - Severe infections: fungus (especially Mucor), parasitic, atypical bacterial (necrotizing fasciitis).
 - Atypical but progressive benign processes resistant to other treatment modalities: sclerosing pseudotumor.
 - Not all exenterations are the same: sometimes a subtotal exenteration suffices, and sometimes exenteration with removal of adjacent bones, cranium, and midface is indicated. In “exenteration+”

reconstruction may be difficult and require vascularized free flaps to cover the defect.

PART V. ORBITAL TRAUMA

1. EVALUATION

Orbital trauma often associated with systemic injuries, sometimes life threatening.

- **Appropriate patient triage!**
If any question about systemic injury exists, the patient should be IMMEDIATELY transferred to the appropriate emergency facility.
- **Life Threatening**
Airway: May need emergency intubation or tracheotomy, especially with thermal/chemical injuries.
Circulation / Vascular
Cervical spine: When in doubt, place a collar immediately. This is especially important BEFORE obtaining direct CT coronal images of the orbit, which requires HYPEREXTENSION of the neck!
Neurologic: Any history of loss of consciousness merits imaging of the brain.
- **Sight Threatening**
Globe injury: Clear the globe before proceeding with any management of lid/orbital injury.
“Orbital compartment syndrome”: Compressive optic neuropathy or globe ischemia from retrobulbar hemorrhage. Manage without delay!
Fracture with marked entrapment: see below.
Retained intraorbital foreign body.
Traumatic optic neuropathy.

2. CLASSIFICATION OF ORBITAL FRACTURES

- **Internal**
1-2 orbital walls (floor, medial)
Rim uninvolved
- **Rim**
Displaced vs. non-displaced
- **Complex**
> 1 wall
Rim involved
- **Unusual orbital fractures**
Naso-orbital ethmoidal (NOE) fractures
Fractures involving the nasolacrimal drainage apparatus (NOE and Lefort II)
Lefort types II and III

Orbital roof fractures
 Blow-in fractures
 Optic canal fractures

3. ORBITAL IMAGING IN TRAUMA

- CT modality of choice:
 - CT is widely available and more economical than MRI, and bony anatomy is seen in detail.
 - 3mm cuts (1.5 mm for foreign body or TON).
 - Axial and direct coronal or coronal reconstructions. An axial scan alone is INADEQUATE.
 - Spiral/helical CT in uncooperative patients / children: More rapid scan times without loss of resolution.
 - Indications for CT
 - Suspected entrapment.
 - Obvious orbital / facial deformity.
 - Ominous mechanism of injury.
 - LOSS OF CONSCIOUSNESS! (Image the brain).
 - Suspect foreign body.
 - ? Infraorbital hypesthesia.
- Essentially no role for plain x-rays, except to rule out metallic foreign body before MRI. On occasion, plain films are obtained postoperatively to check positioning of hardware (miniplates, wires, etc.)
 - Always minimize the amount of radiation exposure needed for adequate imaging, especially in children (see Imaging Handout).
- MRI contraindicated as the initial imaging modality in trauma, since bone is poorly seen and metallic FBs may move in the magnetic field.
 - May be helpful in organic foreign body (e.g. wood).

4. ORBITAL BLOW-OUT FRACTURES

- Internal orbital fracture.
- Buckling / hydraulic mechanisms: Both mechanisms are usually involved.
- Floor / medial wall: One or both walls may be involved, including the inferomedial optic strut.
- Location of most orbital floor fractures is **medial to infraorbital neurovascular bundle**.
 - V-2 hypesthesia: Usually due to contusion injury, not laceration. About 80-90% will resolve, regardless of management, although isolated spots of numbness may be present permanently.
- Rim not involved.
- Complications
 - Diplopia**

- Entrapment- clinical, NOT radiologic diagnosis. Do not state “muscle entrapment noted on CT”!
- Extraocular muscles typically not incarcerated.
There is an important exception (see white-eyed BOF below). Without rapid release, ischemia and Volkmann’s contracture may occur.
- Contusion.
- Rarely, diploia may be due to cranial neuropathy. This is distinguished from entrapment by a force generation test. Any evidence of cranial neuropathy necessitates brain imaging immediately.
- EOM laceration / disinsertion: Occurs in the setting of lacerating injury. Very rare with blunt trauma alone.

Enophthalmos

- >2mm considered to be clinically significant.
 - **>50% CT defect likely to develop late enophthalmos.**
- Orbital compartment syndrome: EMERGENCY!
- Hemorrhage, emphysema.

5. ZYGOMATICO-COMPLEX FRACTURE

- Confusing nomenclature:
Tripod, zygomatic, trimalar/ malar, & cheek bone fracture: All the same fracture pattern.
- Components: Follow the buttresses of the face (Fig. 4).
Fronto-zygomatic suture
Zygomatic-maxillary suture
Zygomatic arch
Orbital floor: Diplopia is uncommon in tripod fractures.
- Indications for repair:
As for BOF, plus
 - Trismus.
 - Malar flattening.
 - Severe stepoff deformity.
 - Usually requires miniplates for stabilization.
 - Note that Hertel exophthalmometry is not very helpful in tripod fractures because the lateral orbital rim is often rotated.

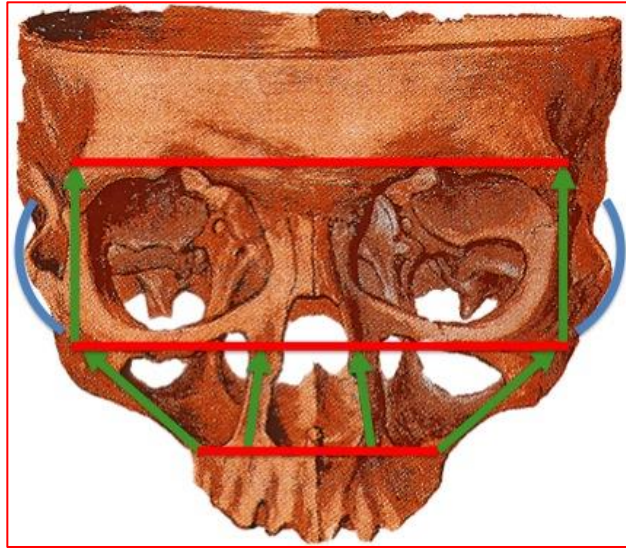


Figure 4. The facial buttresses. Think of the face as a kind of tressle bridge, with 2 levels of horizontal (green lines) and 3 levels of vertical (red lines) supports. The blue curves (zygomatic arches) represent out-of axis support for the face as it projects from the skull. Tripod fractures involve a combination of vertical and horizontal buttresses, whereas Lefort fractures mainly follow the horizontal buttresses with secondary vertical components. Not that often fracture patterns meld into one another in many patients.

6. LEFORT FRACTURES

- Classification of facial fracture patterns – ONLY A GUIDELINE!
- Three triangles or pyramids of fractures (see Fig. 4).

LEFORT I

- Occurs over lower maxilla (upper jaw). Has no ophthalmic/orbital implications.

LEFORT II

- Nasal, lacrimal, maxillary, medial orbital floor.
- **May involve nasolacrimal duct!** Important to explain to patient PREOPERATIVELY that epiphora may occur and may require DCR at a later date.

LEFORT III

- Orbital floor, medial / lateral wall.
- **Craniofacial dysjunction:** “The face comes off the skull”.
- **May involve optic canal!** Check carefully for traumatic optic neuropathy PREOPERATIVELY.

7. NASO-ORBITAL FRACTURES

- Bones: maxilla (frontal process), lacrimal, ethmoid.
Also known as nasoethmoidal-complex (NEC) or naso-orbital-ethmoidal (NOE) fractures.
The MCT attachment to the lacrimal crests is stronger than the bone. With blunt trauma, the MCT usually stays attached to the fractured segment of bone.

- Clinical findings:
 - Depressed nasal bridge
 - Epistaxis
 - Epiphora
 - CSF rhinorrhea: Because of proximity of skull base.
 - Telecanthus
 - MCT rounding
- Treatment: open reduction and fixation
 - Transnasal wiring.
 - Miniplating fixation.

8. REPAIR OF ORBITAL FRACTURES

- **Orbital indications**
 - Entrapment: clinical diagnosis.
 - Significant diplopia within 30 degrees of primary position.
 - Occupational / recreational considerations.
 - Enophthalmos: manifest of > 2mm, especially if present early following trauma.
 - Potential orbital indications:
 - Large internal orbital defect, >50% floor /medial wall on CT imaging.
 - Large rim defect
 - Telecanthus
- **Non-orbital indications**
 - Trismus.
 - Unstable facial skeleton.
 - Panfacial fracture.
 - Paranasal sinus injury, especially posterior table of frontal fracture.
 - Obstructed sinus drainage.
 - CSF leak.
 - Aesthetic.
 - Facial, nasal, zygomatic, or malar deformity.
- **Medical management of orbital fractures**
 - Nasal decongestants (Afrin) for 3 days.
 - No nose blowing.
 - Prophylactic antibiotics? Systemic steroids?
 - Perioperative use generally indicated.
 - Imaging, if indicated
 - Serial examinations
 - Monitor ductions
 - IOP monitoring in primary position and upgaze
 - Quantitative diplopia visual fields
 - Assess globe position
 - Forced ductions / force generation.

- Useful in select cases to distinguish entrapment vs. paresis: difficult with swelling.
- **Timing of orbital fracture repair**
 - Old teaching: Wait at least 1 week to permit edema / contusion to resolve
 - Current teaching: As soon as there are appropriate indications
 - Urgent: <24-48 hours: White-eyed BOF
 - Acute / Early: <7-10 days
 - Multiple facial orbital fractures
 - Early enophthalmos
 - Advantage to non-urgent, acute approach: Permits soft tissue swelling / hemorrhage to resolve.
 - There is no clear evidence that acute or subacute repair is any more effective than late repair in reducing final enophthalmos.
 - Delayed / Late: > 1 month.
 - Delayed onset enophthalmos.
 - Persistent orbital deformity.
- **“WHITE-EYED” BLOWOUT FRACTURE: URGENT REPAIR**
 - Jordan DR, et al. *Ophthal Plast Reconstr Surg* (2000)16:306-7.
 - Children < 16 yrs old.
 - **Severe motility disorder with few soft tissue signs.**
 - 2 week wait may have been harmful.
 - Signs and symptoms:
 - Severe diplopia.
 - Nausea / vomiting from oculocardiac reflex.
 - Inferior rectus muscle ischemia, Volkmann’s contracture.
 - Urgent CT imaging – small “greenstick” fracture may be missed!
 - Repair within 24-48 hrs of injury.

9. ORBITAL HEMORRHAGE / ORBITAL COMPARTMENT SYNDROME

- Orbit is a confined space bound posteriorly by the orbital walls and anteriorly by the orbital septum.
- Orbital compartment syndrome (OCS): Pressure within the orbit in the setting of trauma or other causes increases to the point where orbital blood flow is compromised, resulting in some or all of the following:
 - Ischemia to the globe and optic nerve.
 - Impaired visual function (optic neuropathy).
 - Raised intraocular pressure.
 - Retinal artery or vein occlusion.

- This is an ophthalmic emergency diagnosed by clinical findings and is NOT dependent upon adjunctive imaging (i.e. DO NOT delay the cantholysis while waiting for CT!).
- Mannitol has been found to be effective in lowering intraorbital pressure and may buy time until cantholysis can be performed (e.g. during patient transfer for outside hospital or as the hapless resident is trying to get to an outside hospital but is stuck in traffic). Note that mannitol is usually only temporizing. Should only be used in appropriate patients (i.e. no medical or neurosurgical contraindications).
- If medical therapy is not rapidly effective in reversing the optic neuropathy, emergent canthotomy and cantholysis is indicated.

The major shortcoming of soft tissue decompression (lateral canthotomy/inferior cantholysis) is an inadequate cantholysis.

- **Important features of orbital compartment syndrome:**

A lateral canthotomy alone is not sufficient: An inferior cantholysis is needed to adequately release the orbital-septal diaphragm.

– **The presence of an orbital fracture does not exclude the possibility of concomitant OCS!** A fracture may help to decompress the orbit, but if bleeding continues, it will simply fill the adjacent sinus and result in sino-orbital compartment syndrome.

– **A cantholysis is effective therapy only if active bleeding has stopped.** If active arterial bleeding or orbital venous outflow is compromised (as in CCF), the decompressed orbit will simply fill with more blood and the OCS will recur. Fortunately in most cases of OCS, the increased orbital pressure helps to tamponade active bleeding and cantholysis is therefore effective and definitive therapy.

– **Evacuation of a hemorrhage is usually not needed:** Most hemorrhages are diffuse within the orbital fat, thus it is not feasible to evacuate the hemorrhage. The only setting in which is practical and advisable to remove an orbital hemorrhage is if it is localized to the subperiosteal space.

Treatment should not be delayed: Studies have demonstrated that 90 minutes of ocular and optic nerve ischemia result in irreversible visual loss.

EXTERNAL SIGNS	Ecchymosis with tense eyelids. Increased resistance to retropulsion. Subconjunctival hemorrhage. Chemosis. Proptosis. External ophthalmoplegia.
OPHTHALMOSCOPIC SIGNS	Elevated intraocular pressure. Retinal venous congestion or occlusion. Central retroartery pulsations if intraocular pressure is greater

	than diastolic blood pressure. Central retinal artery occlusion. Retinal edema. Optic nerve head swelling.
NEUROPTHALMIC SIGNS	Afferent pupillary defect. Visual acuity: Highly variable, from normal to no light perception. Dyschromatopsia

Table 23. CLINICAL FEATURES OF ORBITAL COMPARTMENT SYNDROME

10. TRAUMATIC OPTIC NEUROPATHY (TON)

- Usually refers to posterior indirect TON.
- Typically occurs with a deceleration injury: the skull (and bony optic canal) stops suddenly against a rigid object while the orbital soft tissue (including the optic nerve) continues to move forward.
- Because the optic nerve is strongly tethered at the optic canal, a shearing injury occurs.
- Signs and symptoms:
 - The diagnosis cannot be made if another cause for visual loss is present (ruptured globe, vitreous hemorrhage, etc).
 - Patient complains of sudden visual loss following trauma.
 - A progressive form of TON is much less common.
 - Visual acuity varies from near normal to NLP.
 - An afferent papillary defect and relative dyschromatopsia are invariably present.
 - Fundus exam, including the optic nerve head, is normal.
 - CT imaging may or may not show fracture across the optic canal.
- **Treatment is highly CONTROVERSIAL**, but may include:
 - Observation alone with no specific treatment.
 - Megadose (neurosurgical) intravenous doses of corticosteroids.
 - A recent study and meta-analysis showed no clear advantage over no treatment.
 - Significant potential side effects must be discussed with the patient.
 - May be considered in healthy adult patients if within 8 hours of injury *with no evidence of intracranial injury*.
 - Optic canal decompression (NOT optic nerve sheath decompression).
 - Usually performed endoscopically by Otolaryngology.
 - Only performed in progressive cases of TON which have failed a trial of steroids or if obvious impingement of the optic nerve by bone fragments is noted on CT.
 - Surgical risks include carotid injury, etc.
 - Efficacy has never been proven conclusively and a recent meta-analysis found no clear evidence of efficacy.

- **Treatment caveats regarding corticosteroid use in TON:**
 - Megadose corticosteroids have NOT been shown conclusively to be effective (or detrimental) in the treatment of TON.
 - Megadose corticosteroids have significant and potentially devastating side effects.
 - The NASCIS (spinal cord injury) trials have concluded that megadose corticosteroids are effective only if given within the first 8 hours of injury, and are DETRIMENTAL if given after this time window.
 - *The CRASH study (use of corticosteroids in acute head injury) showed a significantly increased risk of MORBIDITY and MORTALITY if corticosteroids are used, regardless of severity of initial head injury.*
 - **Given these findings, the use of megadose corticosteroids in the treatment of TON should only be considered for a very small percentage of TON patients.** Steroids should NOT be offered in:
 - Patients with any head injury.
 - Patients outside the initial 8 hour window.
 - Very young or elderly patients or any patient with relative contraindications to corticosteroid use (diabetics, immuno-compromised individuals, etc).
 - **As it stands, very few patients would meet these criteria.**
- Although no sweeping statement regarding steroid use with TON can be made, at present, the clinician should regard steroid use as the exception, rather than the rule, in the management of TON.**

END OF ORBIT SECTION