Imaging in Ophthalmology

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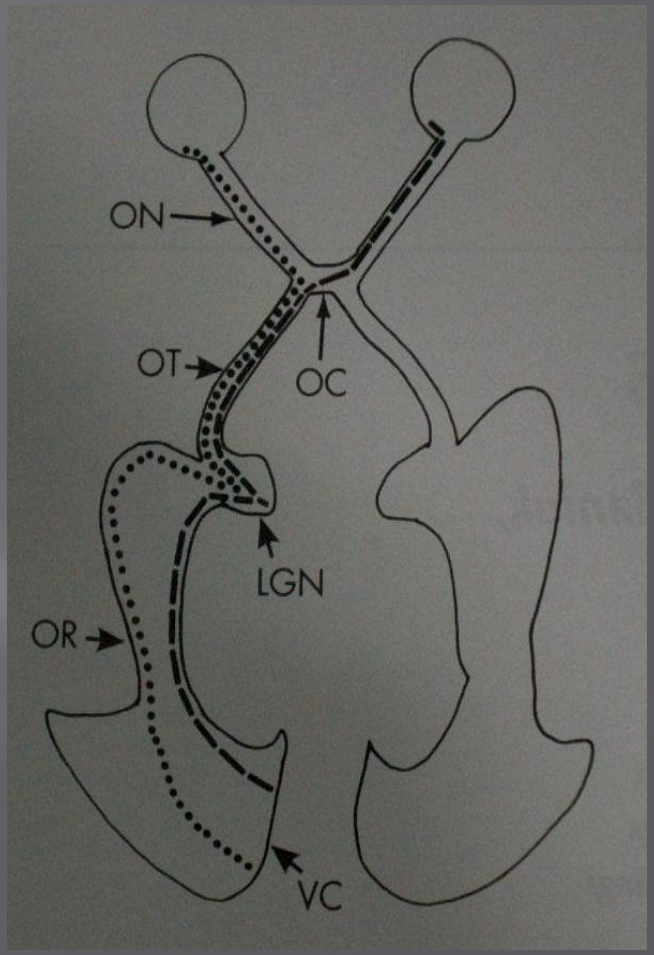
THE VISUAL PATHWAY

Optic nerve from posterior globe to the *Optic Chiasm* . After the characteristic crossing, fibers of optic nerve travel as *Optic Tracts* to the *Lateral Geniculate Body.*



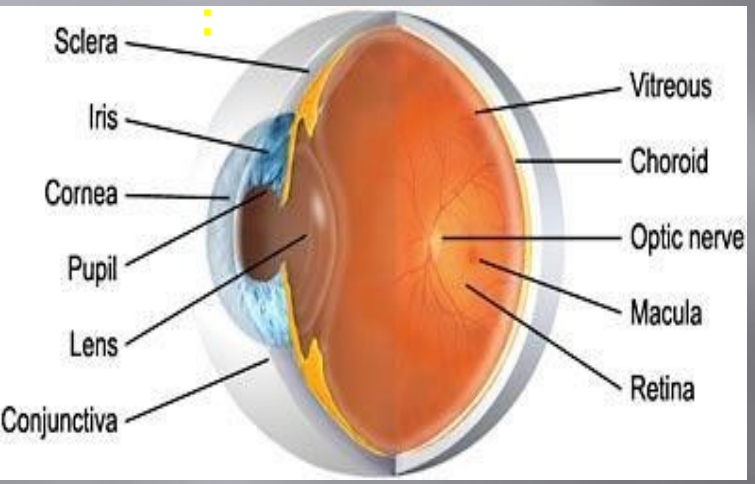
The optic nerve has 2 sets of fibres:

1. *Visual* going to lateral geniculate body.
2. afferent fibres of the *pupillary reflex* going to *tectum of midbrain*

Motor system(Extraocular nerves)

Normal Orbital Anatomy (Globe)

THE GLOBE



Outer layer:

constitutes sclera & transparent cornea anteriorly
fibrous protective layer

Middle layer (uveal tract)

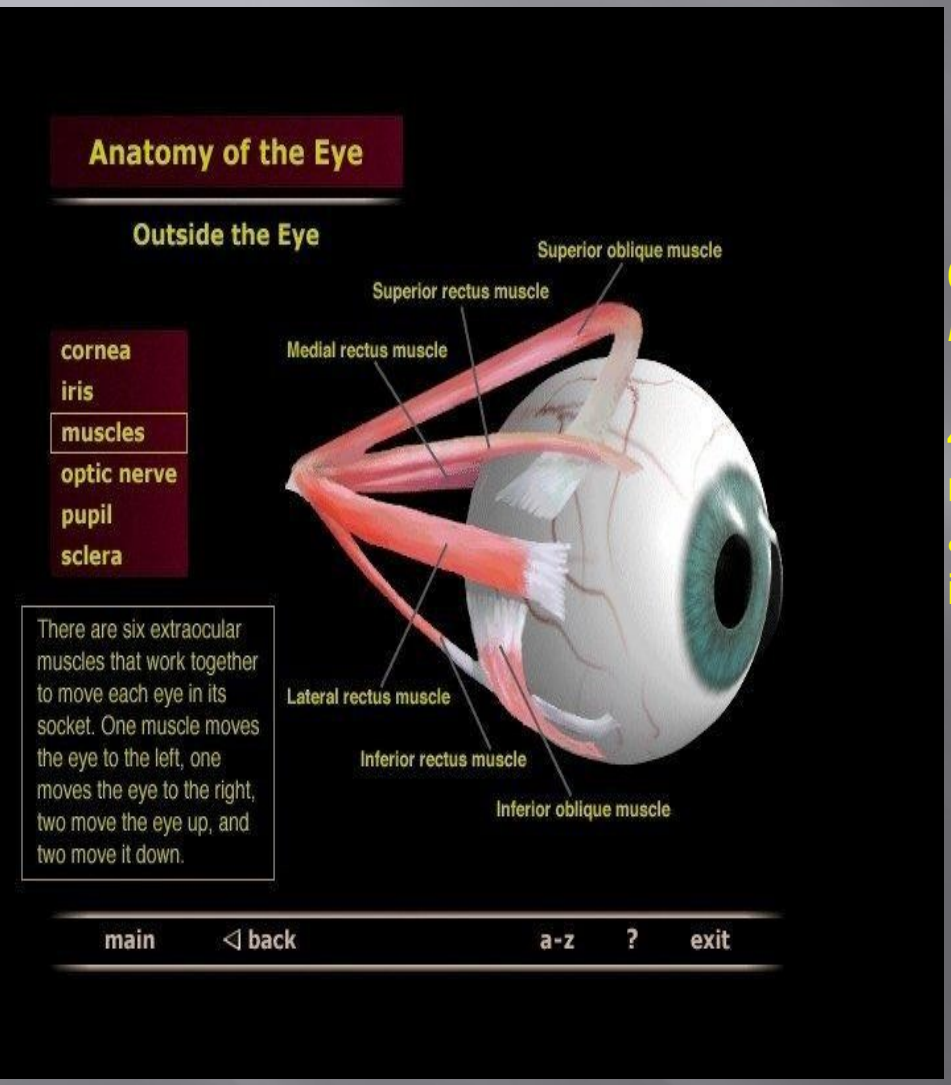
choroid, ciliary body and iris

vascular and nutritive functions contains blood vessels, numerous nerves, connective tissue, and pigmented melanocytes.

Inner layer (retina):

consists of a thin, outer retinal pigment epithelium layer and an innermost sensory retina contains neural elements for visual perception

Normal Orbital Anatomy (EOM)



6 skeletal EOM insert on the sclera and control *motion* of the globe

4 rectus muscles (superior, inferior, lateral, & medial) arise from a common tendinous ring, *the annulus of Zinn,* and form a muscle cone that inserts onto the front of the sclera

Normal Orbital Anatomy (Vessels)

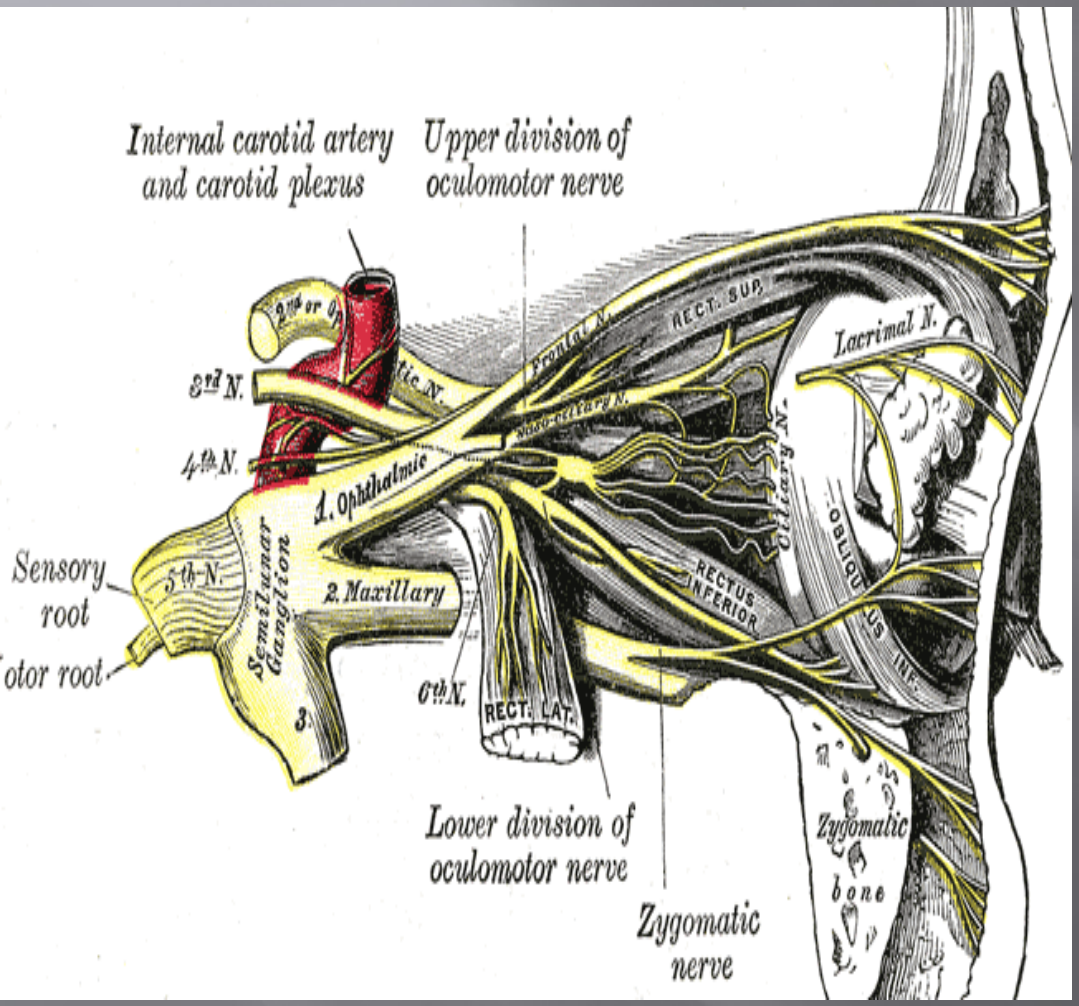
Ophthalmic artery

Chief artery of the orbit

Arises medial to the anterior clinoid process from the supraclinoid internal carotid artery

Superior and inferior ophthalmic veins drain the orbital structures

Normal Orbital Anatomy (Nerves)



- **oculomotor (3rd cranial nerve)** is the major motor supply for movements, supplying extraocular muscles except the superior oblique and lateral rectus muscles.
- **trochlear (4th cranial nerve),** supplies only the superior oblique
- **abducens (6th cranial nerve)** supplies only the lateral rectus muscle.

Normal Orbital Anatomy (Nerve)

optic nerve (2nd cranial nerve)

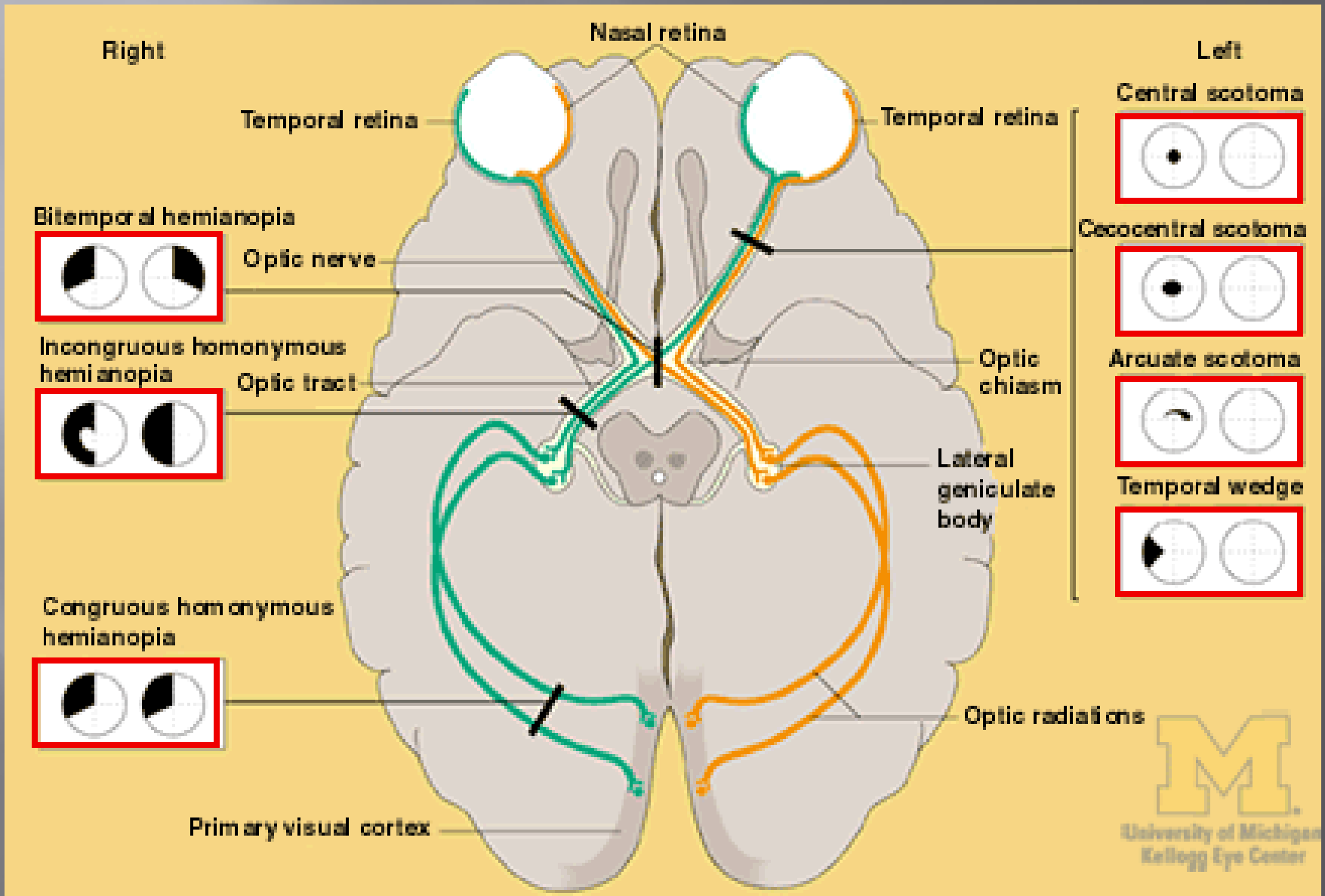
interconnects retina to brain and extends approximately 3.5 to 5 cm between posterior globe and optic chiasm

approximately 90% of its fibers are afferent

ophthalmic nerve (first division of the 5th cranial nerve)

sensory nerve that receives input from the globe and its conjunctivae, the lacrimal gland, the nose and nasal mucosa, the upper lid, frontal sinus, scalp, and forehead

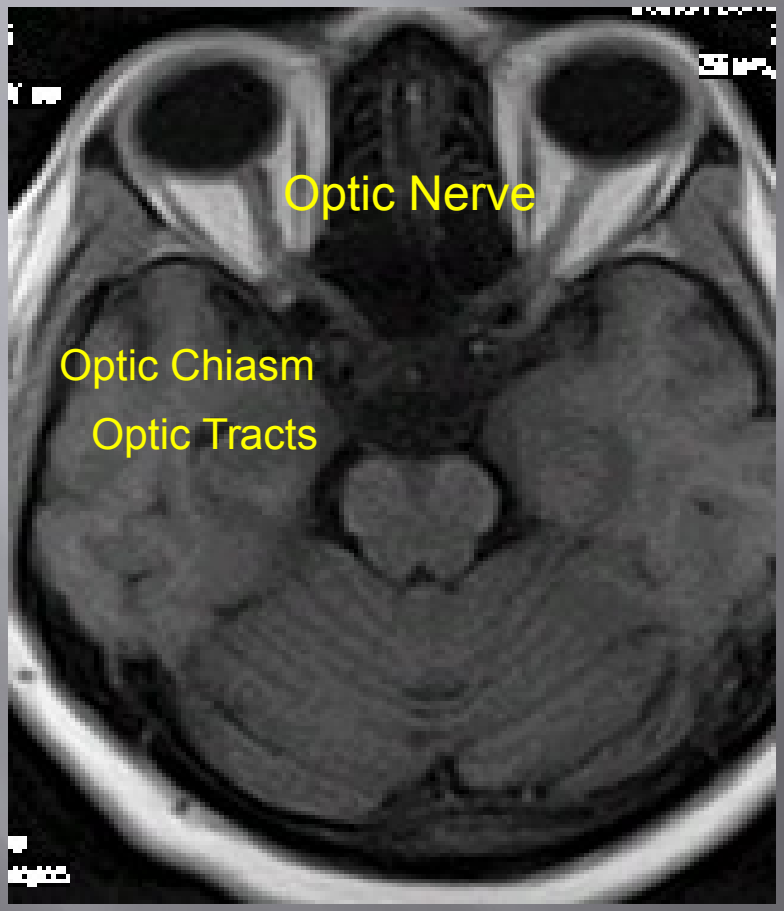
Disturbances of the visual pathway

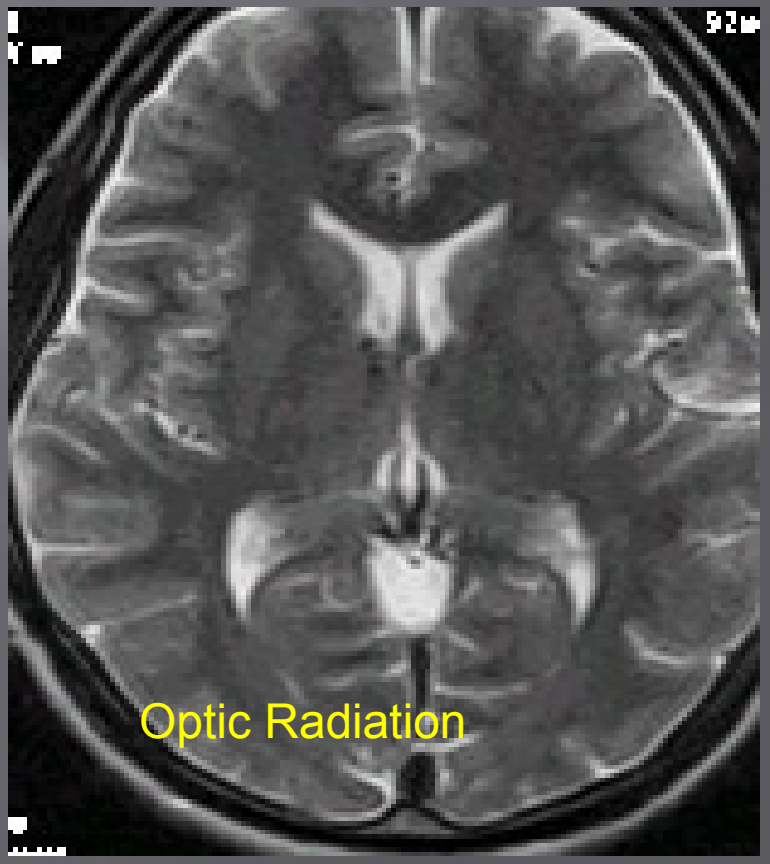


Imaging modalities

- Plain Radiographs
- USG
- CT:
  - :Axial
  - :Coronal,
  - :Reformats
  - :3D
- MRI:
  - : DWI
  - : MRS
  - : MRV
- Carotid angiography (CT,MRI,DSA)

THE VISUAL PATHWAY





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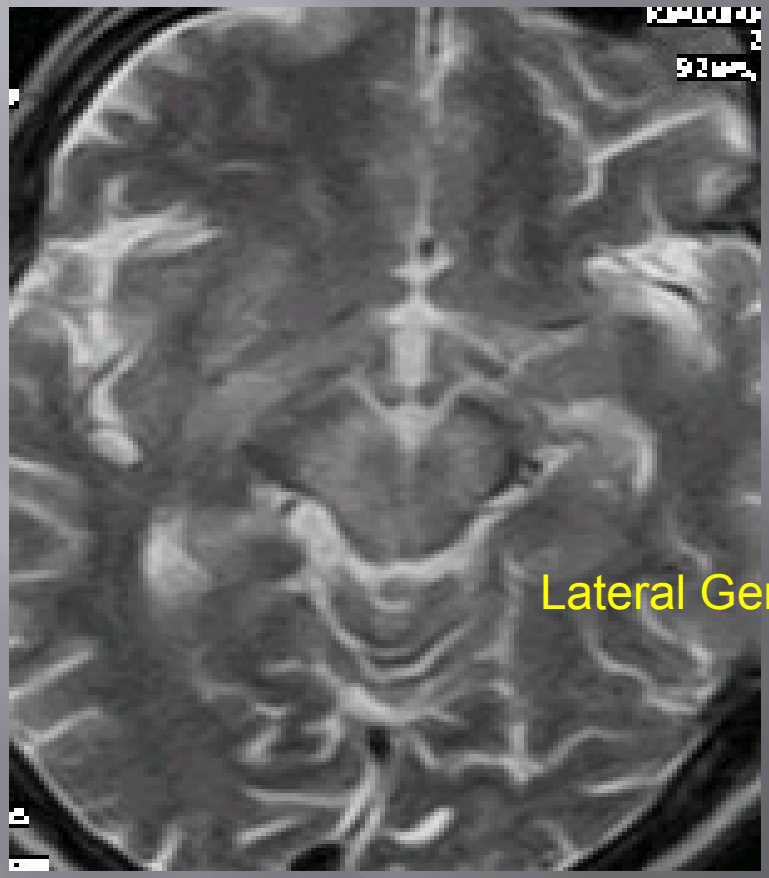
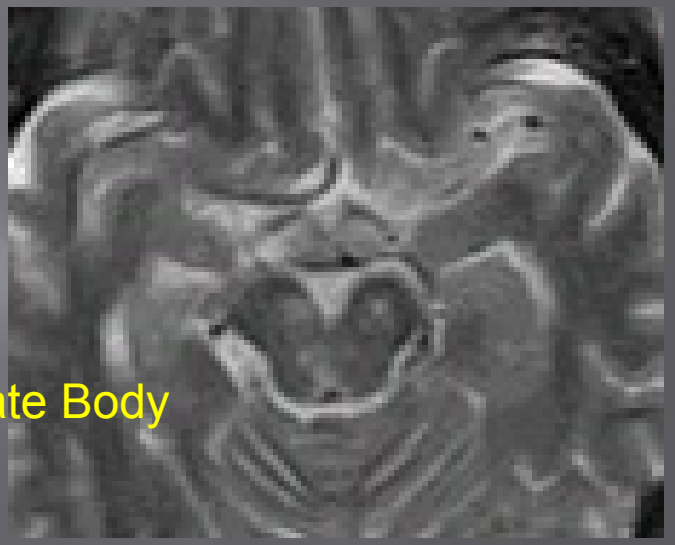




Lateral Geniculate Body

THE VISUAL PATHWAY

Primary Visual (Calcarine) Cortex

THE VISUAL PATHWAY

Optic Nerve is divided to 4 parts:

A-Intraocular

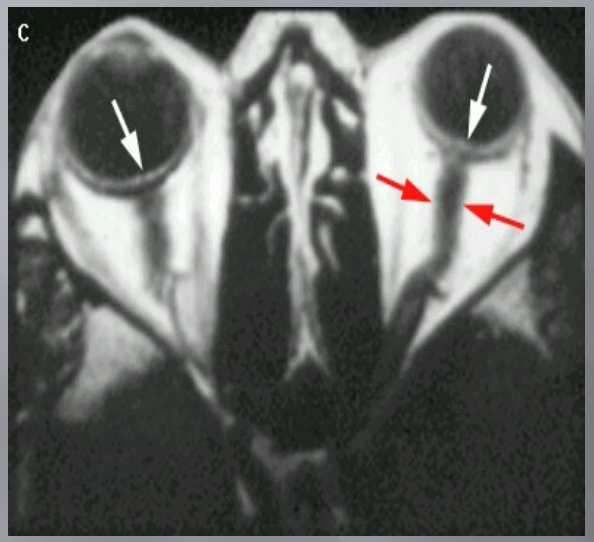
B-Intra-orbital

C-Intra canalicular

D-Intracranial

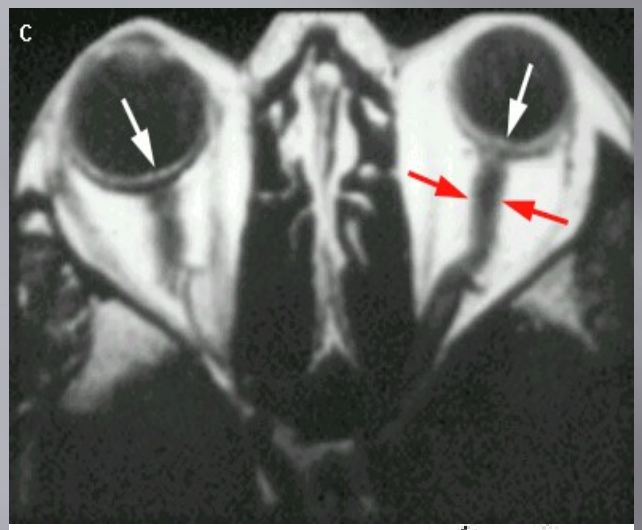
Division of Optic Nerves

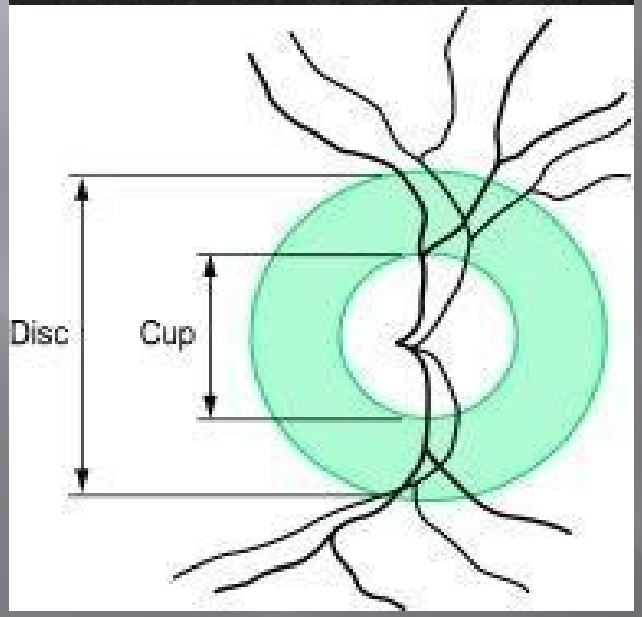
1. The Intraocular portion:



- All the retinal nerve fibers merge to the optic nerve here
- Central retinal vessels enter and leave the eye here
- Absence of photoreceptors at this site creates a gap in the visual field known as the *blind spot*.
- Visible on ophthalmoscopy as the *optic disc*

Intraorbital portion:





Optic cup:

Cavitation of the optic nerve & brightest part of the optic disc, no nerve fibers exit from it and there is a correlation between the size of it and the size of the optic disc.

The intraorbital portion begins after the nerve passes through a sieve-like plate of scleral connective tissue,

the *lamina cribrosa*

It is particularly important to document the size of the optic cup. This is specified as the horizontal and vertical ratios of cup to disc diameter (cup – disc ratio).

4. Intracranial Portion of the Optic Nerve:

After the optic nerve passes through the optic canal, the short intracranial portion begins and extends as far as the optic chiasma.

Like the brain, the intraorbital and intracranial portions of the optic nerve are surrounded by sheaths of dura mater, pia mater, and arachnoid. The nerve receives its blood supply through the vascular pia mater sheath.

Extraocular Cranial Nerves

3rd nerve (Oculomotor)

4th nerve (Trochlear)

6th nerve (Abducens)

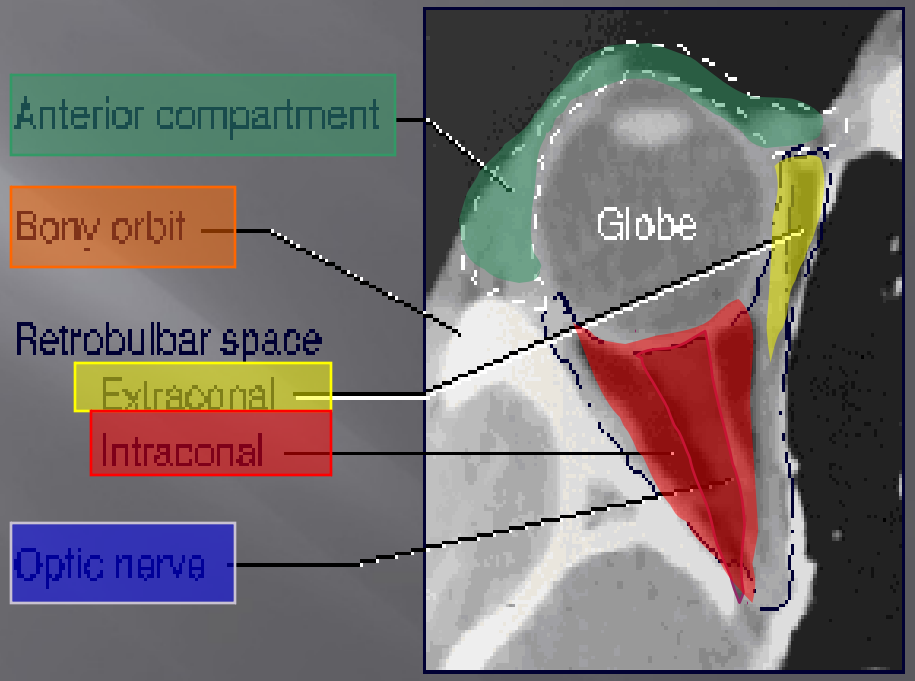
Normal Orbital Anatomy (Compartments)

Anterior compartment:
consists of eye lids, lacrimal apparatus and anterior soft tissues

Posterior compartment (Retrobulbar space):
divided into intraconal and extraconal spaces

The cone:
consists of extraocular muscles and an envelope of fascia

optic nerve is located within the intraconal space



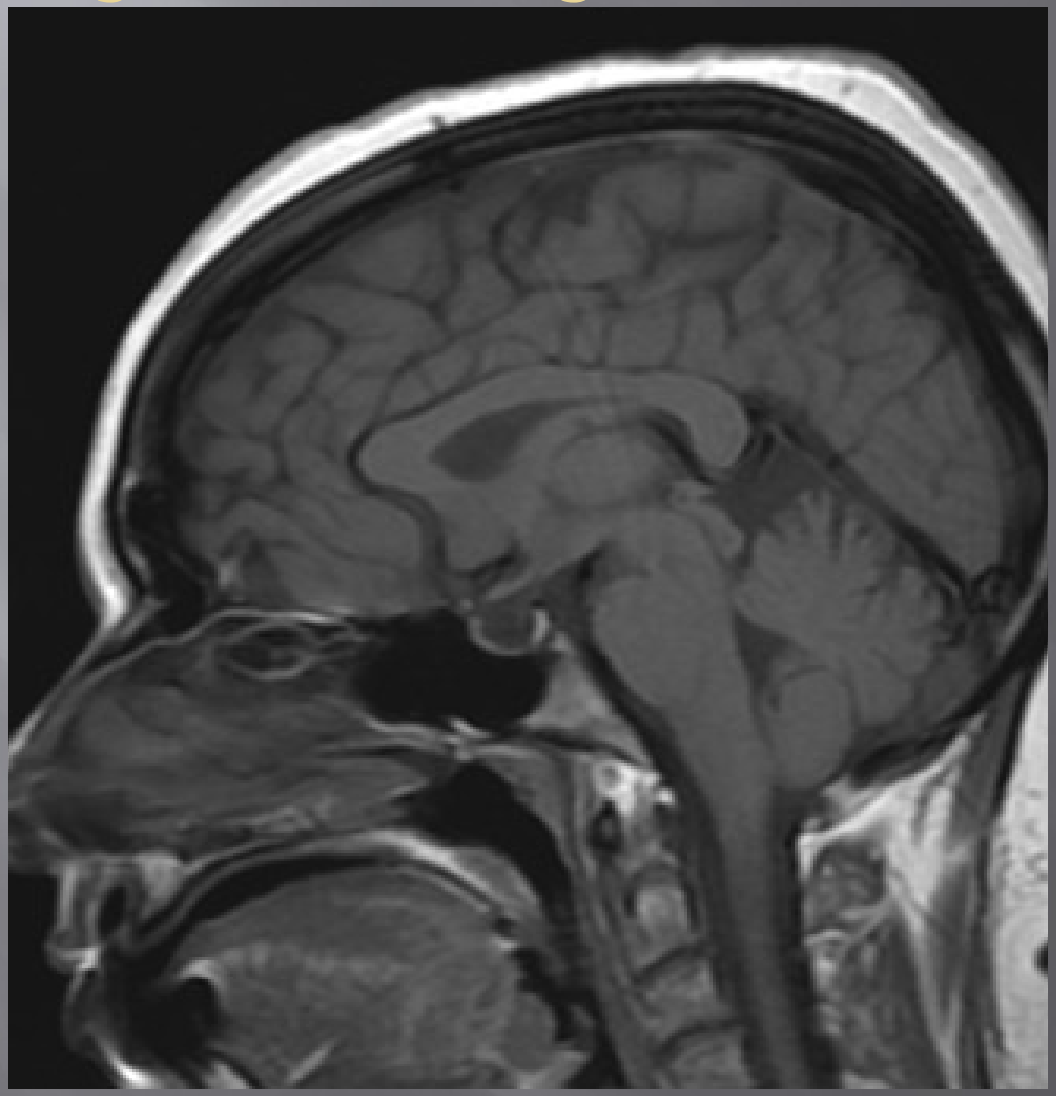
Idiopathic Intracranial Hpt

- It is a disease entity in which patients present with signs and symptoms of increased **intracranial pressure** (ICP) of unknown cause.
- It predominantly affects obese women of childbearing age.
- Papilloedema is the primary **ocular** finding and may progressively lead to optic atrophy and blindness if no treatment is provided.

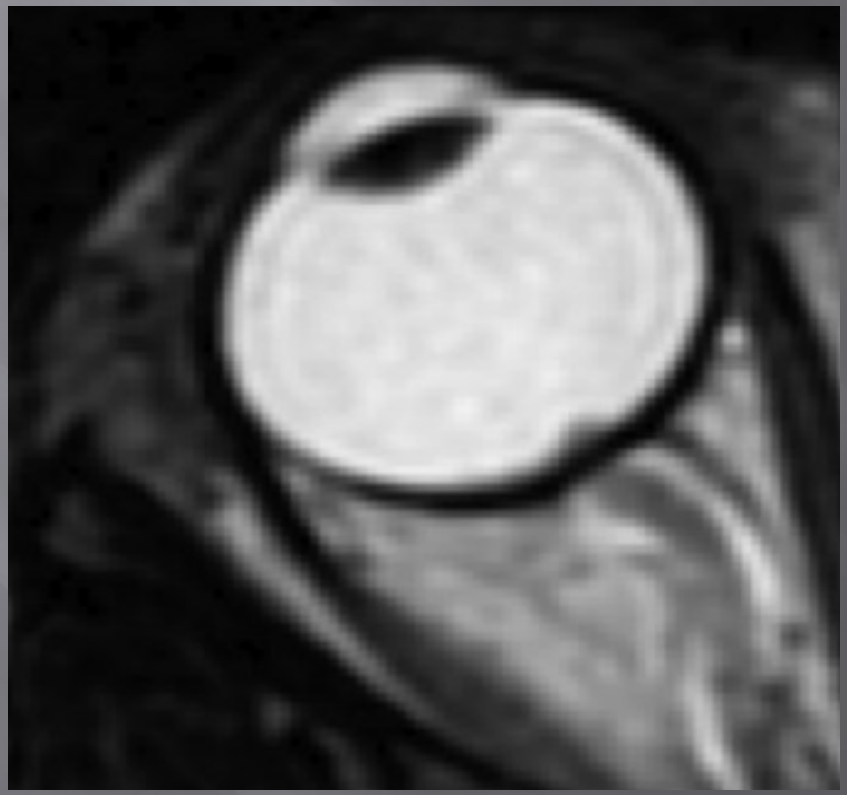
Imaging Findings in IIH

- Empty sella
- Partially empty sella/decreased pituitary height
- Flattened posterior globe/sclera
- Enlarged ONS (perioptic subarachnoid space)
- Increased tortuoussity of the optic nerve
- Enhancement of the optic nerve
- Intraocular protrusion of the optic nerve head
- Slitlike ventricles

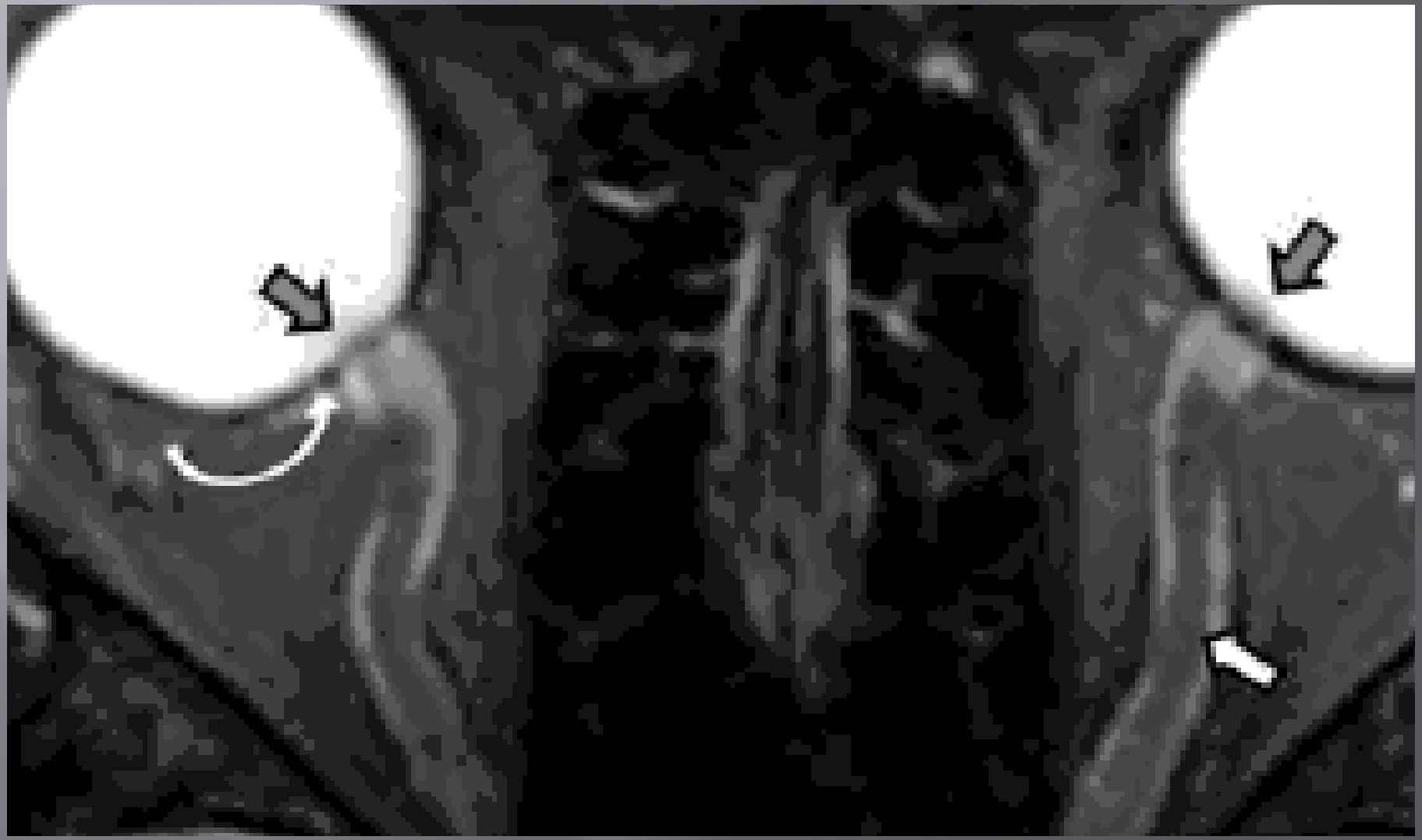
This 31-year-old woman presenting with headache is found to have an empty sella on sagittal T1-weighted MR imaging.



Protrusion of the right optic nerve head and horizontal tortuosity of the optic nerve are seen on axial T2-weighted MR imaging. Clinically, the patient presented with headaches, vision changes, and papilledema noted on examination.



Enlarged optic nerve sheath, optic nerve tortuosity, protrusion of the optic nerve head, and concavity or flattening of the posterior globes



The ONS is widened with expanded CSF hyperintensity surrounding the optic nerve, seen on axial T2-weighted MR imaging in conjunction with posterior flattening of the globes. ONS widening is thought to coincide with papilledema, which is seen in this 27-year-old woman who presented with headaches.

Coronal T2-weighted MR imaging in a 55-year-old woman with headache demonstrates increased peri-ONS space marked by hyperintense signal intensity surrounding the optic nerve.

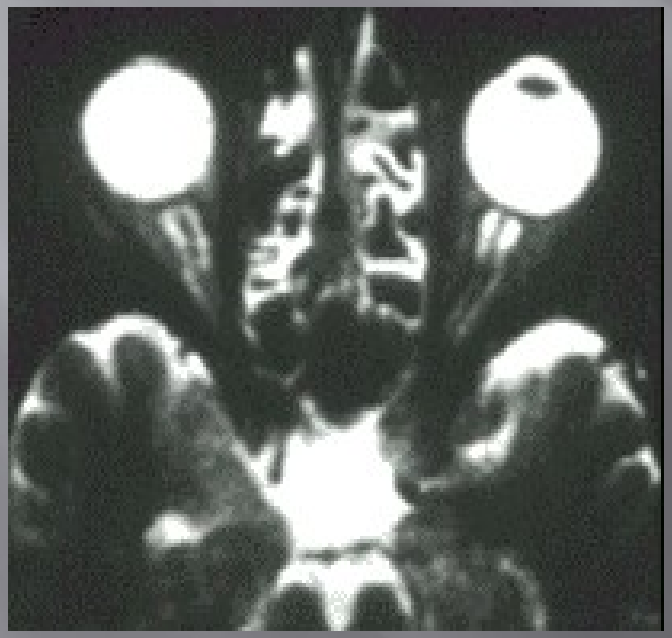
OPTIC NEURITIS

- Acute inflammation that is usually idiopathic or viral
- Commonly associated with multiple sclerosis (initial manifestation of MS in 25%. 60% of patients with ON will eventually develop MS: when ON is caused by MS, 50% of patients show cerebral lesions on MRI)
- May be secondary to infections or inflammations of sinonasal cavities, meninges and orbital tissues (pseudotumour) or radiation

- On MRI, T2WI show hyperintense and enlarged ON that enhances.
- ON sheath may also enhance.
- With chronic optic neuritis, the ON becomes thin with prominent surrounding CSF space

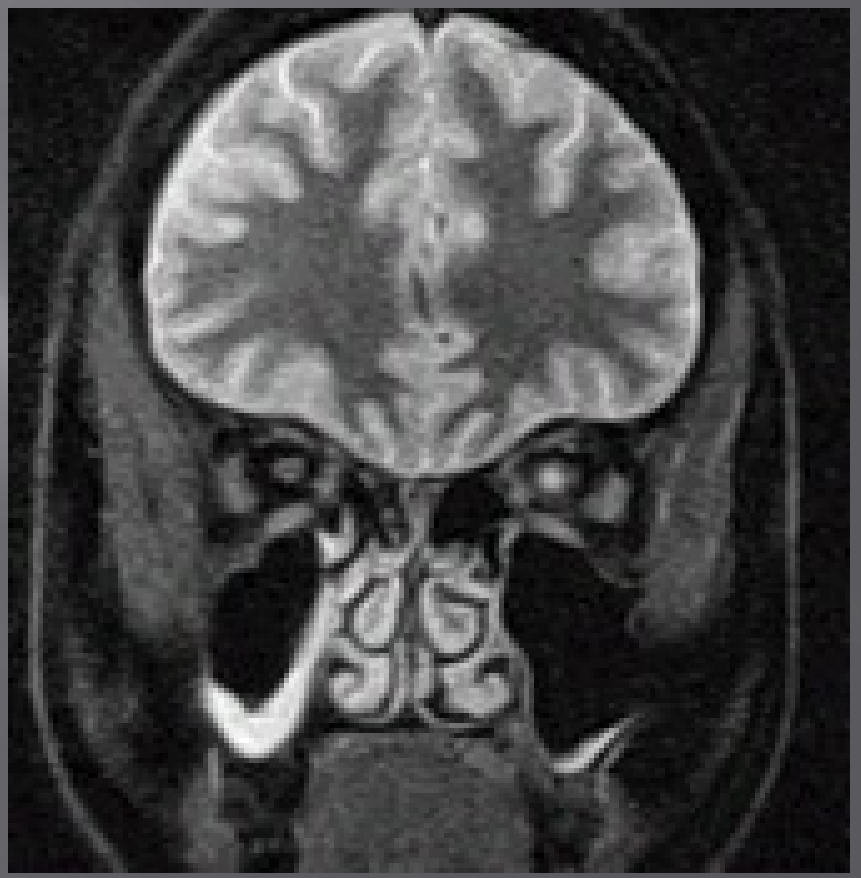
Optic Neuritis

MS



Optic Neuritis

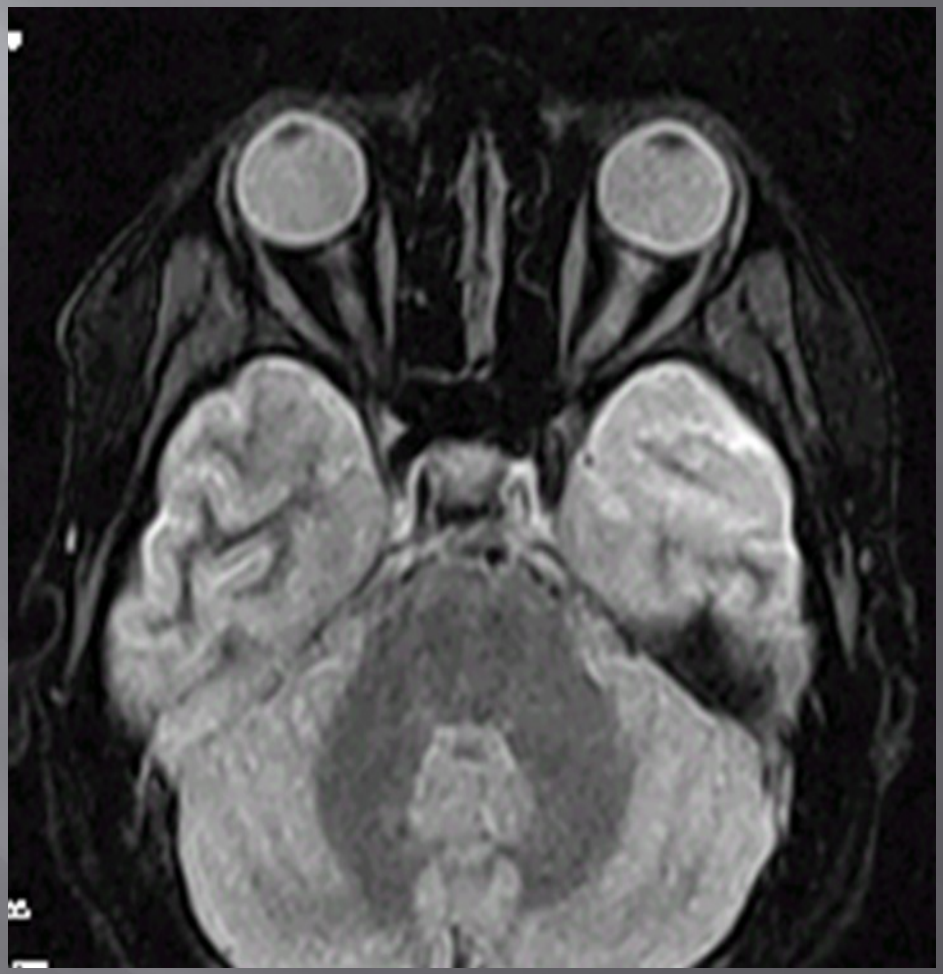
MS



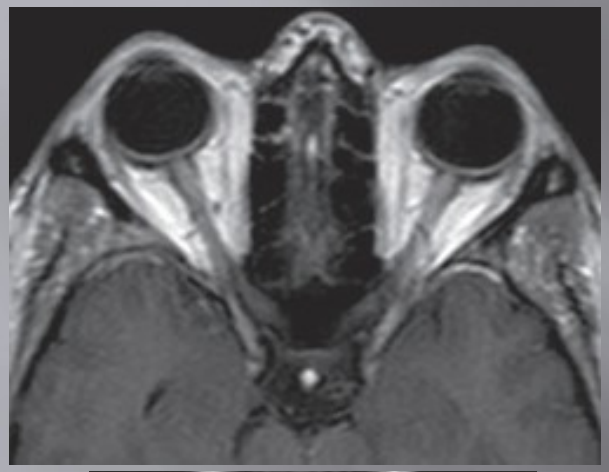
Optic Neuritis

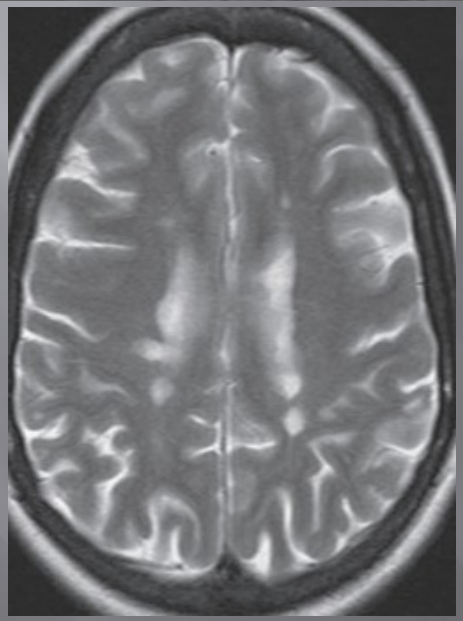
MS

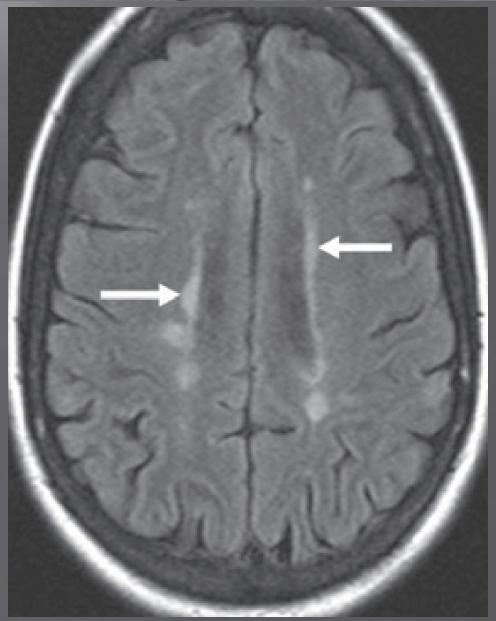
Post traumatic optic neuritis



Value of fat suppression & fluid attenuation inversion recovery (FLAIR)

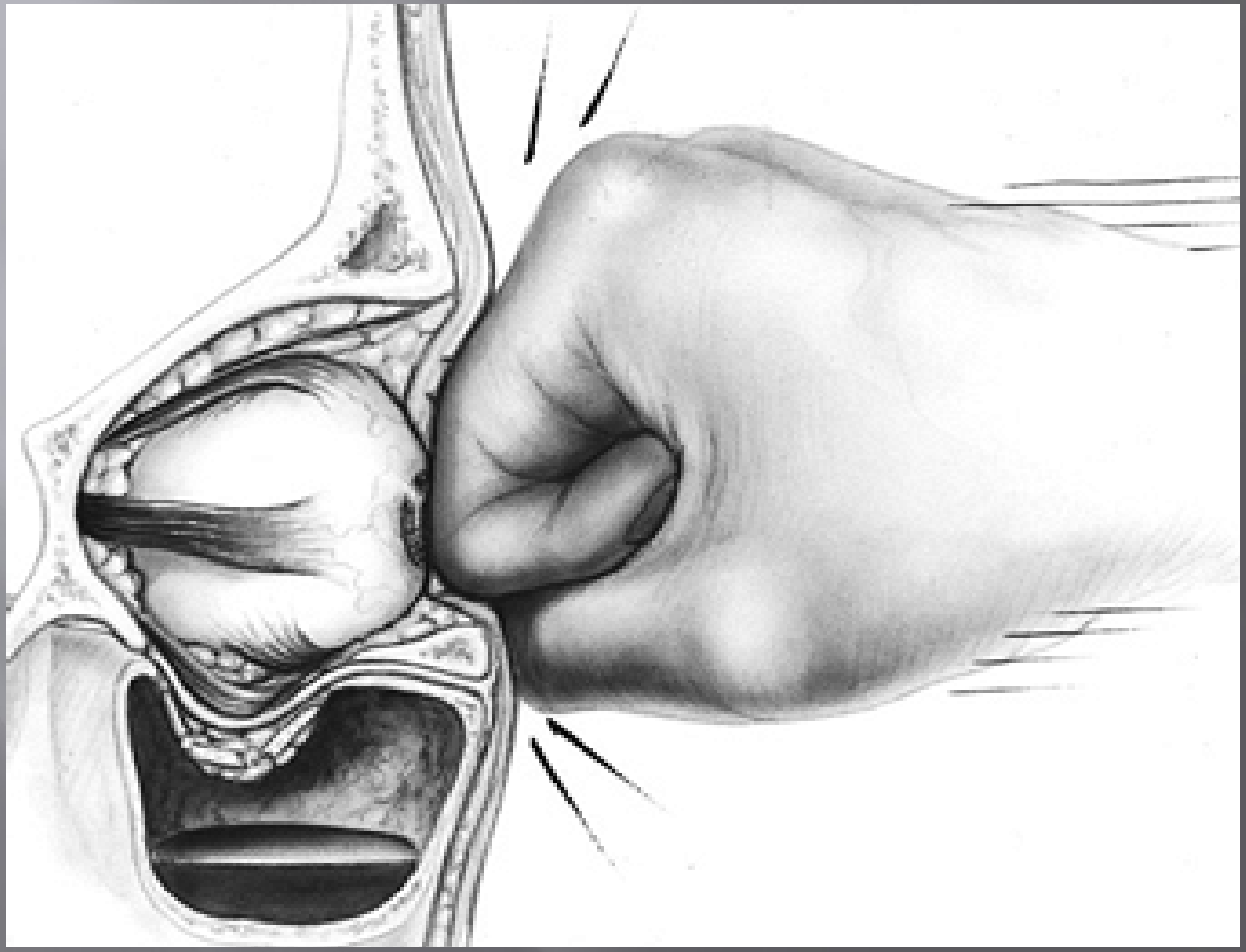






Orbital Trauma

- Commonly associated with craniofacial trauma
- Mechanism: MVA, violence, falls
- Predominantly affects young adult males



Indications for further Imaging

- Significant blunt or penetrating trauma
- Suspected Orbital Fractures
- Suspected Foreign Bodies
- Suspected Open Globe

X-ray vs CT vs MRI????

Imaging

- CT: #1 choice for acute orbital trauma
  (Obtain CT with ≤3mm axial cuts & with coronal images)
- MRI: complementary role to CT in the evaluation of subacute orbital trauma
- Plain film: no primary role

MRI in Orbital Trauma

- Advantages:
  - Images in multiple planes (good for surgical planning)
  - Detection of fat herniations into the paranasal sinus
  - Distortion, avulsion or herniation of extraocular muscles are well demonstrated by MR
  - MR is best for evaluating chronic orbital soft tissue trauma and chronic hemorrhage
- Disadvantages:
  - Poor detection of focal acute hemorrhage in orbit
  - Poor depiction of subtle bony detail
  - Contraindicated if metallic foreign body in orbit

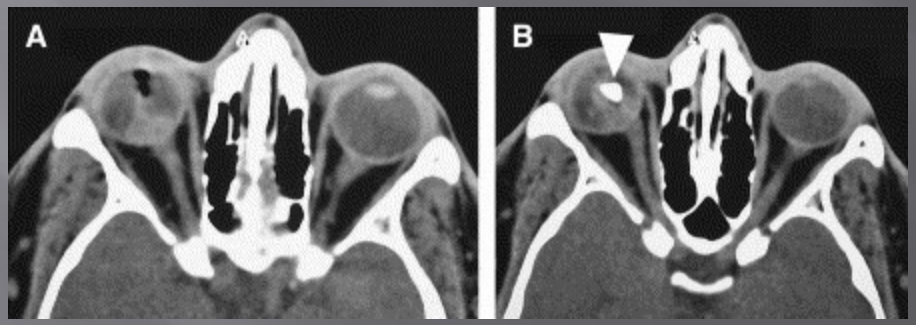
Type of Orbital Injury

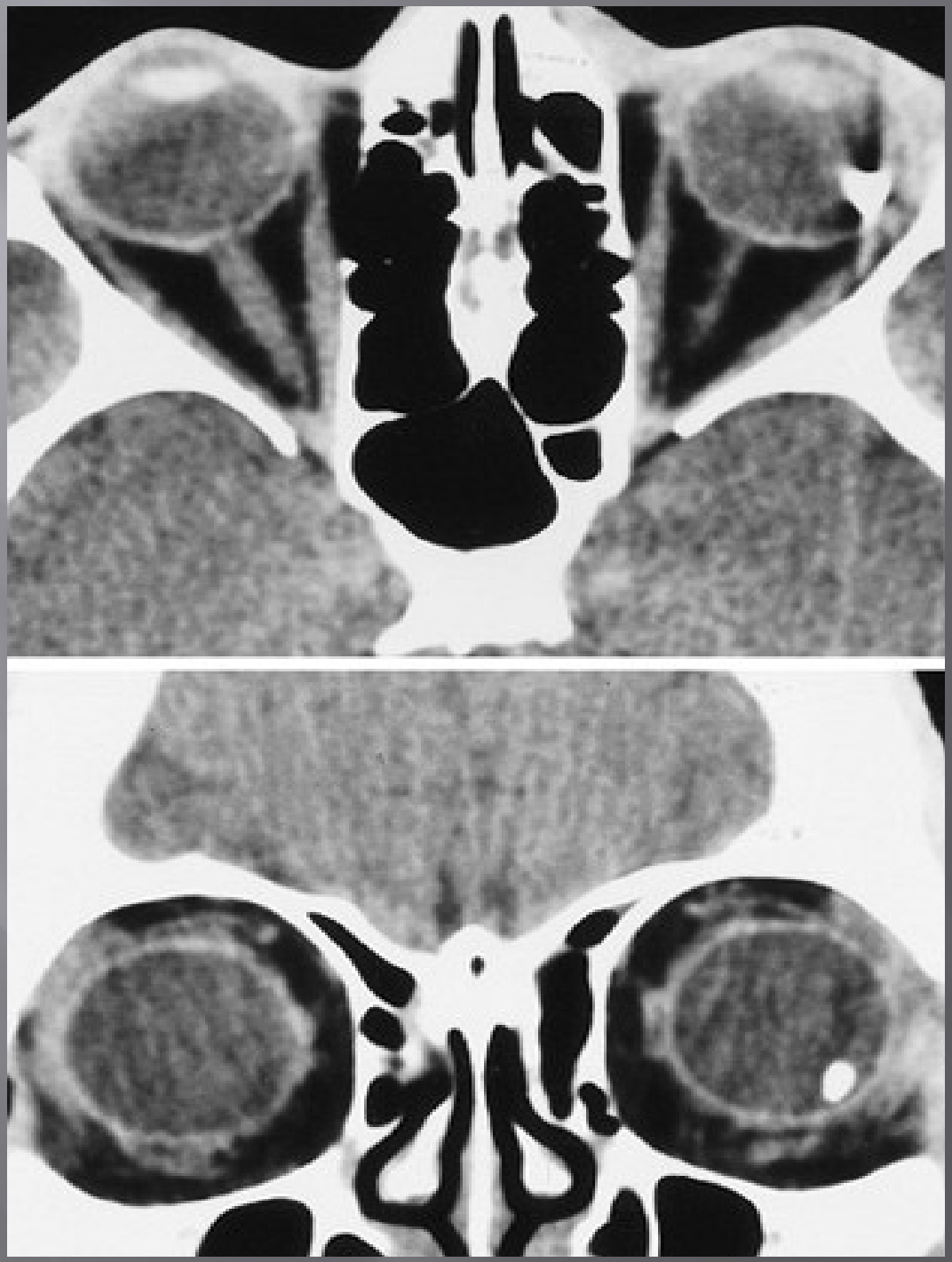
- Depends on site of impact
- Depends on nature of Injury:
  - blunt injury
  - pentrating/lacerating/sharp injury
  - chemical/burn injury

  +/- propagation of injury
- Can result in orbital wall fracture and/or soft tissue injury to the globe, optic nerve and orbital soft tissues

Orbital Foreign Body

- CT may miss nonmetallic foreign bodies, such as wood or plastics
- CT should be performed in at least 1.5-mm thin axial cuts to detect small foreign bodies reliably
- Additional planes of imaging are also helpful, particularly oblique sagittal views oriented along the optic nerve.
- Intraocular air seen on CT should cause suspicion of penetrating injury with a potential foreign body





Open Globe

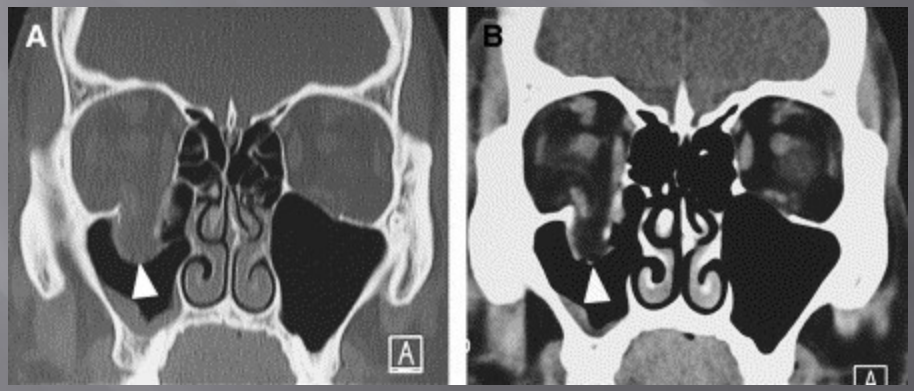
- Globe injury can manifest as penetrating or blunt injury.
- “Flat-tyre” appearance of a shrunken and irregular contoured globe is classic appearance on CT
- A normal-app[illegible]es not rule out an open glob[illegible]

Orbital Fracture in Detail

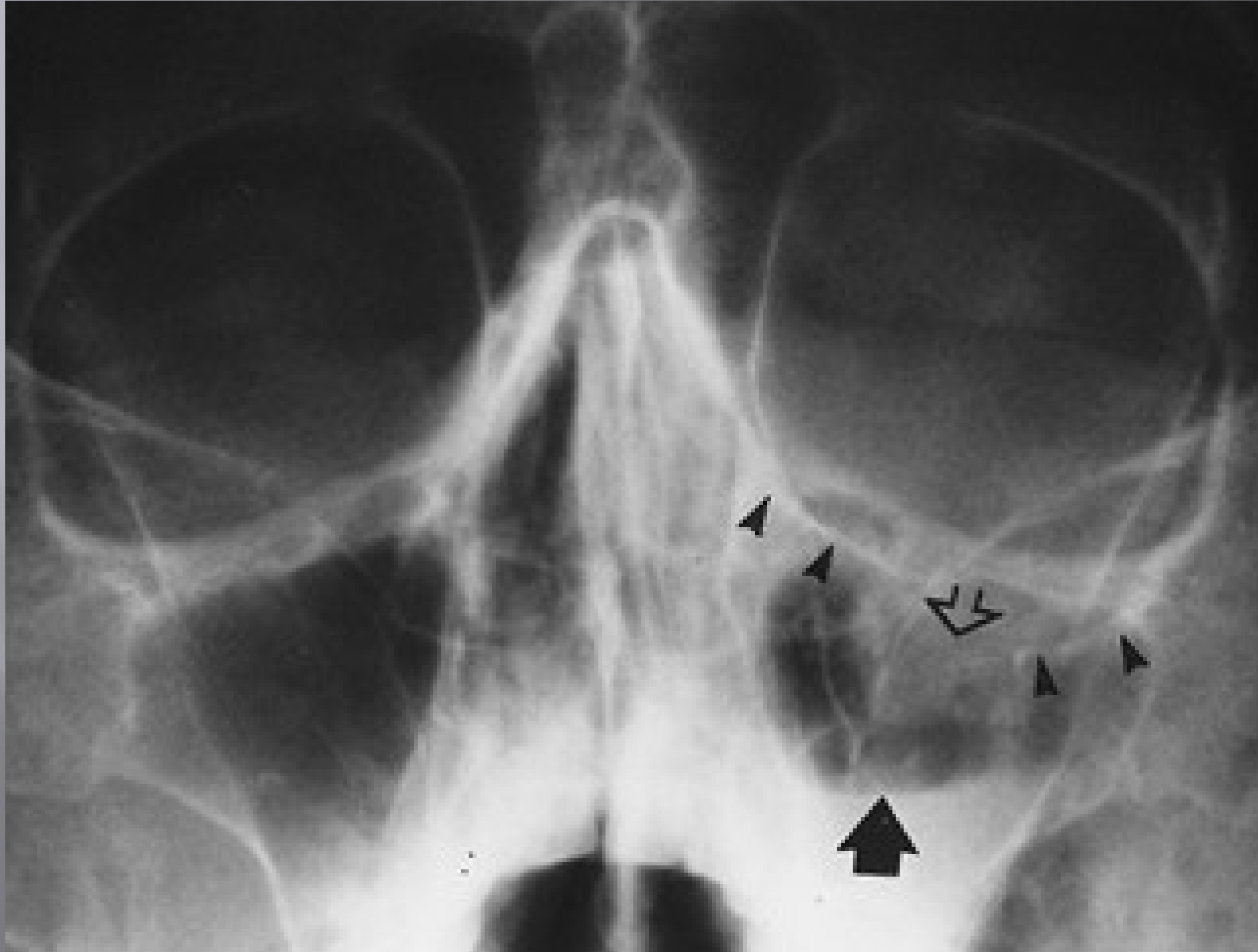
1. Blow-out Fracture – medial wall and floor
2. Lateral Wall Fracture
3. Roof Fracture
4. Combined Fractures – tripod, nasoorbital and LeFort I-III

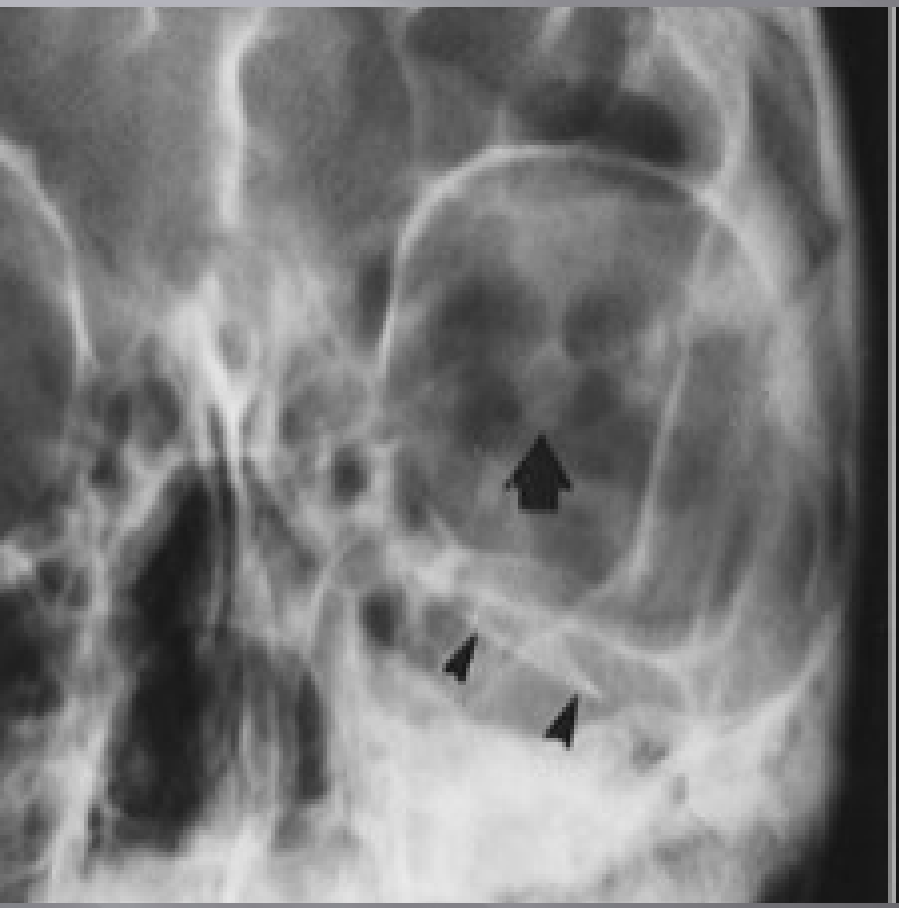
Blow-out Fracture

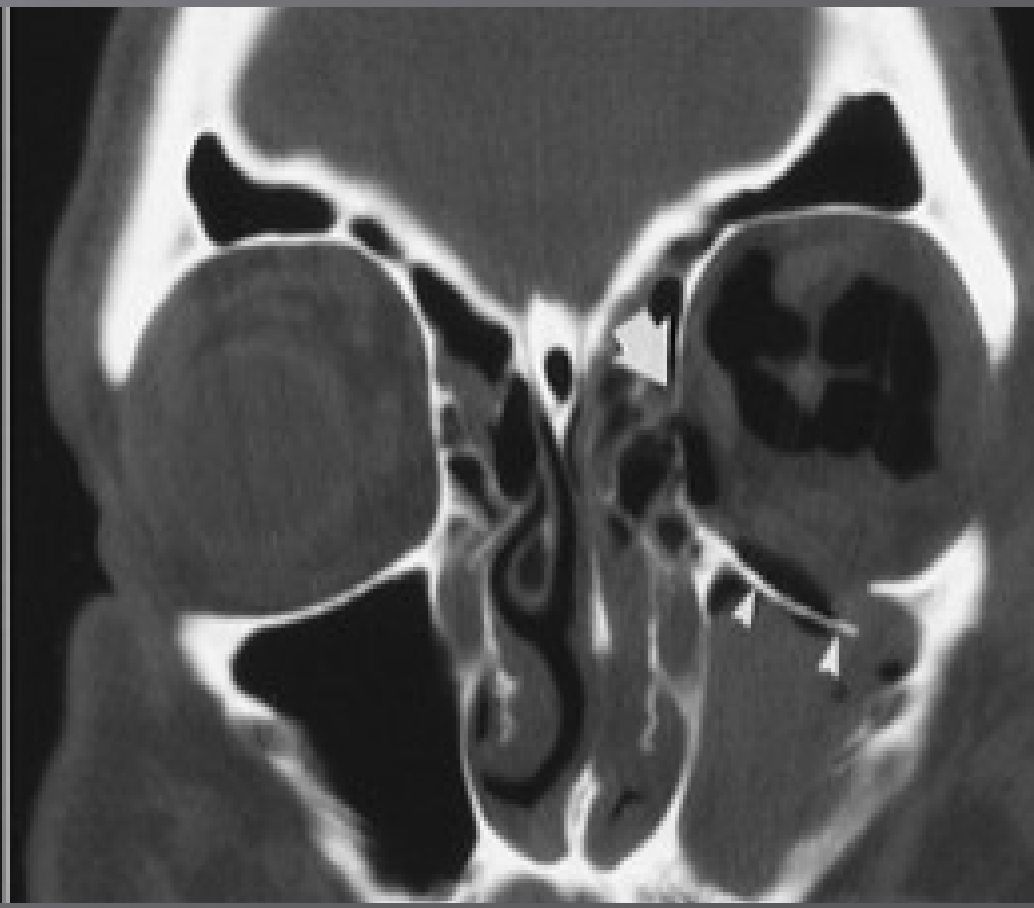
- Most common orbital fracture
- Mechanism: blunt trauma compresses orbital contents, raising intraorbital pressure, which then fractures weakest region of orbit: medial wall and/or floor

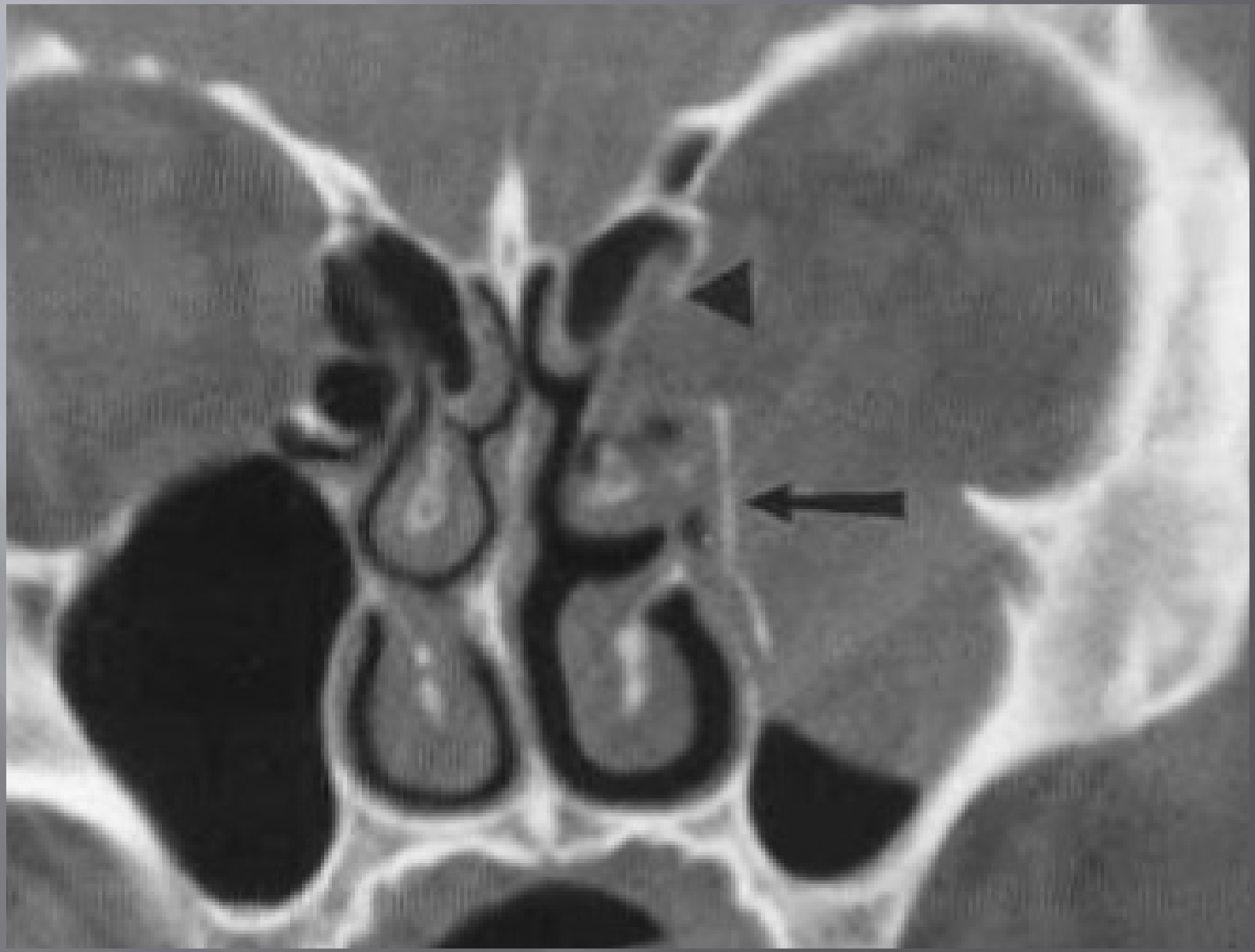


Coronal CT demonstrates blow-out fracture involving inferiororbital wall









Lateral Wall Fracture

- Rare since lateral wall is thick and strong
- Mechanism: direct lateral blow, also known as “blow-in” fracture when displaced toward orbital space
- Commonly associated with diastasis of the frontozygomatic suture and displacement or fracture of the zygomatic arch

Coronal CT demonstrating tripod fracture of the lateral wall

Orbital Roof Fracture

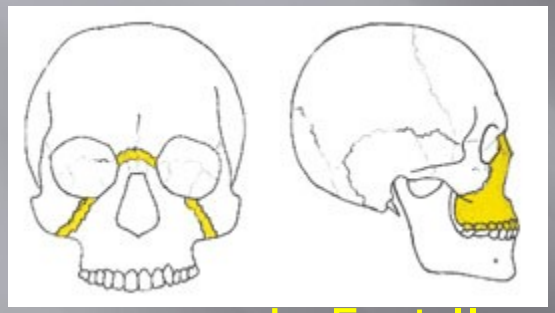
- Rare since superior orbital rim is strong & well-supported
- Mechanism: severe blunt trauma (ie MVA)
- Potential communication between the orbit and anterior cranial fossa - consult neurosurgery

Coronal CT demonstrating orbital roof fracture

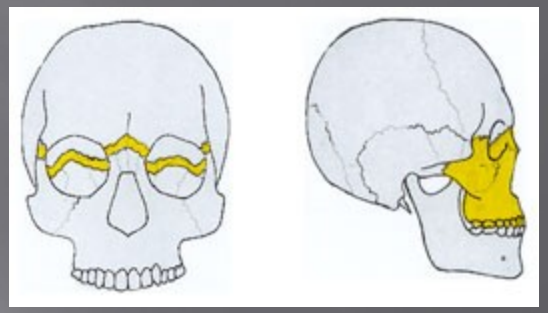
Combined Fractures

- Tripod Fracture: force to malar eminence results in separation of the zygoma from its maxillary, frontal and temporal attachments
- LeFort Types II & III: symmetric orbitomaxillary fractures that extend posteriorly, typically involving the pterygoid plates and pterygomaxillary fossa
- Nasoorbital Fractures: Ant ⎓ Post force (dashboard injury) pushes medial wall posteriorly

LeFort Type II & III Fractures



LeFort II



LeFort III

Normal Orbital Anatomy (Compartments)

Anterior compartment:
consists of eye lids, lacrimal apparatus and anterior soft tissues

Posterior compartment (Retrobulbar space):
divided into intraconal and extraconal spaces

The cone:
consists of extraocular muscles and an envelope of fascia

optic nerve is located within the intraconal space

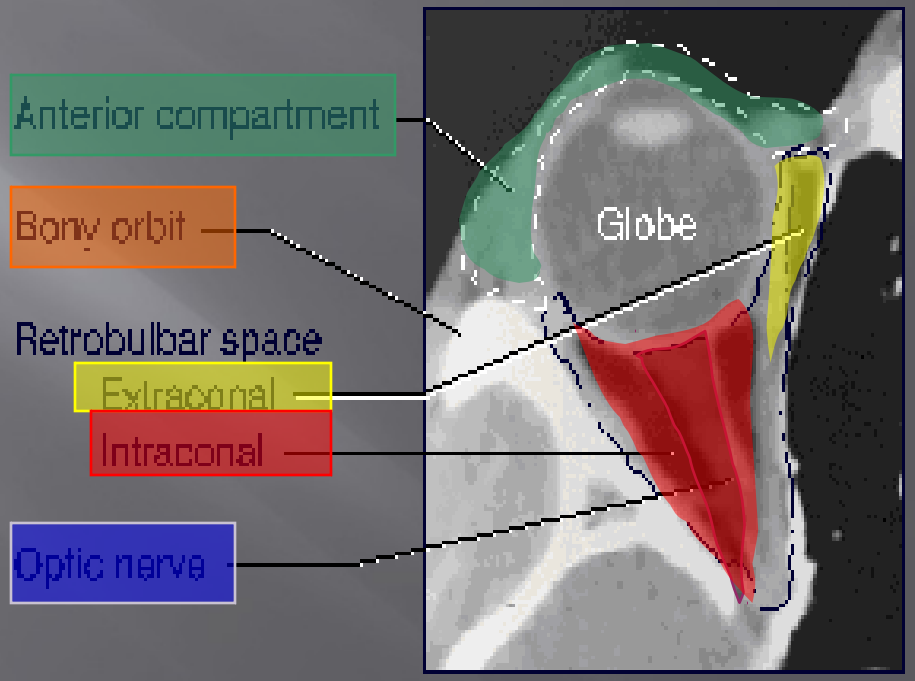


Table 1. Intraconal Lesions

- Common
  - Cavernous hemangioma
  - Schwannoma (1% to 6% of all orbital masses)
  - Neurofibroma (localized type) (2.4% for all types)
  - Lymphoma (no. 3 cause of proptosis)
  - Fibrous histiocytoma (1% of all orbital masses)
- Uncommon
  - Capillary hemangioma (children)
  - Rhabdomyosarcoma (nonembryonal types, children)
  - Malignant rhabdoid tumor (children)
  - Primary orbital melanoma
  - Leiomyoma
  - Leiomyosarcoma
  - Granular cell tumor
  - Hemangiopericytoma
  - Venous varix
  - Arteriovenous malformation

Table 2. Extraconal Lesions

- Common
  - Lymphoma
  - Lymphangioma
  - Metastasis
    - Adults: breast, lung, unknown primary, prostate, melanoma
    - Children: neuroblastoma, Ewing sarcoma, leukemia
  - Rhabdomyosarcoma (embryonal type, children)
  - Dermoid
  - Epidermal inclusion cyst
  - Paranasal sinus neoplasms
- Uncommon
  - Cavernous hemangioma
  - Capillary hemangioma (children)
  - Langerhans cell histiocytosis (<1% of all orbital masses)
  - Fibromatosis (most common orbital lesion of infancy)
  - Teratoma
  - Hematic cyst
  - Hemangiopericytoma
  - Burkitt's lymphoma
  - Granulocytic sarcoma
  - Primary osseous neoplasm
    - Ossifying fibroma
    - Osteoma
    - Plasmacytoma/multiple myeloma (0.5% of all orbital masses)
    - Osteosarcoma

Table 3. Intercompartmental Lesions

- Lymphangioma
- Rhabdomyosarcoma
- Neurofibroma (plexiform and diffuse)
- Capillary hemangioma
- Venous varix
- Arteriovenous malformation

Classification of tumours of orbit

Intraocular

In paediatric age group

Retinoblastoma

D/D : PHPV
Coat disease

In Adults

Malignant melanoma

Choroidal haemangioma

Metastasis

Orbital tumours

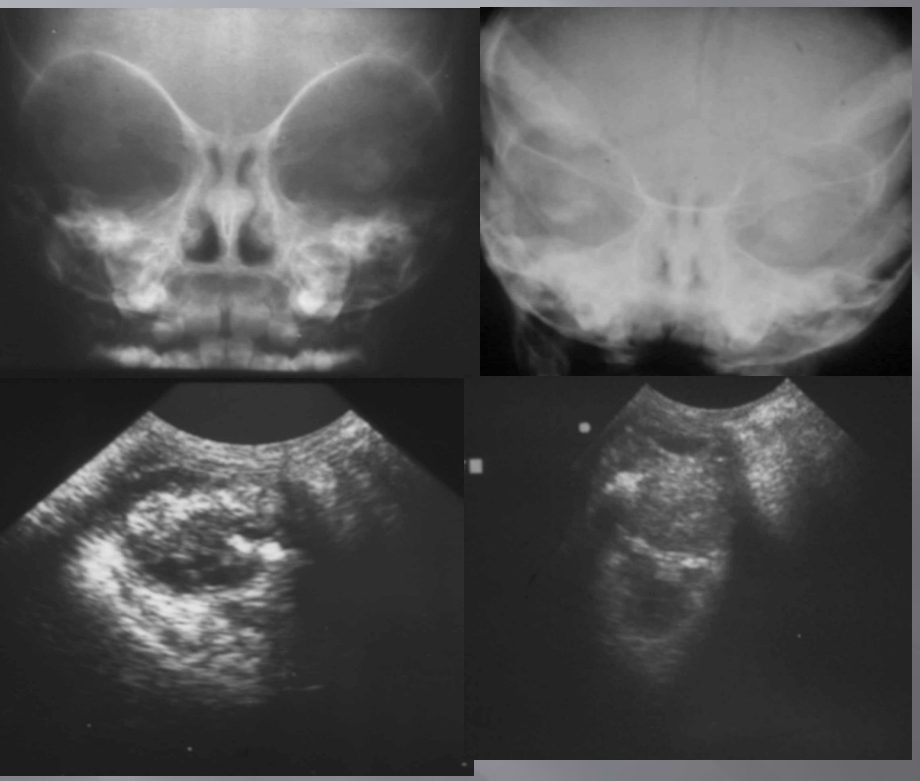
In paediatric age group

- Haemangioma
- Rhabdomyosarcoma
- Metastasis from Neuroblastoma

In Adults

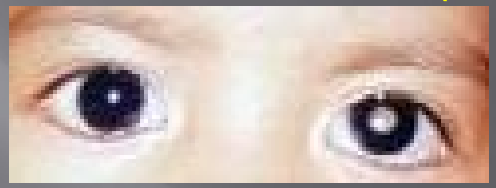
- Haemangioma
- Lacrimal gland tumour
- Optic nerve glioma
- Meningioma
- Lymphoma
- Orbital Metastasis from lung, breast, prostate

Retinoblastoma



- **Most common** tumour (commonly 1-3 yrs of age)

- Leukokoria in 60% (white pupil)



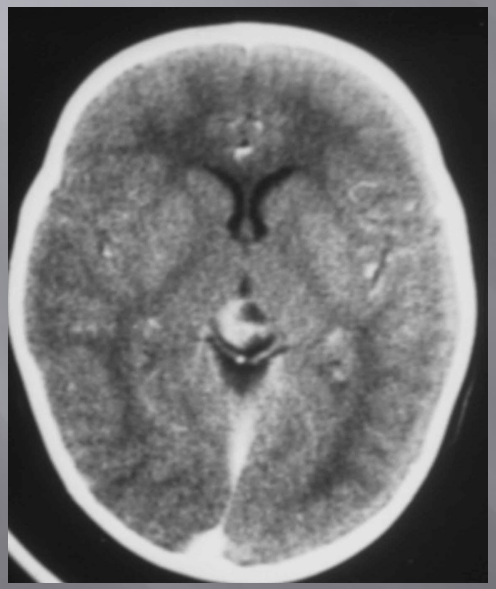
- Causes leukocoria in children. Other causes include congenital cataract, trauma, retrolental fibroplasia etc)

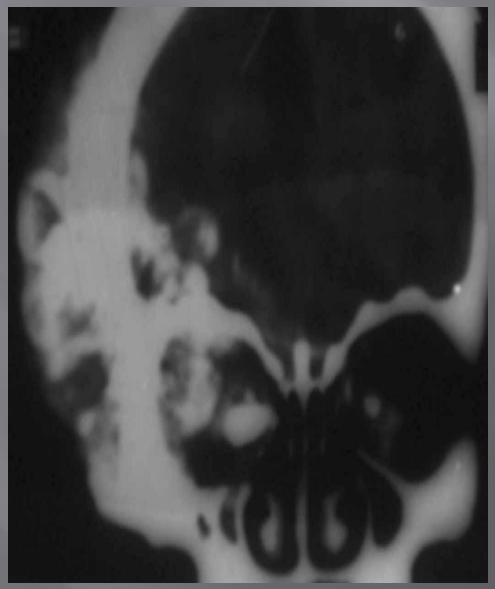
- Approx 30% bilateral

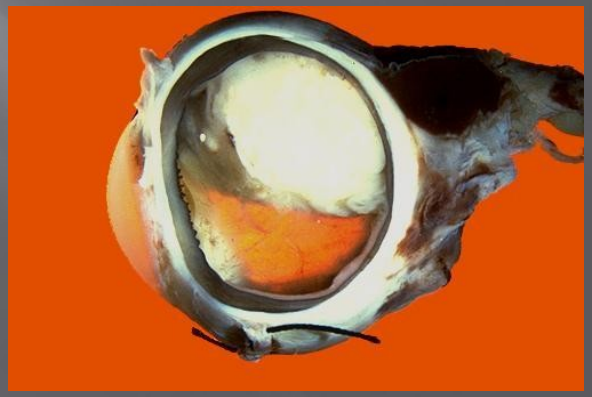
- (90%)associated with inherited forms)

Retinoblastoma

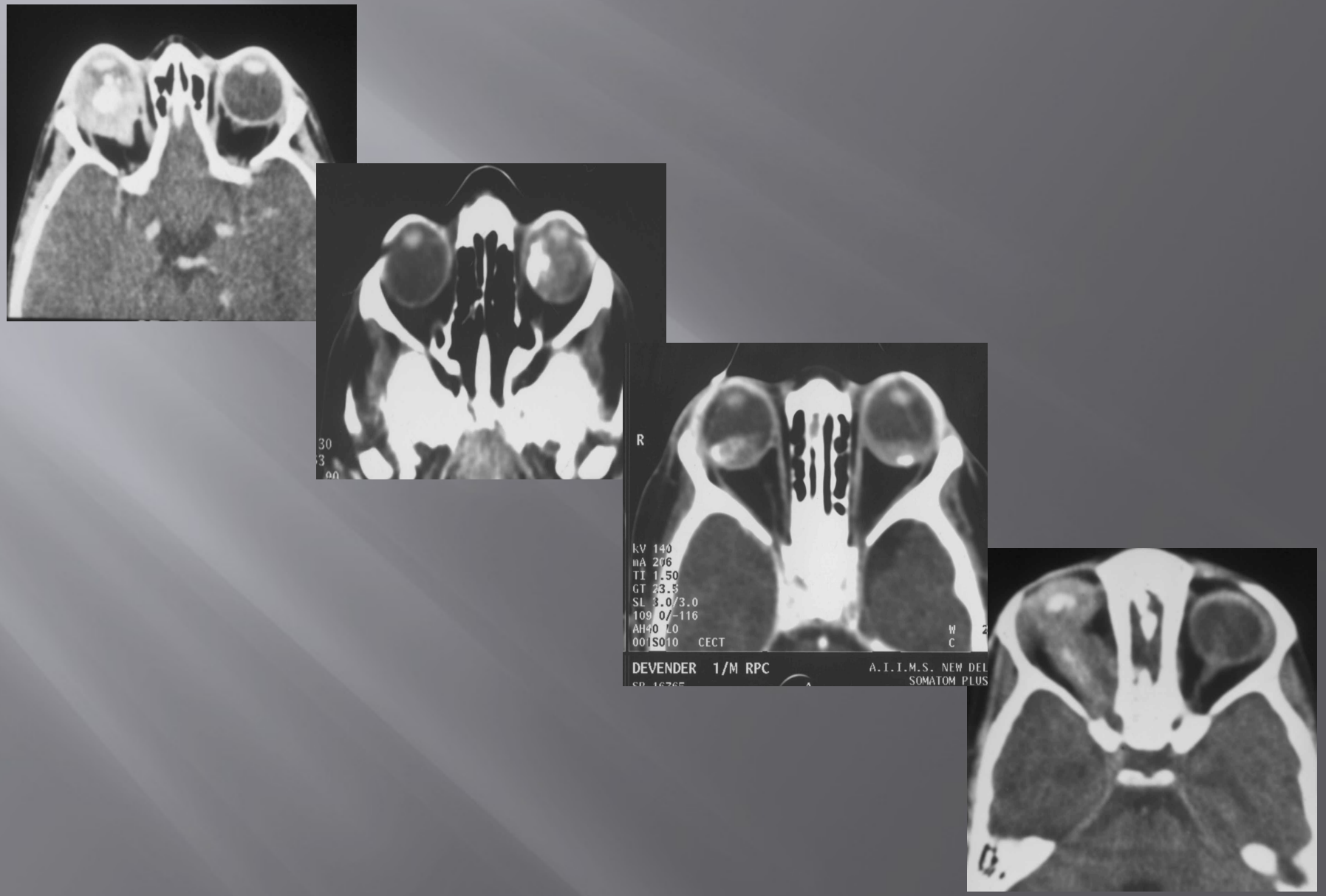
- commonly : posterolateral globe wall
- solid, retrolental hyperdense mass (endophytic type)
- most common cause of orbital calcifications (90%)
- retinal detachment invariably present
- usually enhances with contrast
- extraocular extension in 25%: optic nerve enlargement, intracranial extension, abnormal soft tissue in orbit



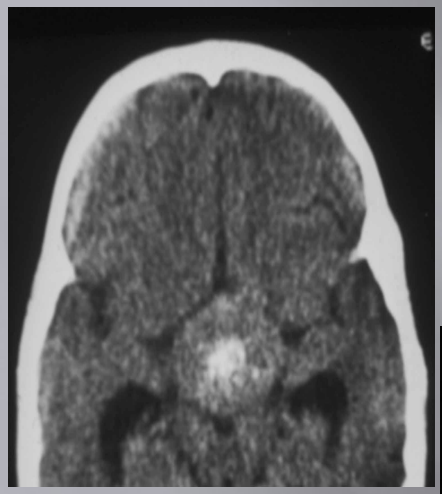




Retinoblastoma



Trilateral Retinoblastoma



30% multifocal in one eye; also may occur “trilaterally”

D/D of pineal region masses includes germinoma, teratoma, and pineocytoma/blastoma

Melanoma:

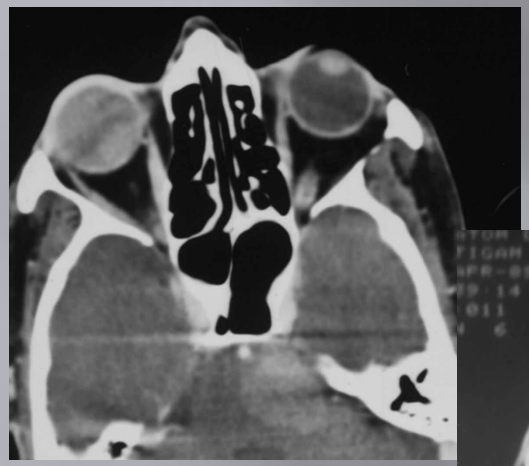
- MC - adult ocular malignancy
- 6^{Th}-7^{th} decades of life
- almost always uniocular and single
- aggressive malignant tumor of uveal tract; most arise from preexisting choroidal nevi
- invades along choroid, into vitreous & through sclera into ON and RB Space

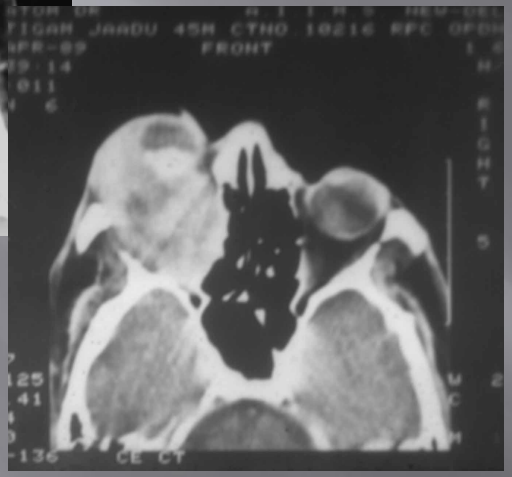
Imaging : CDFI - Mass very vascular
: CT – high density; do not calcify; enhances
: MRI – compared to the vitreous, high signal on T1 and low on T2WI
(secondary to paramagnetic properties of melanin)

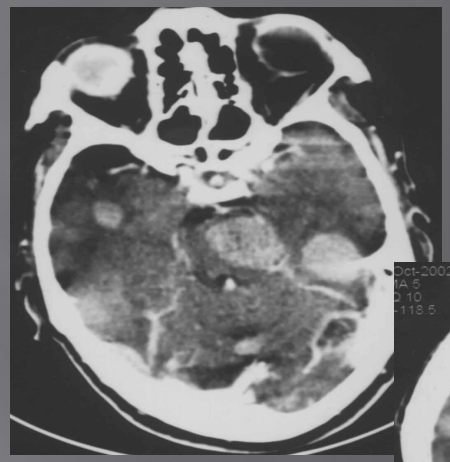
- thickening/irregularity of choroid or exophytic/biconcave mass
- sub retinal effusion and retinal detachment very common

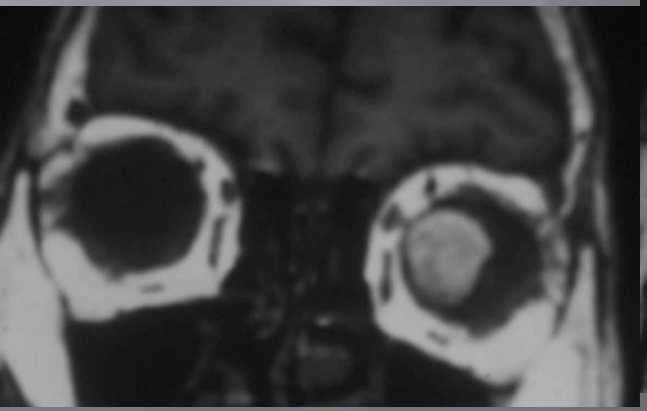
- Primary D/D: choroidal metastasis (esp. breast and lung Ca) : moderate signal on T1 and high signal on T2

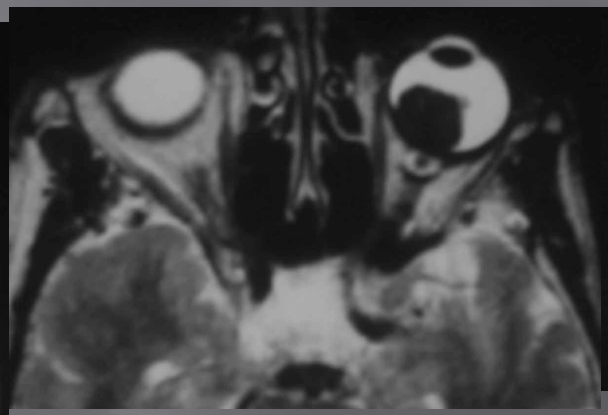
Melanoma:

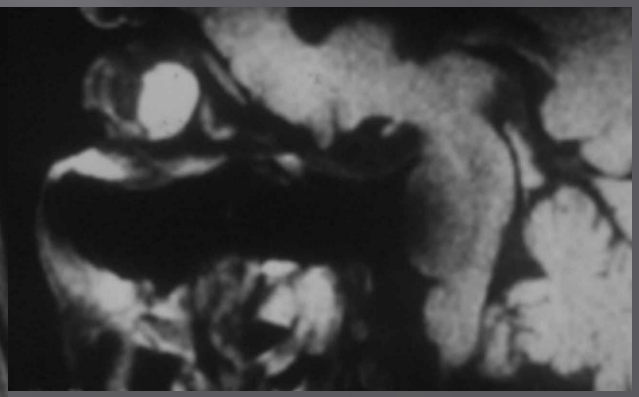






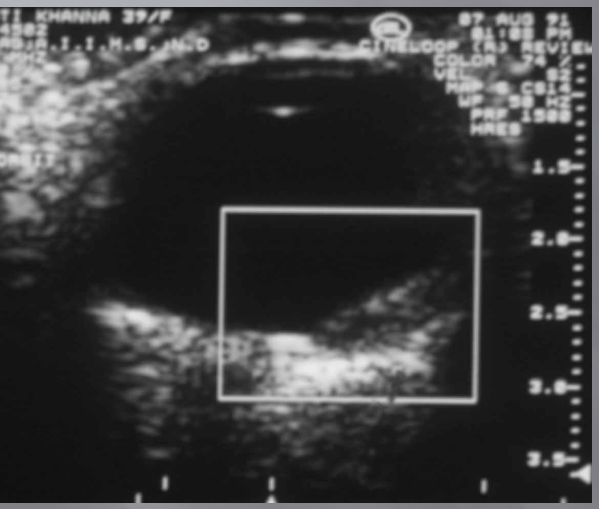




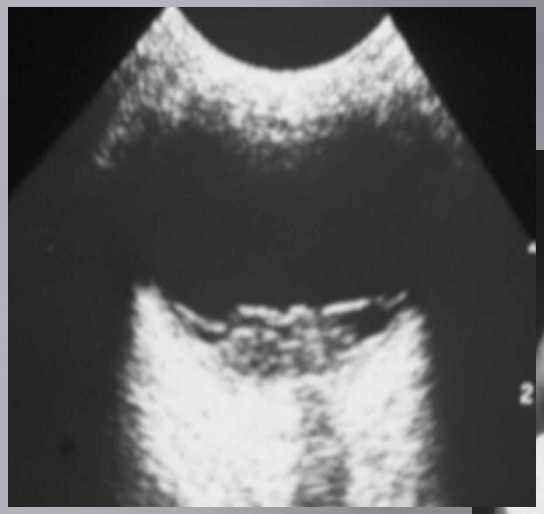


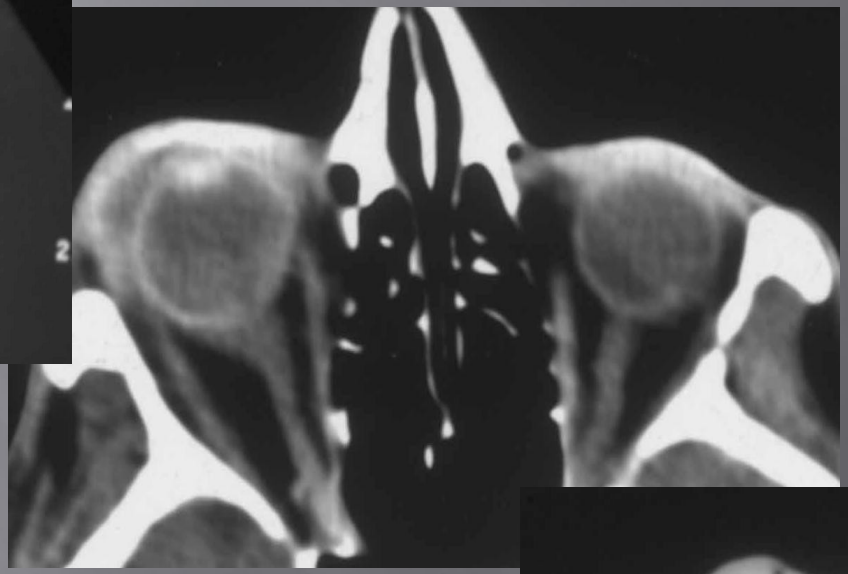
Intraocular Metastasis

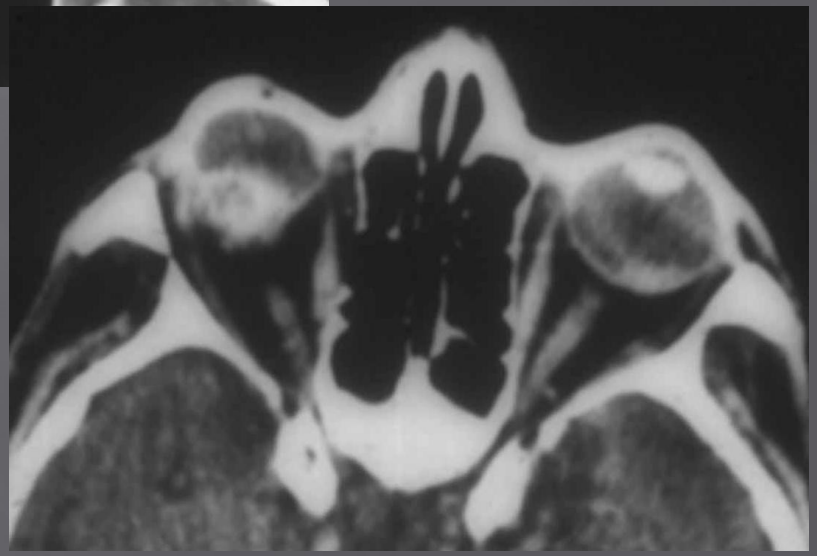
- Sub retinal masses located in posterior part of fundus.
- flattened or placoid masses and may be multiple.
- Common primary tumors : Lungs, breast, prostate etc.



Intraocular Metastasis







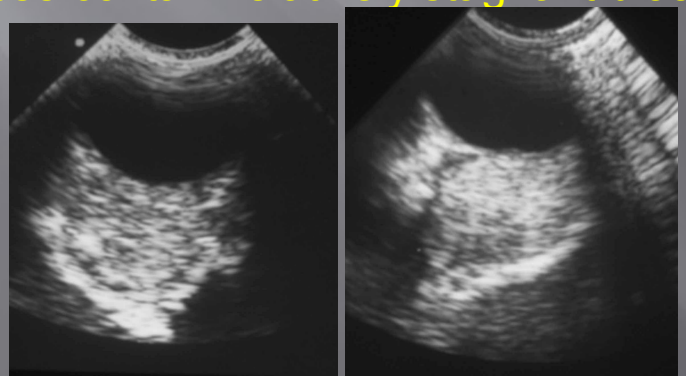
Orbital Tumours: Haemangioma

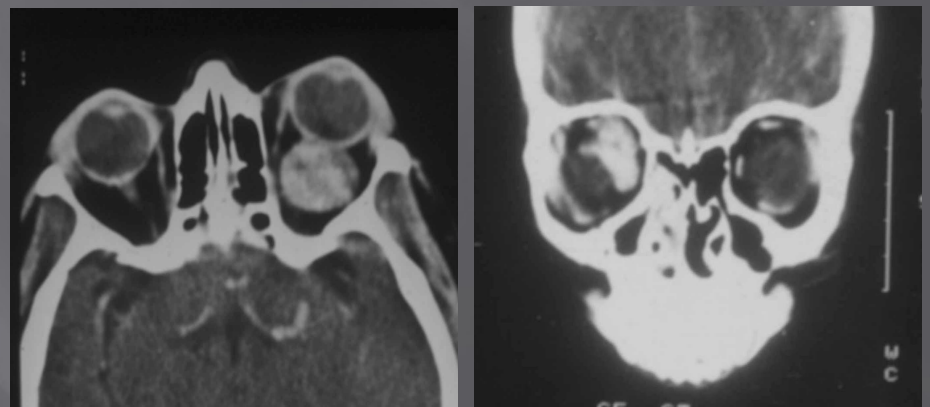
Capillary Haemangioma:

- MC vascular tumor of orbit in children
- 10% of all pediatric orbital tumors
- first year of life , spontaneously involutes >1 year
- no fibrous capsule (unlike cavernous haemangioma)
- can infiltrate both intraconal/extraconal spaces
- 90% associated with cutaneous angiomas

Cavernous Haemangioma:

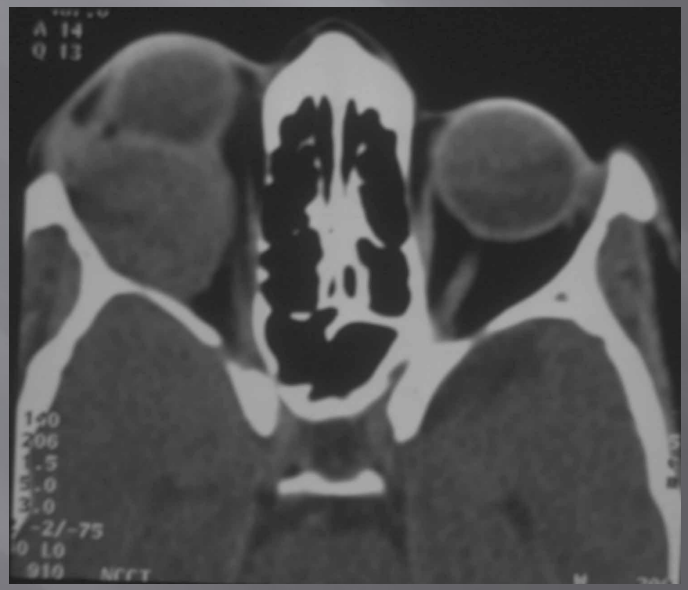
- Commonest intraorbital tumour in adults
- Commonly intraconal may be extraconal .
- Well encapsulated round, oval or lobulated
- Histologically – large dilated vascular channels (sinusoid like spaces) lined by endothelial cells.
- These contain relatively stagnant blood.

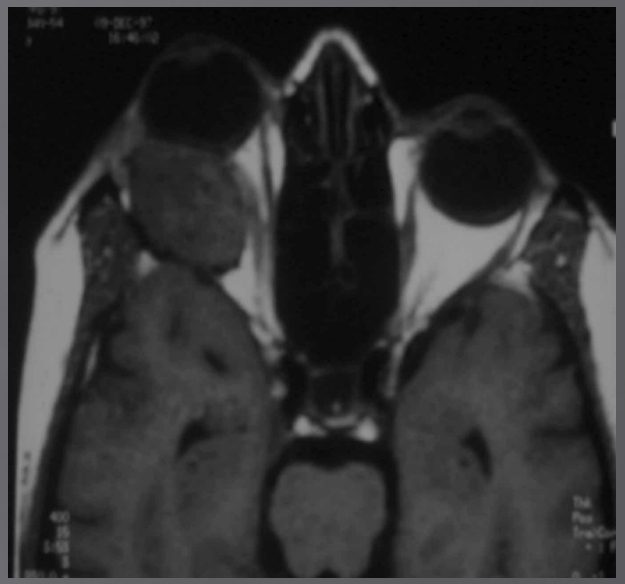


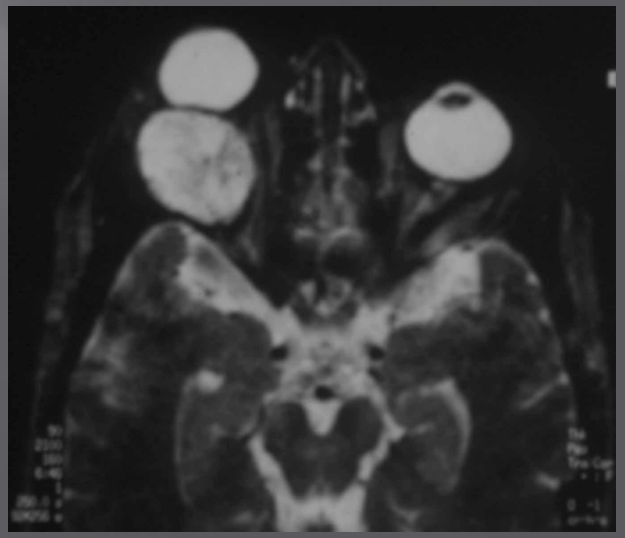


Haemangioma

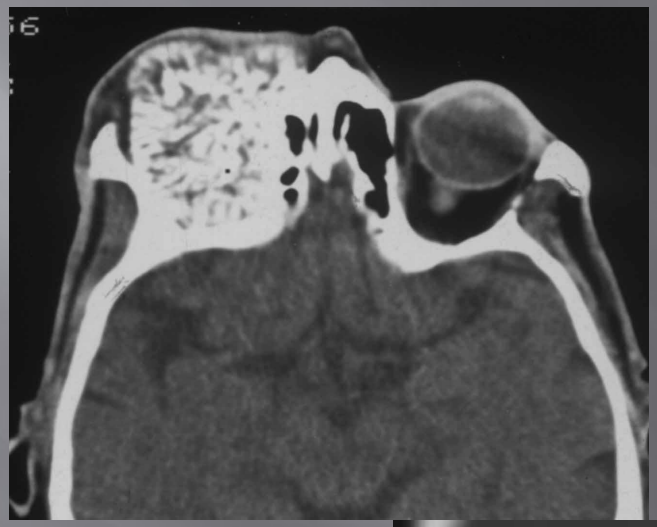
- vascular nature not apparent on MR because they are not high flow lesions
- most found in intraconal space, lateral to optic nerve

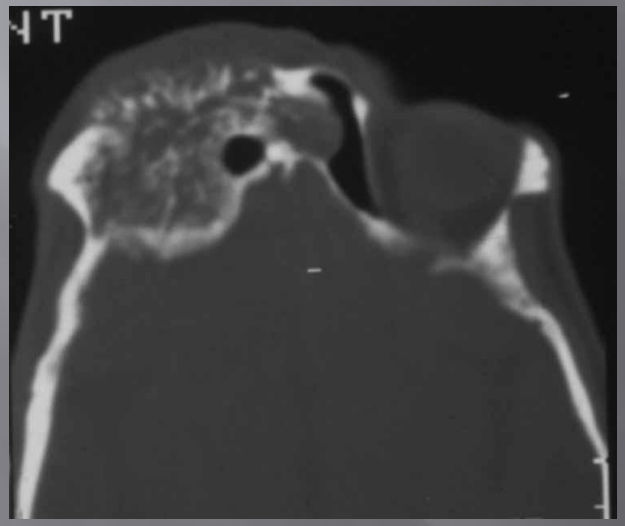


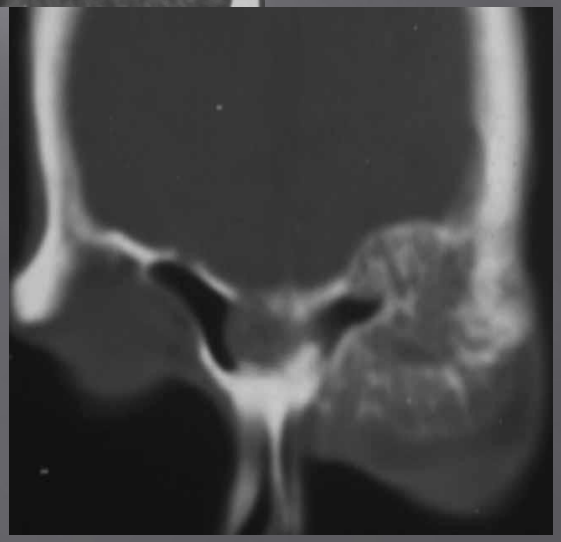




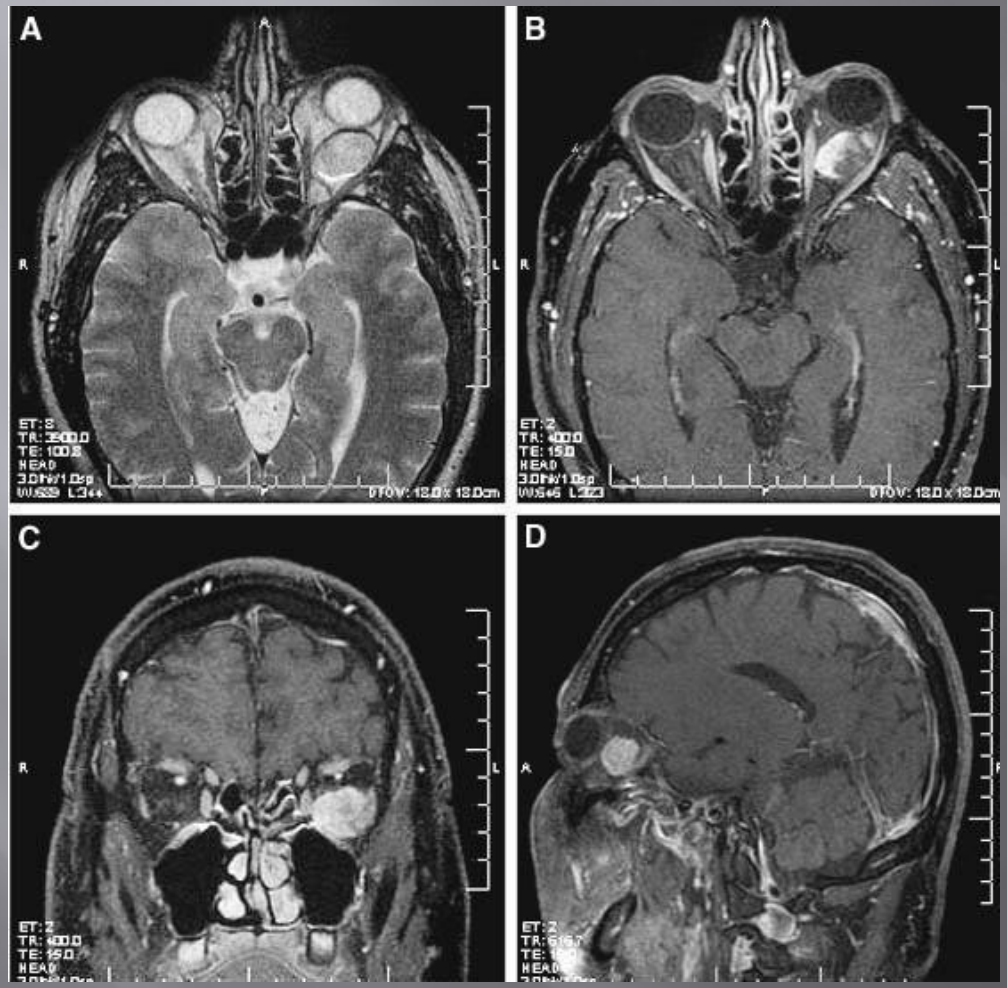
Osseous Haemangioma







Cavernous Hemangioma



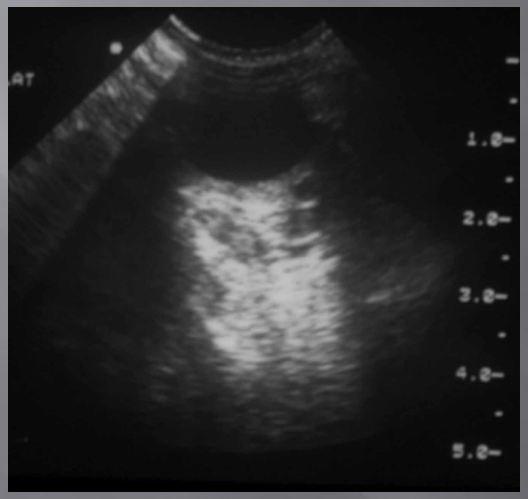
A.chemical-shift artefact on T2 sequence (indicating the presence of fat)

B-D. characteristic pattern of progressive enhancement from periphery to center with gad

Lymphangioma

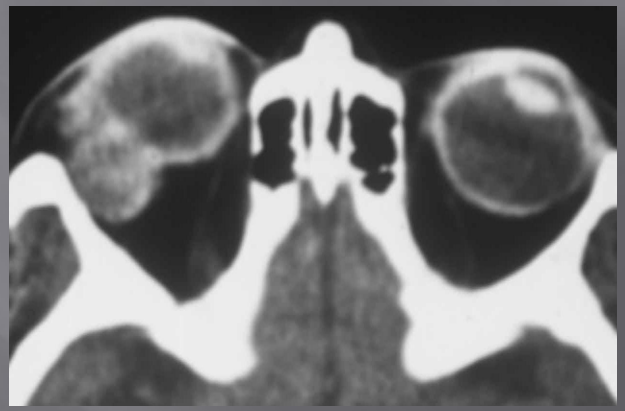
•Most lymphangiomas present during childhood.
•Benign tumours containing lymphatic channels (lymph fluid alone / lymph / blood products) separated by septae.

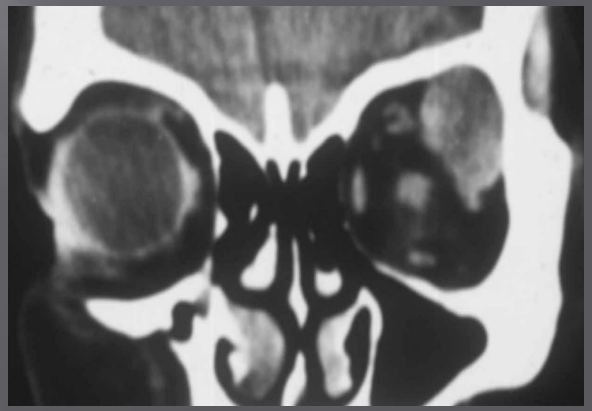
Imaging: Undulating or irregular margins consisting of septae which separate it into lobules and cysts of varying size and echo/density/intensity.
The ability to characterize the various stages of evaluation of the haemorrhage makes MR on ideal diagnostic modality for studying these lesions.



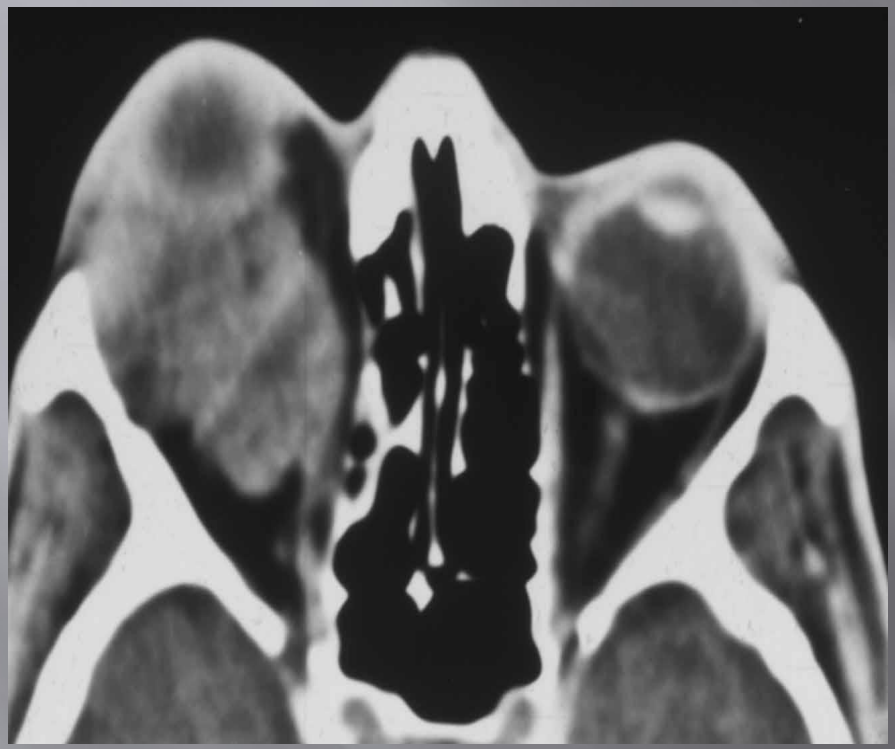
Lacrimal gland tumours

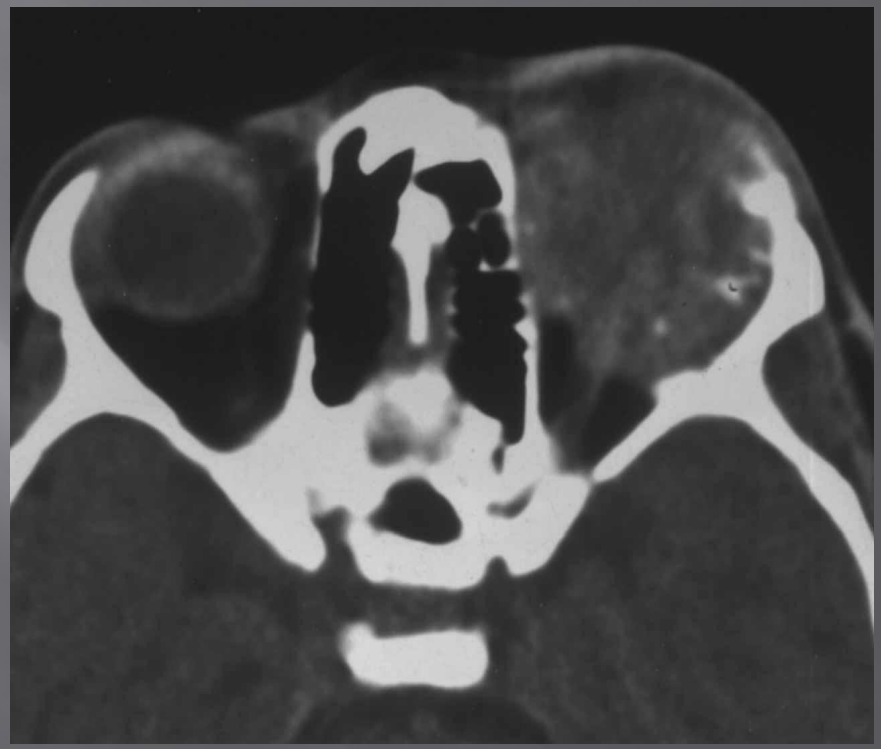
- Benign mixed tumours (Pleomorphic adenoma)-MC benign tumour
- Most often involves the orbital part of the lacrimal gland.
- Well defined mass with posterior rounded configuration.
- Fossa formation in superolateral part of bony orbit.
- Presence of calcification, necrosis and bone destruction, all suggestive of malignancy.





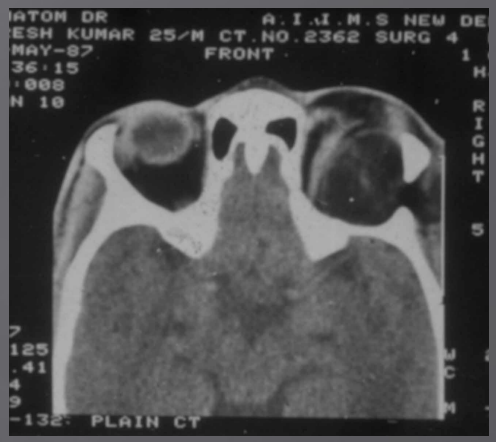
Lacrimal gland tumours





Orbital Dermoids and Epidermoids

MC benign paediatric orbital tumour congenital developmental tumours arising from embryonic epidermis that gets trapped in developing sutures of the orbital bones.



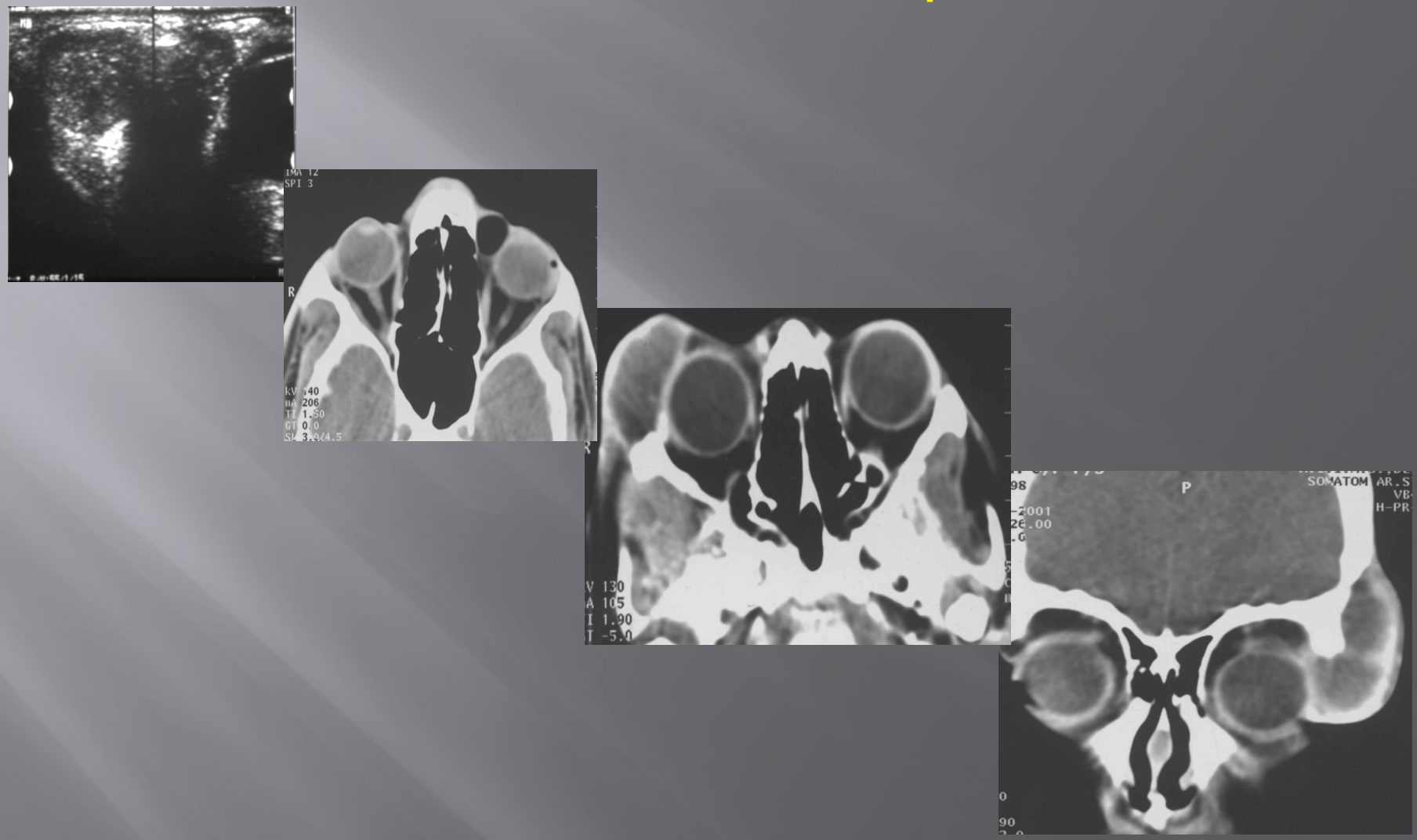
Most frequently located in superolateral quadrant.

Dermoid tumours contain hair and sebaceous glands containing keratinaceous debris and fatty substances. Bone changes by expansion and pressure erosion leading to thinning and scalloping of adjacent bone.

Imaging oval, lobulated, dumb bell, shaped with cystic or solid components. Orbital bone changes may be seen.

A specific diagnosis can be made if fat fluid level is demonstrated

Orbital Dermoids and Epidermoids



Optic Nerve / Sheath Tumour

- Meningioma
- Glioma

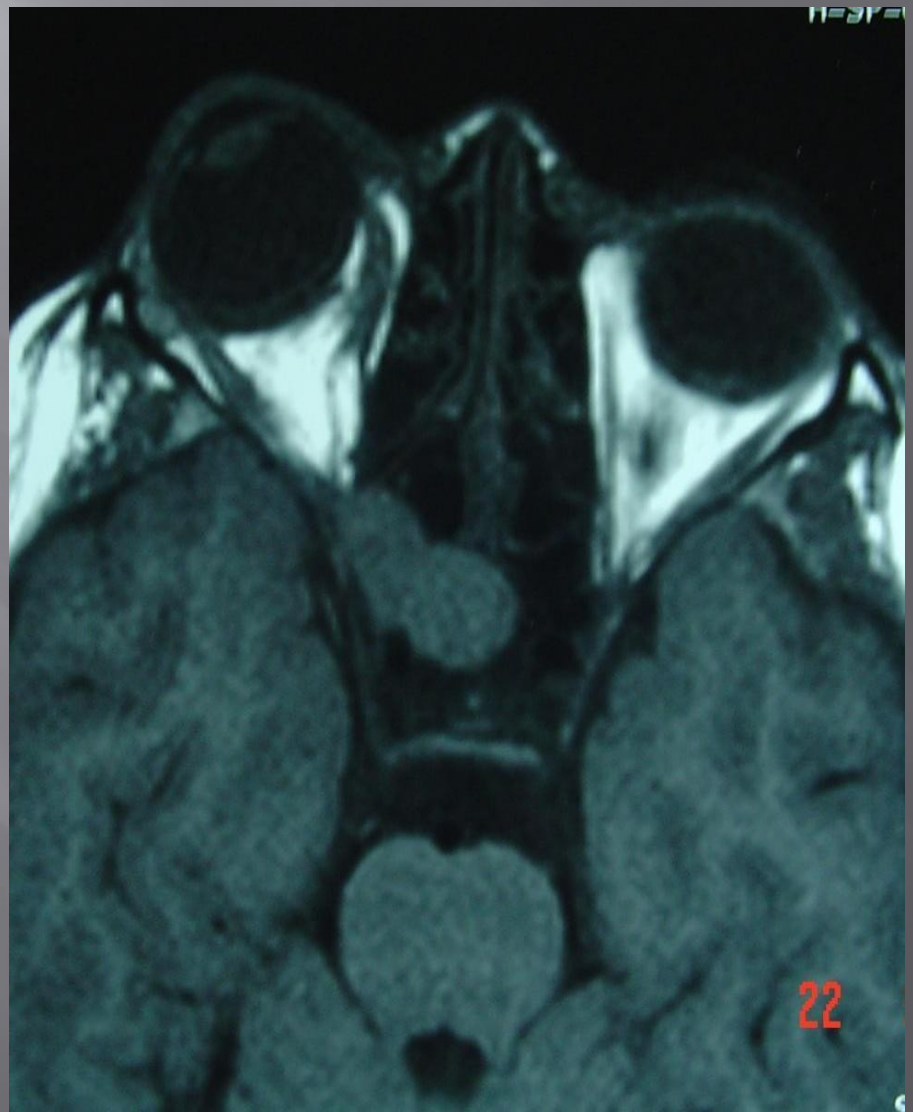
OPTIC NERVE GLIOMA

- Common childhood tumour with a female preponderance.
- High association with neurofibromatosis (over 50%).

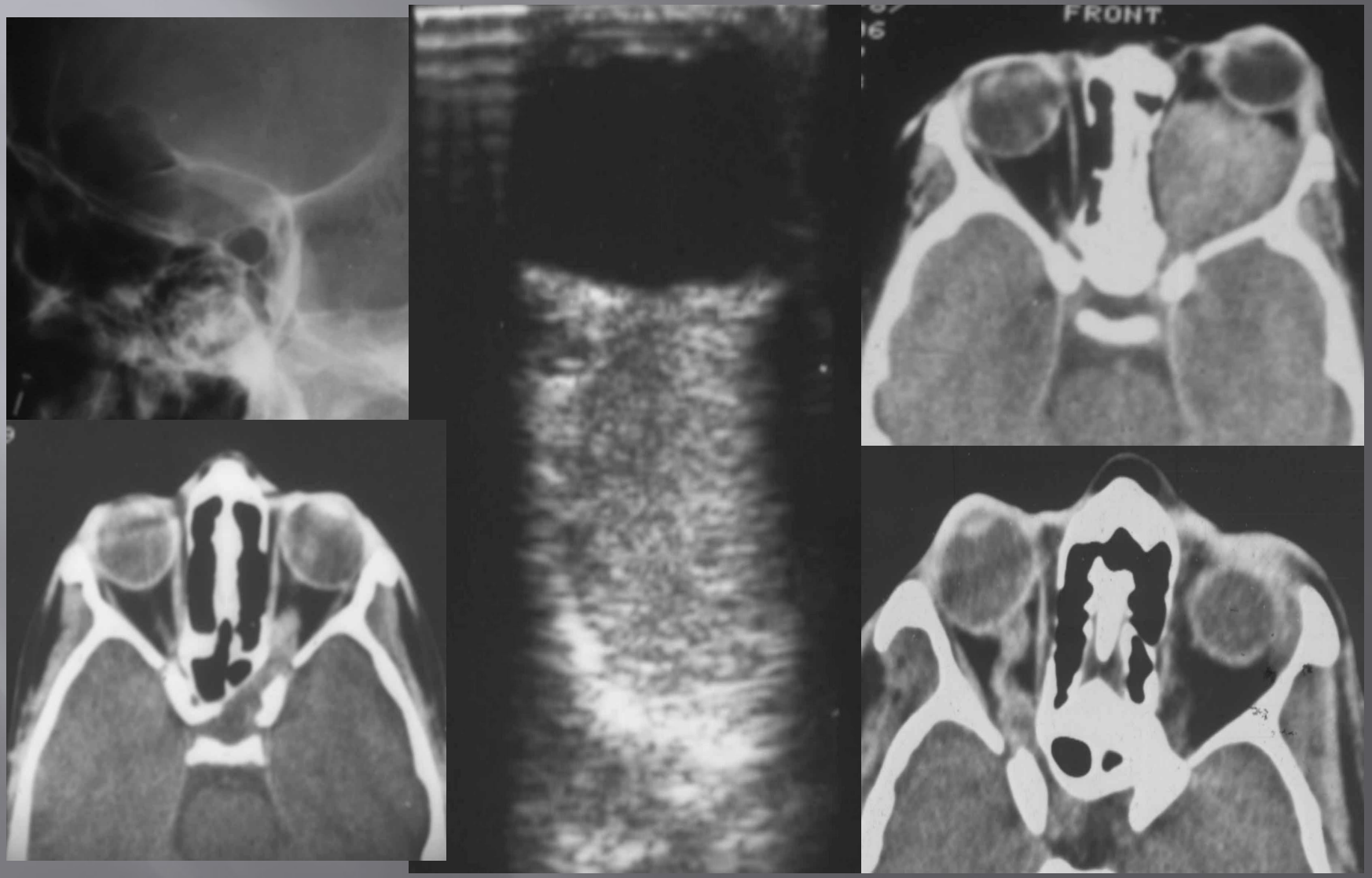
- Enlargement of optic foramen may be seen.
- Tubular, fusiform or saccular enlargement of the optic nerve.
- Tortuous course of the nerve goes in favour of optic nerve glioma.
- Contrast enhancement less intense.
- Calcification rarely.
- MRI better evaluates intra canalicular and intracranial parts.

Glioma

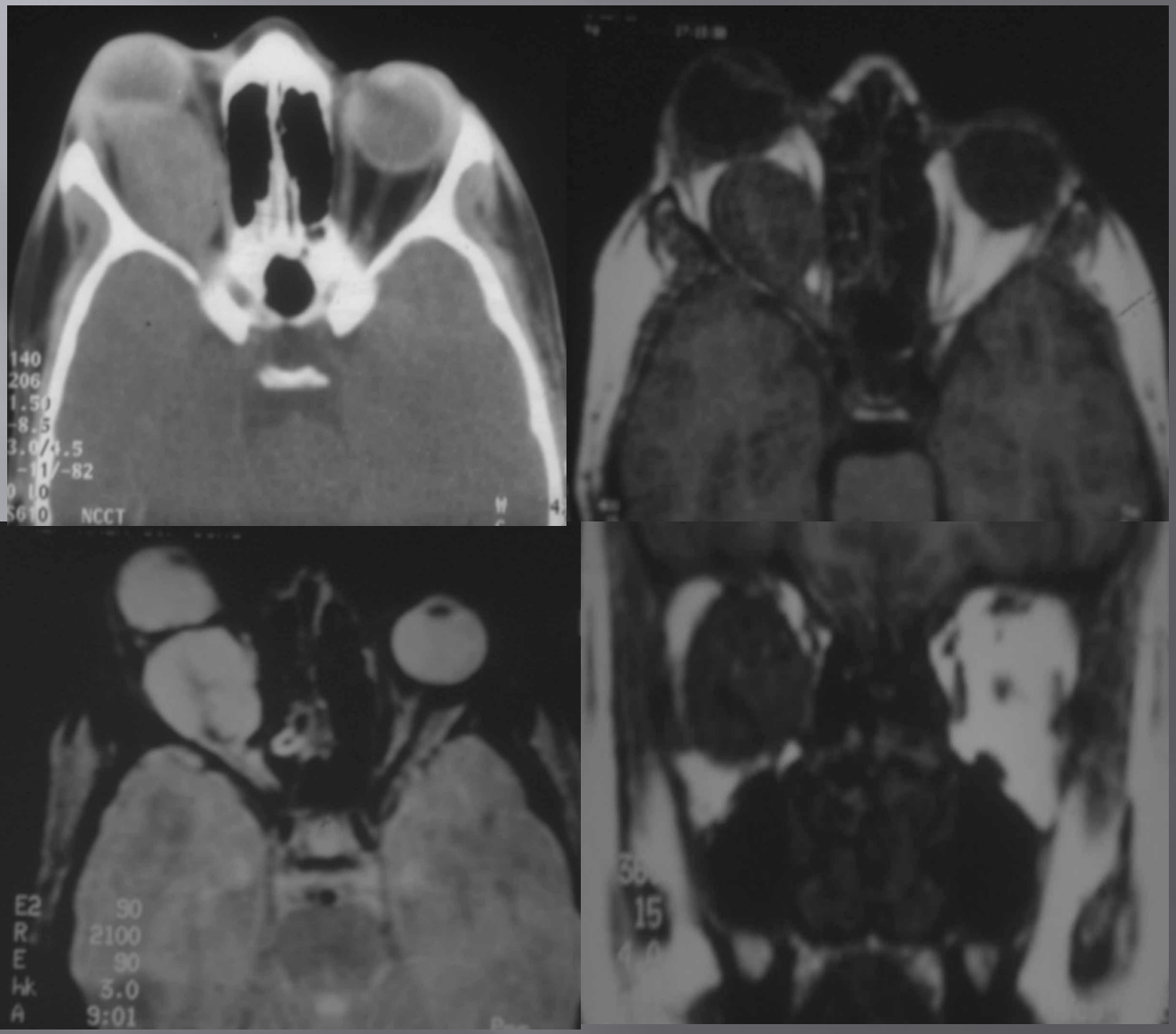
Glioma



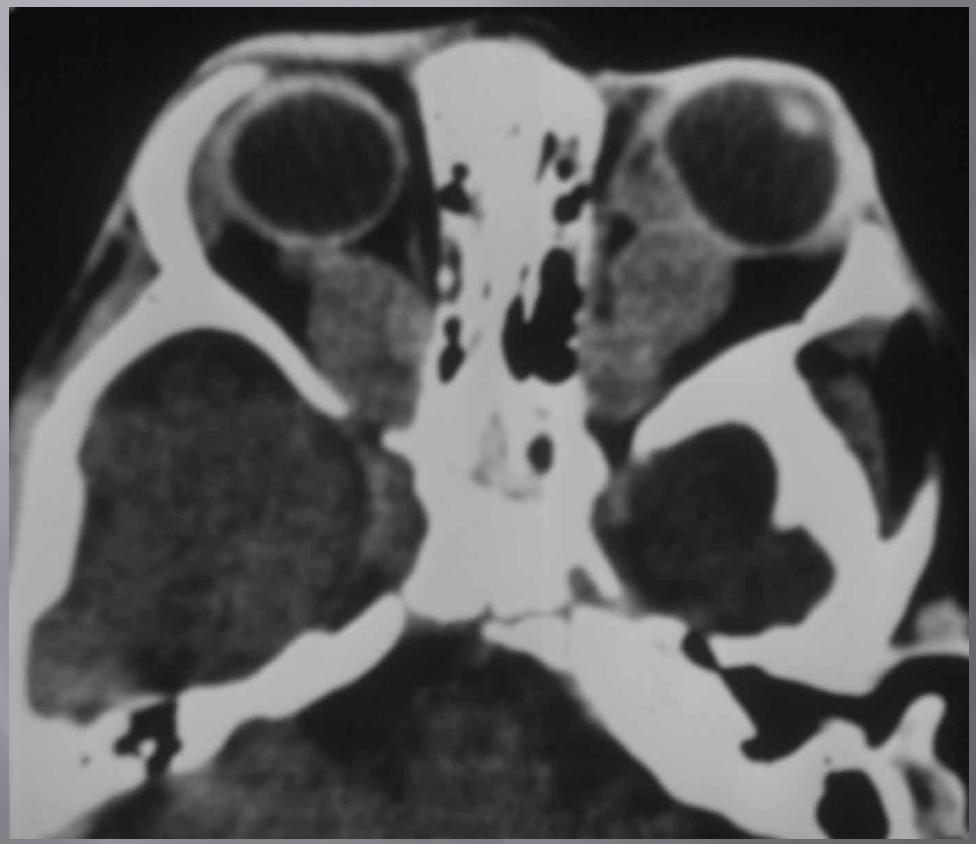
Optic Nerve Glioma

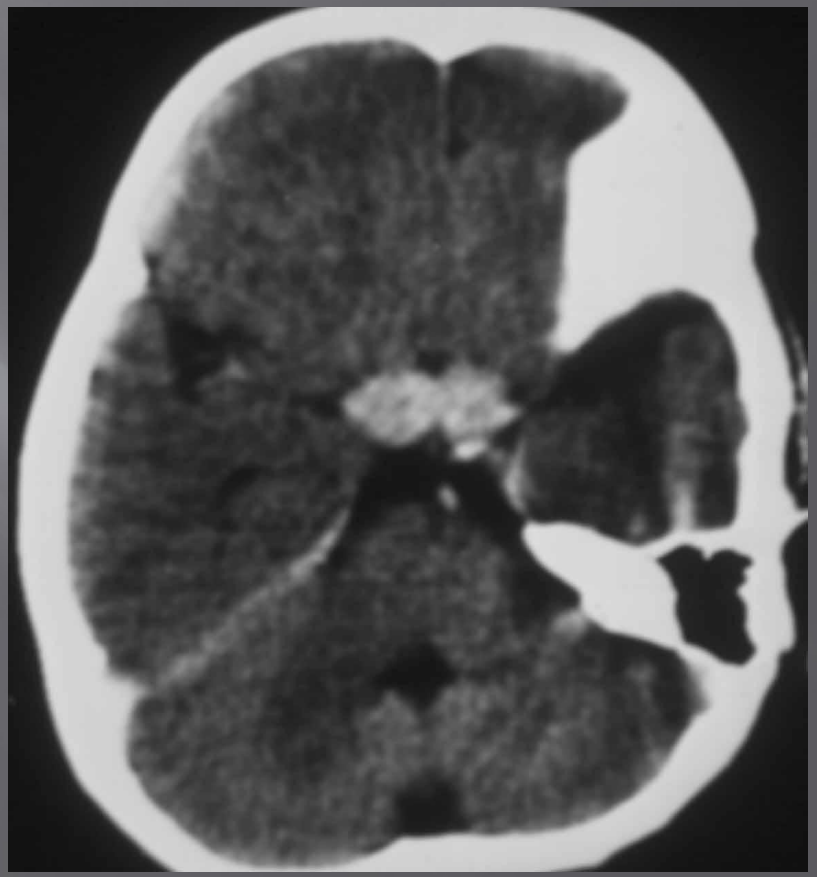


Optic Nerve Glioma



Bilateral Optic Nerve Gliomas





MENINGIOMA OF THE ORBIT

More common in women

occurs most frequently in middle age

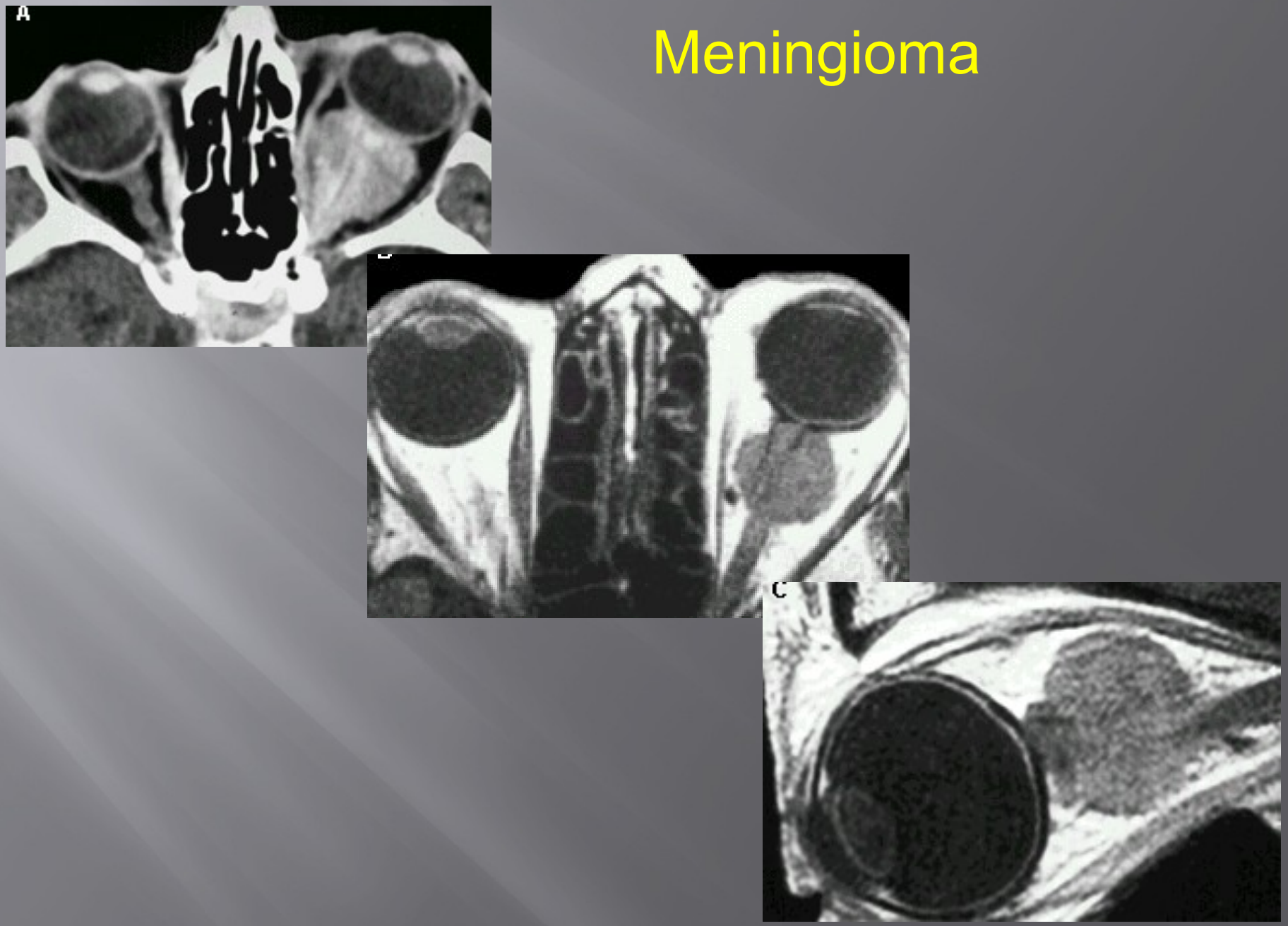
Meningiomas of the orbit are of 3 types :

I Sphenoid wing meningioma with extension to the orbit

II Optic nerve sheath meningioma

III Meningioma arising de novo from arachnoid cells in the orbit.

Meningioma

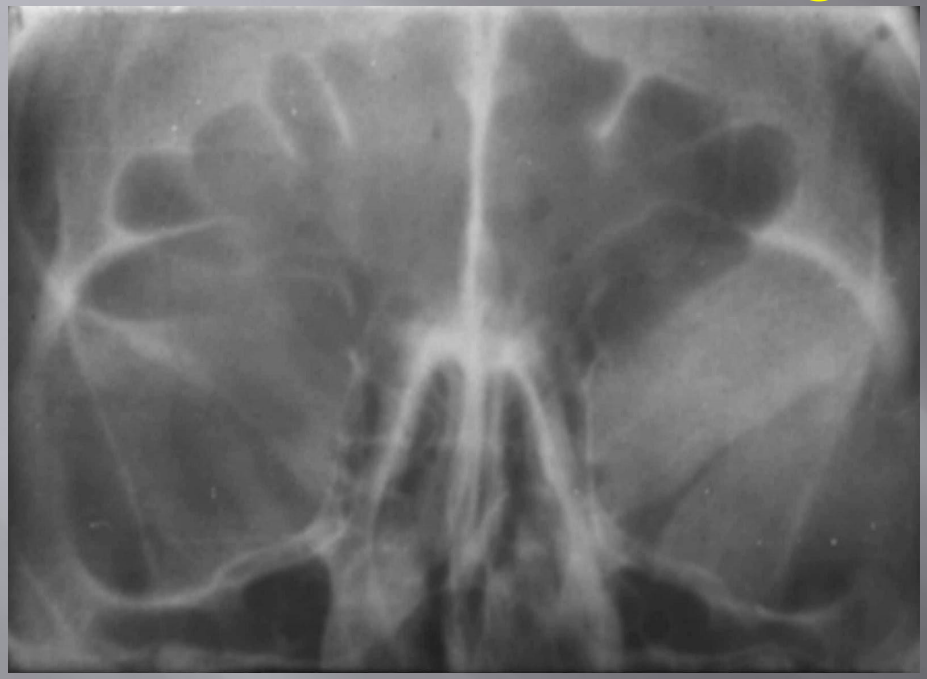


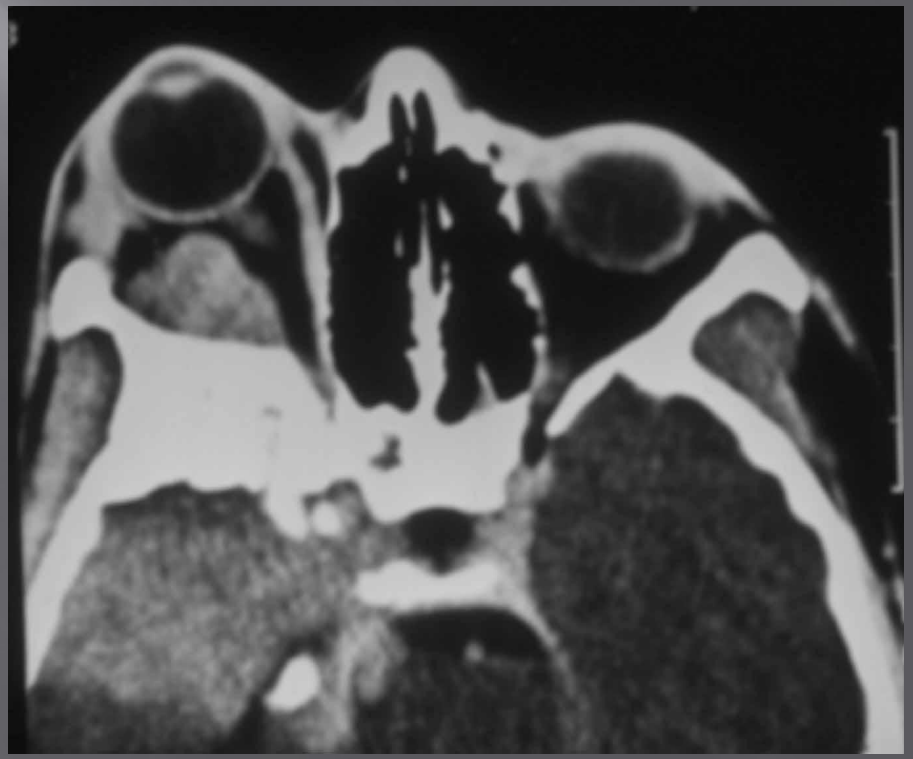
Sphenoid Wing Meningioma

Type I : Sphenoid Wing Meningioma

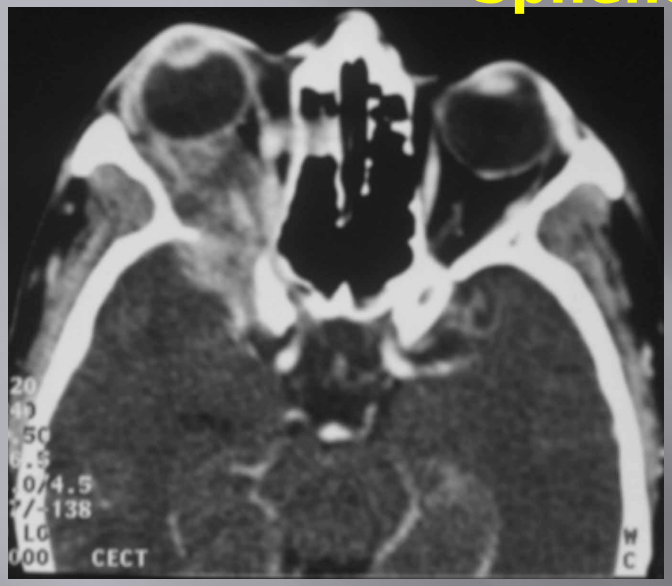
- Results in hyperostosis and expansion of the bone
- The osseous tumour as well as soft tissue component may extend into the orbit, anterior or middle cranial fossa or extracranially to temporal fossa.

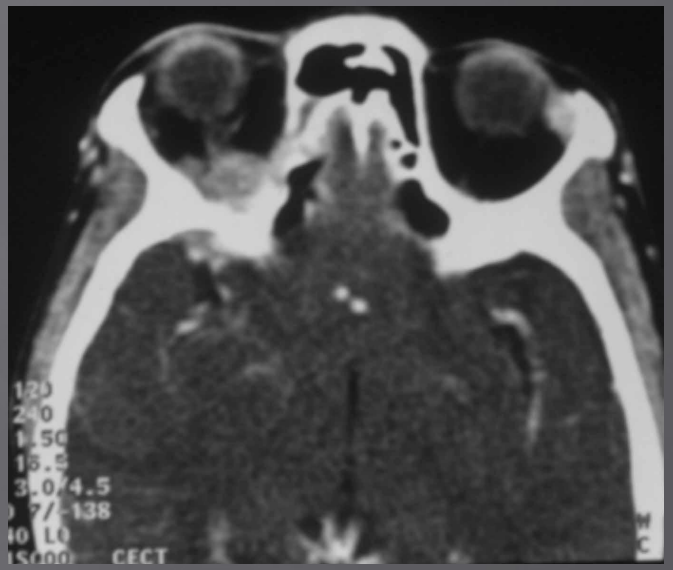
Sphenoid Wing Meningioma

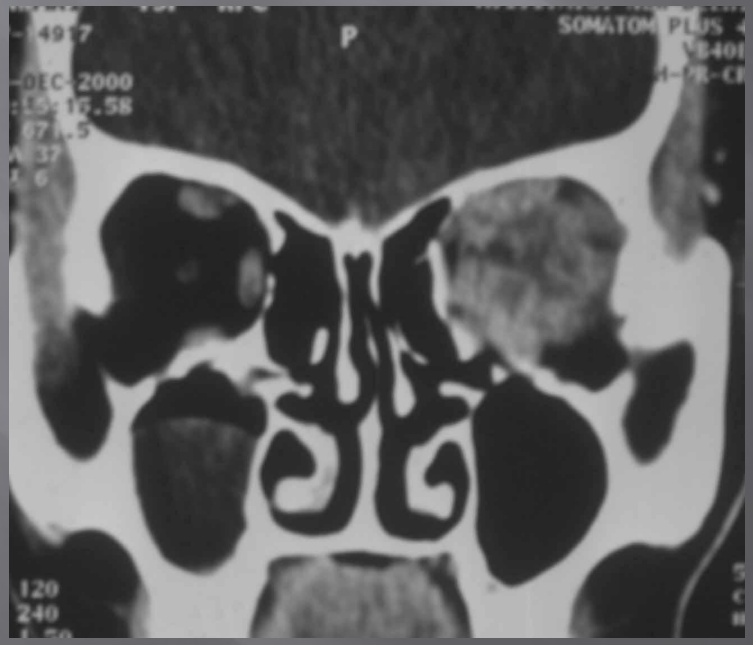




Sphenoid Wing Meningioma





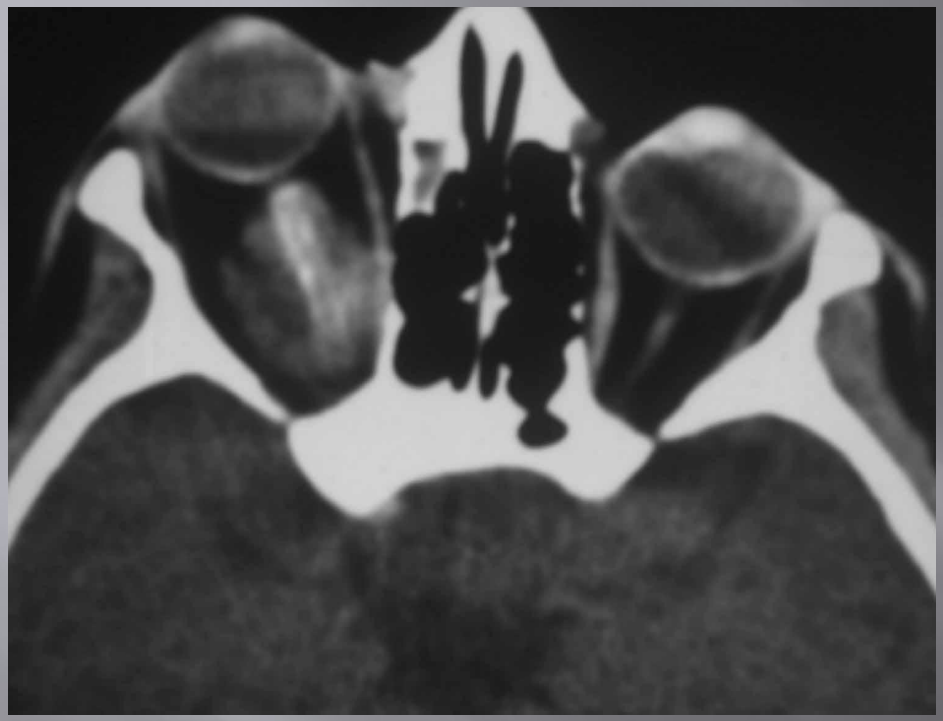


OPTIC NERVE SHEATH MENINGIOMA

Type II : Optic Nerve Sheath Meningioma

- **Arises from arachnoid cells of the dural sheath covering the optic nerve.**
- **Diffuse enlargement of the optic nerve sheath complex results in a tubular, fusiform or saccular appearance**
- **Rather straight course. Sheath shows marked enhancement following IV contrast.**
- **Calcification is a common feature and may appear diffuse, coarse, punctate, or tubular shaped along the O.N. sheath.**

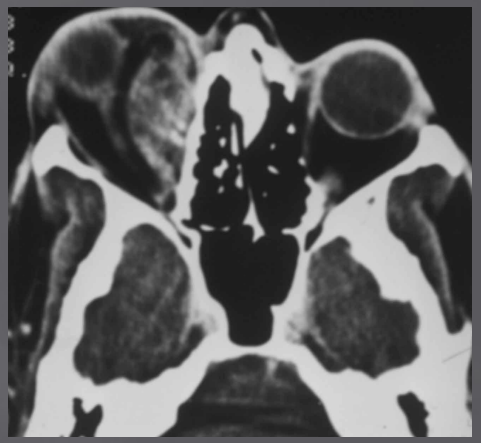
Optic Nerve Sheath Meningioma



MENINGIOMA ARISING DE NOVO

Type III :

- **Meningioma arising from rests of arachnoid cells inside the orbit.**
- **Very rare, variety.**
- **No characteristic features.**
- **Seen as an orbital mass located in any part of the orbit.**

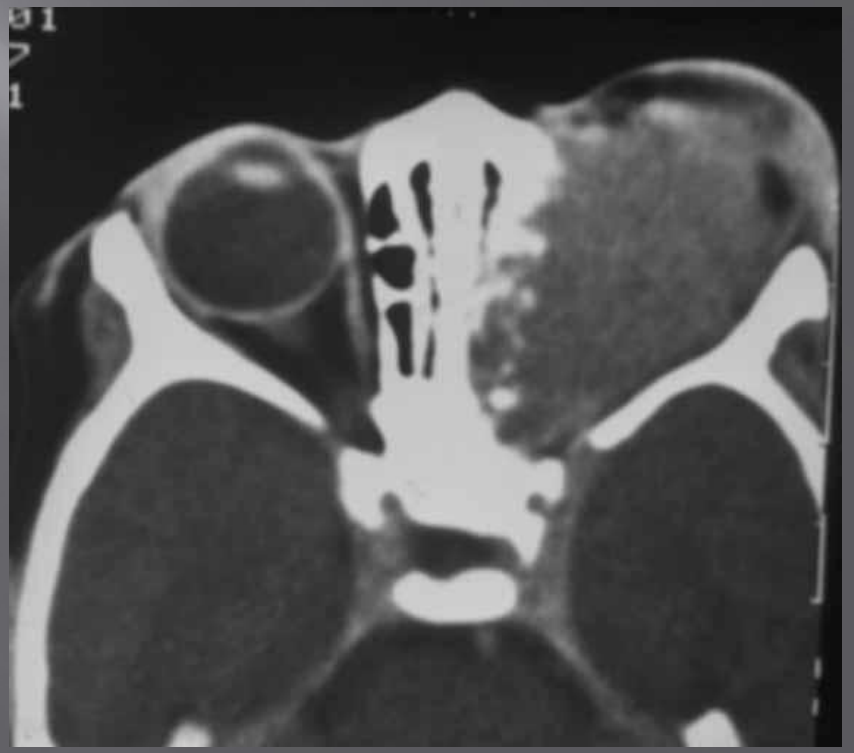


RHABDOMYOSARCOMA

Most common primary orbital malignancy of childhood.

- Mean age of onset 6 yrs.
- Rapidly progressive proptosis
- Tumour arises from extraocular muscles
- Superonasal quadrant most common
- Mass may be associated with bone

Rhabdomyosarcoma

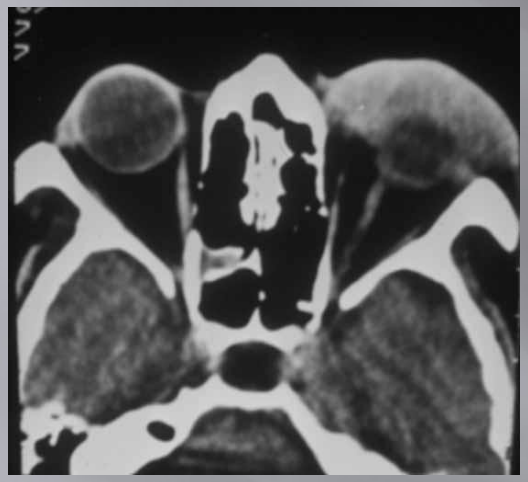


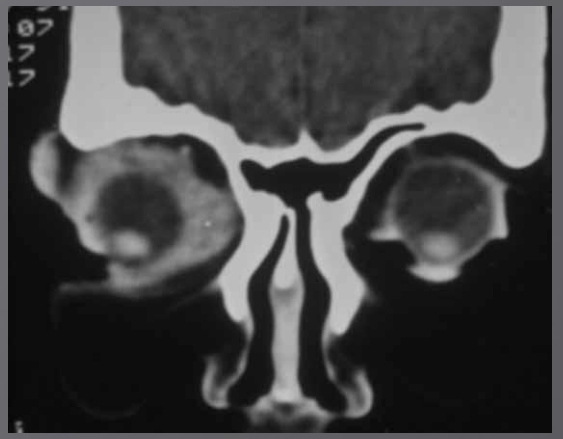
LYMPHOMA

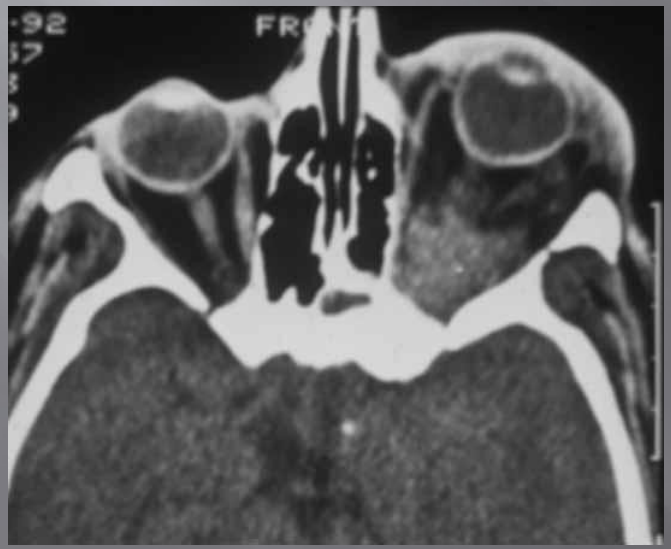
More often seen in anterior part of orbit or retrobulbar area

Generally lesions mould themselves to pre-existing structures such as globe, optic nerve and bony orbit without eroding the bone

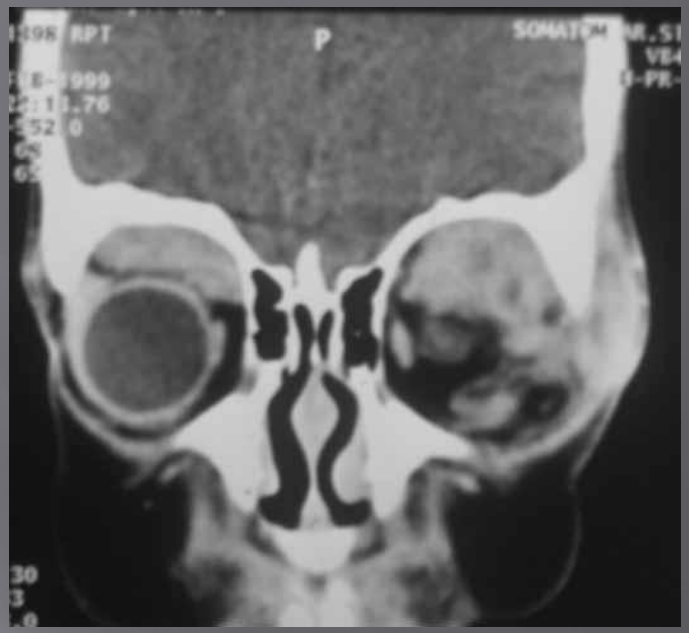
Lymphoma







Leukemia



Squa. Cell Ca. Lower Eyelid

ORBITAL METASTASES

Relatively rare

In children

- Neuroblastoma
- Ewing’s sarcoma
- Leukemia

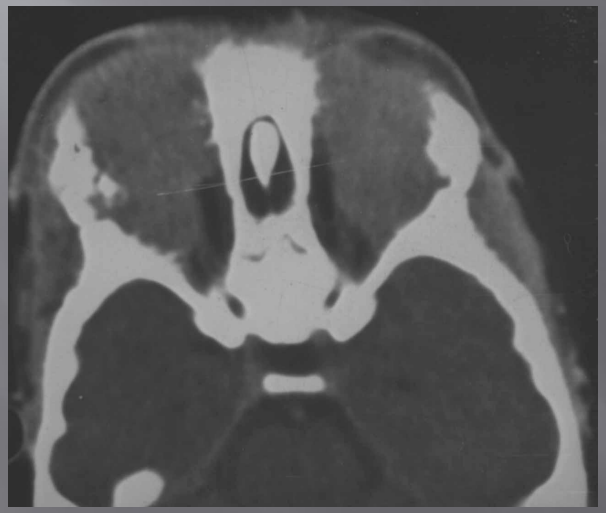
In adults

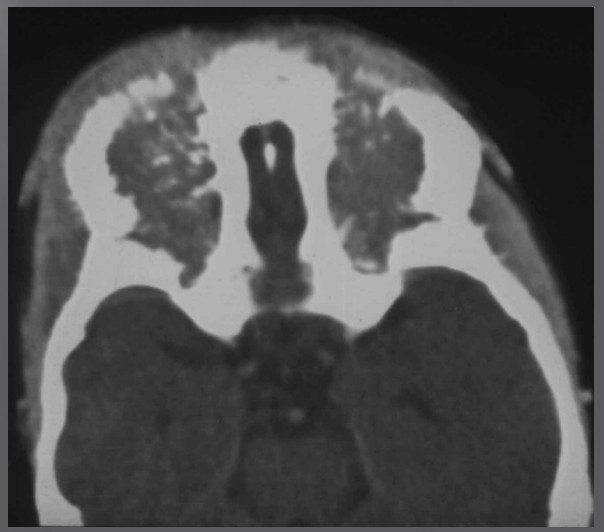
- Breast
- Lung
- Prostate etc.

ORBITAL METASTASES IMAGING

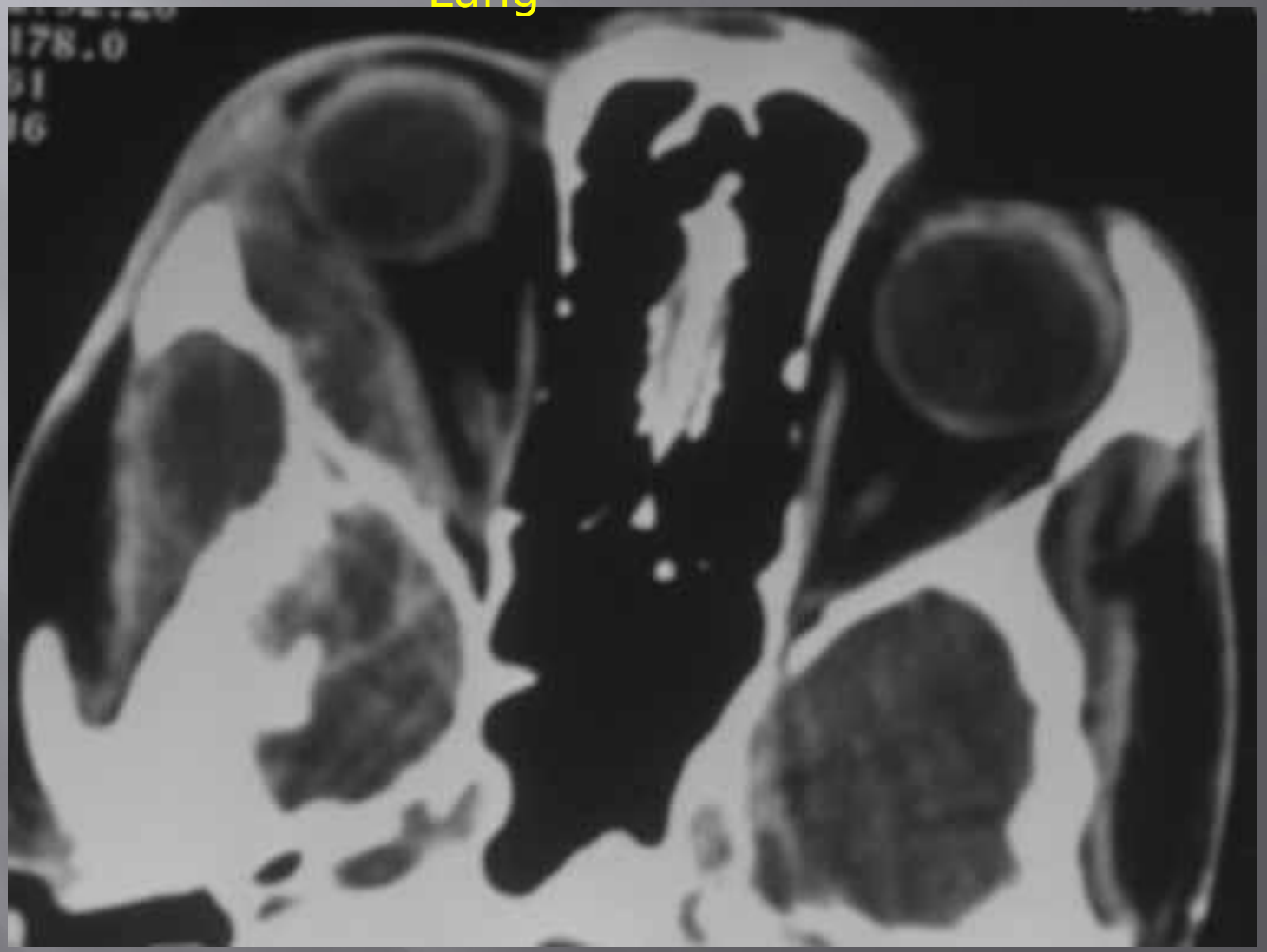
Infiltrative, poorly defined or well defined masses.

Neuroblastoma
Metastases





Mets. from Ca Lung



CONCLUSIONS

Ocular Tumours

- US has an edge over CT
- CT has a definite complimentary role.

Orbital Tumours

- CT has an edge over US
- CT & MR comparable in general
- CT being cheaper and easily available has wider acceptance.

THE END

THANKS FOR YOUR ATTENTION