Imaging of Orbital Masses: Can Imaging Influence Surgical Approach and Treatment Options?

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Learning objectives

- Discuss multimodality imaging features of orbital masses in adults, including mass-like lesions
- Outline key imaging findings in orbital pathology that influence medical and surgical options for patient management and prognosis
Background

Orbital masses may be benign or malignant. The patient's age and location of the lesion helps to narrow the differential diagnosis. Additionally, orbital masses may be classified as primary, secondary or metastatic. Ophthalmologists rely on clinical exam including dilated fundoscopy and clinic-based investigations including optical coherence tomography and B-scan ultrasound.

High resolution imaging is essential to delineate the extent of disease, as this cannot be directly visualized with fundoscopy, such as retrobulbar involvement, perineural invasion, bony erosion and metastases.

Orbital imaging is important in surgical planning to determine the lesion location and the nature of its pathology. Important features to be considered in orbital mass characterisation are contour (smooth versus irregular or poorly-defined), effect on surrounding tissues (e.g. inflammation, bony erosion), intrinsic characteristics of the lesion such as cystic change or calcification, and dynamic changes such as flow characteristic and expansion with Valsalva.

"Traditional" orbital anatomy can be divided into globe, intraconal, extraconal, subperiosteal and the extraocular muscle cone itself.

In addition, it is useful for the orbital surgeon to know whether the lesion is

- Anterior, mid-orbit or apical; and
- From which quadrant or surgical space it arises - inferior, medial/superomedial, superior, lateral/superolateral (note that these overlap)

This approach helps identify the pathology pre-operatively and assists with choice of surgical approach (Fig. 1 on page 5).
Baseline CT imaging is valuable, and a non-invasive ultrasound of the orbit provides significant diagnostic information in posterior chamber pathologies, particularly when the posterior chamber cannot be directly visualised by an ophthalmologist due to an opaque lens or vitreous. MRI is a key imaging modality and valuable in making critical surgical decisions like vision-preserving surgery or orbital exenteration. Imaging is also used in the preparation of custom-made prosthetics and intraoperative navigation.
**Fig. 1:** Surgical approaches to regions of the orbit and examples of conditions encountered(1,4)

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Imaging findings OR Procedure details

Thyroid Orbitopathy

57yo woman presented with intermittent horizontal and vertical diplopia for 1 year on a background of Graves and Hashimoto's disease. She was a non-smoker and had not had radioiodine therapy. She experienced pain behind the globes and with eye movements. She had lid oedema, conjunctival injection and chemosis and elevated intraocular pressures. She had severe, active disease with the maximum Clinical Activity Score of 7/7 (first visit). Her optic nerve function was intact.

MR orbits in Fig. 2 on page 24 demonstrated marked enlargement of the extraocular muscle cone with relative sparing of the superior and inferior oblique muscles (best visualised on coronal images). There was retrobulbar fat stranding from inflammation bilaterally, and crowding of the orbital apex. There was bilateral proptosis, right worse than left, with traction effect on the optic nerves.
Fig. 2: MR Orbit shows severe active thyroid orbitopathy with bilateral proptosis, note enlargement of the muscle cone (C) and retrobulbar fat stranding on T2 FS images (A,D) there is traction effect on optic nerves and apical crowding. Muscles demonstrate marked enhancement on post contrast sequence (B)

References: Gold Coast Health - QLD/AU

Imaging helps to differentiate thyroid orbitopathy from other diseases, as well as detect active disease in more subtle presentations. In thyroid eye disease, some studies have suggested that extraocular muscle enlargement spares the tendon, and that inferior and medical recti are more frequently and severely involved (although it is possible to have symmetrical enlargement of all four recti)\(^5\).

Imaging is essential to identify orbital apex compression and patients at risk of dysthyroid optic neuropathy. Orbital apex compression or corneal damage from exposure indicate urgent medical treatment as per EUGOGO guidelines\(^6\)(e.g. pulsed IV glucocorticoids) usually as a first line. If there is no improvement within 1-2 weeks then orbital decompression is the next step. Preoperative imaging will identify which muscles are
affected and the structure of paranasal sinuses. CT of the bony structures allows planning of which orbital walls will achieve best decompression. This helps in determining the combination of orbital walls to be decompressed to achieve a balanced result\(^1\).

**Orbital Fracture**

CT is the preferred modality of imaging in orbital trauma emergencies. Its advantages include fast acquisition times to provide an overview of the structure (or damage to) the orbit's contents, the ability to detect fractures and evaluate surrounding structures such as the paranasal sinuses and intracranial abnormalities including haemorrhage, just to name a few. It is essential for surgical planning. Ultrasound should not be used in suspected globe rupture.

A 28yo man was punched in the head and developed a right orbital floor fracture with anaesthesia to his right cheek and lip. He had normal vision without diplopia. He had pain on downgaze but was able to move his eyes fully in all directions. There was 1mm hypoglobus on right with a small air fluid level in the right maxillary sinus likely from bleeding. Hertel exophthalmometry showed the right globe was marginally proptosed 1mm compared to the left.

On CT face study (Fig. 3 on page 24), he had a depressed fracture of the right inferior orbital wall with herniation of of orbital fat and the temporal edge of the inferior rectus. There were also comminuted nasal bone fractures and right preseptal soft tissue swelling.
Fig. 3: CT Orbit shows right orbital floor fracture with herniation of fat and inferior rectus(A, B). There was no diplopia or significant eye movement restriction on clinical exam hence urgent surgery was not indicated.

References: Gold Coast Health - QLD/AU

Orbital floor repair done more urgently if upgaze is severely impaired due to muscle entrapment, intractable pain, nausea or bradycardia from oculocardiac syndrome.

Patients are usually evaluated a week post injury to allow swelling to improve before reassessing for surgery. Surgical repair is required if orbital imaging identifies large fractures greater than 50% of the orbital floor size. Other clinical criteria are enophthalmos more than 2mm or significant diplopia within 20 degrees of up and downgaze\textsuperscript{1}.
Squamous cell carcinoma with globe tethering

Orbital exenteration is radical surgery most often done to achieve local control of orbital or periorbital malignancies, or in some cases invasive fungal infection. It has different forms depending on the extent of invasion and pathology being treated. A combined exenteration to remove the orbit, infiltrated bone and involved surrounding structures may be required for disease that extend beyond the orbit, or skull base malignancies that extend into the orbit. If the lesion in question originates from the globe or orbit but spares the eyelids, a subtotal exenteration sparing the eyelids may be performed\(^1,7\). Of periocular skin malignancies, an estimated 3-14% of SCCs have associated perineural invasion compared with 1% of basal cell carcinomas (BCC)\(^8\). A study suggests that the survival of patients may be more reliant on the type of disease (e.g. non-squamous cell lid malignancies) rather than type of exenteration surgery performed or surgical margins achieved\(^9\).

Enhanced MRI is essential for delineating the soft tissues and assessing perineural invasion. CT is useful to evaluate bony infiltration.

A woman in her 50s presented with a skin lesion that rapidly enlarged over a few months. It was an exophytic mass over the left lateral canthal region. Biopsy revealed it was invasive squamous cell carcinoma (SCC).

It was heterogenous on T2 fat saturation, with extension into the left lateral orbit, lacrimal gland and invasion of the left temporalis fascia and muscle (Fig. 4 on page 25). The tumour had spread into the upper and lower eyelids, left nasolabial fold and left malar region extending to the left masseter. T2 fat saturation coronals demonstrated tumour extension 6cm below the left lateral canthal mass. Furthermore, infiltration extended into the left lateral globe and lateral rectus. Perineural spread into mainstem V1, V2 was not seen. The orbital apex, Meckel's cave and the cavernous sinuses had a normal appearance. There were multiple left intraparotid lymph nodes and left level II-III lymph nodes. Thus, left orbital exenteration with temporalis resection, neck dissection and radial arm free flap to close the defect was performed. This was a joint case between Ophthalmology, ENT and Plastics Surgery. She also had post-operative radiotherapy.
Fig. 4: MR orbit illustrates left lateral canthal invasive SCC on T2 FS axial images (B). Enhancing mass (A, C) is seen extending into the left lateral orbit and fixity to the globe and involvement of lateral rectus, temporalis muscle, eyelids and inferior extension to the nasolabial fold. A, B, and C are preoperative images. D and E show post exenteration appearance. Note normal post-operative enhancement on T1 FS coronal images (D)

References: Gold Coast Health - QLD/AU

Perineural Invasion 1

A 65yo woman had a right supraorbital squamous SCC previously excised. Histopathology showed cystic squamous cell carcinoma with involved margins and focal perineural involvement.

MRI imaging (Fig. 5 on page 26) was done to assess for depth of invasion and decide further management. Deep to the scar tissue at the site of resection, there was a subdermal region hyperintense on T2 imaging. There was also signal change within
the right frontal bone, implying bony destruction in the absence of radiation therapy. The right supraorbital foramen was widened to 7mm in comparison to the contralateral side which was 2mm. Post-contrast MR neurogram traced the enhancing tumour along the right frontal bone where it had a broad-based attachment of 4cm in maximal dimension. Perineural spread along right V1 extended into the mid to posterior orbit (a length of approximately 3.5cm) without spread into the trigeminal ganglion, Meckel's cave or cavernous sinuses. She had right orbital exenteration with post-operative radiotherapy.

![Figure 5](image)

**Fig. 5:** MR Neurogram in a 65yo woman that had a right supraorbital cystic SCC excised. Note thickened and enlarged right V1 (A, B), perineural spread noted along right V1 which extends up to mid orbit (C, D). In this case there was no proximal involvement of Meckel's cave

**References:** Gold Coast Health - QLD/AU

**Perineural Invasion 2**
A woman in her 70s presented with paraesthesia in the left V2 distribution. She had a previously excised non-melanotic skin cancer which recurred in the infraorbital region several years later. Histopathology demonstrated squamous cell carcinoma.

Imaging was done to assess for perineural invasion. On post-contrast images (Fig. 6 on page 27), abnormal enhancement was seen in the soft tissue mass along the left inferolateral orbit. There was extensive large nerve perineural spread along left V2 that could be traced from the infraorbital foramen, into the orbit, with proximal extension into the left cavernous sinus into Meckel's cave. There was also perineural spread along left V3 extending to the mental foramen. As this was unresectable, after discussion with the patient, she was referred for palliative radiotherapy.

**Fig. 6**: MR Neurogram demonstrates extensive perineural spread along left V2 and V3 extending from Meckel's cave up to mental foramen from an infraorbital SCC

**References**: Gold Coast Health - QLD/AU

**Venous Varix**
A 37yo man presented due to left-sided headaches. Visual acuity was 6/5 bilaterally, and there was no optic neuropathy or proptosis. On MRI (Fig. 7 on page 28), a lobulated, T2 high signal intensity mass was seen intraconally in the left orbit. It contained multiple fluid levels, and appearance was consistent with a cavernous haemangioma. There was extension into the posterior orbit reaching the apex and left-sided proptosis. It displaced the optic nerve nasally. Optic nerve function was intact. He remained stable clinically and on radiological follow up over 2 years.

**Fig. 7**: Left orbital varix is seen as a lobulated well defined mass on T1W axial (A) and appears hyperintense on T2 FS images (B,D) with marked progressive enhancement (C)

**References**: Gold Coast Health - QLD/AU

Vascular lesions of the orbit may be congenital or acquired. These can have communication with the brain circulation. Congenital vascular malformations of the orbit may be further subdivided into high flow or low flow\(^1\). Low flow lesions include venous malformations, lymphatic malformations and combined veno-lymphatic malformations.
Flow can be assessed a number of ways including Valsalva manoeuvres which can be combined with ultrasound colour Doppler or MRI with contrast for example\textsuperscript{1}.

Patient positioning plays an important role in imaging patients with inducible dynamic proptosis. If dynamic proptosis exists, then positional orbital imaging with and without Valsalva manoeuvre is recommended. Otherwise dynamic proptosis may mask clinical enophthalmos, or the proptosis may be captured as static on imaging\textsuperscript{10}.

Cavernous haemangiomas typically expand slowly and painlessly, and may be incidentally found on imaging. Surgical intervention is indicated when function is impacted through worsening proptosis, optic nerve compression and mass effect on the globe\textsuperscript{1,11}.

**Cavernous Haemangioma**

A 69yo woman experiencing headaches was referred by her GP for a vascular lesion of her right orbit found on imaging.

On MRI, a well-circumscribed lobulated mass was seen in the intraconal portion of the right orbit (Fig. 8 on page 29). It mildly displaced the right optic nerve inferomedially. The lobulated lesion contained small fluid levels, consistent with a cavernous haemangioma. There was no haemorrhage. The lesion has remained stable under surveillance for over 4 years.
Fig. 8: Right cavernous haemangioma, a lobulated mulberry-like mass which is hyperintense on T2 FS images (B,C) and has minimal enhancement in early stage because of slow flow (D)

References: Gold Coast Health - QLD/AU

Haemorrhagic posterior vitreous detachment

A 65yo man experience complete loss of vision in his right eye. He noticed floaters in his right eye for the preceding two days. There was no history of trauma and he was non-diabetic. Ophthalmology could not view his fundus due to a dense vitreous haemorrhage, hence he was referred for orbital ultrasound (Fig. 9 on page 30). The ultrasound showed vitreous haemorrhage with vitreous tethering to the optic nerve head and uncertain retinal status. The patient subsequently had same-day right vitrectomy, cryotherapy to multiple retinal tears and insertion of air bubble. Patients with haemorrhagic posterior vitreous detachment are at high risk of having an associated retinal tear that could allow fluid to track in behind the retina and cause a rhegmatogenous...
retinal detachment and vision loss. Vitreous haemorrhage may also be caused by trauma or tumour. Ultrasound of the orbit may detect a culprit intraocular tumour.

Fig. 9: Ultrasound orbit - Vitreous haemorrhage with posterior vitreous detachment. The vitreous is strongly adherent to the optic nerve head (indicated with arrow). A vitreous haemorrhage will often obscure the fundus view on eye exam

References: Gold Coast Health - QLD/AU

Orbital Lymphoma

A woman in her 50s presented with worsening, painless right upper eyelid swelling for 12 months and no other significant past medical history. Best corrected vision was right 6/9, left 6/5 with good colour vision and no diplopia. The globe was both proptosed and displaced inferiorly. A large, non-fluctuant mass was palpable in her superotemporal orbit causing upgaze limitation.

CT orbit revealed a lobulated soft tissue density mass which was in the superolateral, extraconal space of the right orbit. It was intimately associated with both the lacrimal gland and the anterior two-thirds of the lateral rectus muscle without definable intervening fat planes. There were no surrounding bony changes or intraconal fat stranding. The mass had mild homogenous enhancement on post contrast. The optic nerve and globe defined normally.

MR orbit (Fig. 10 on page 31) demonstrated involvement of the lacrimal gland, superior and lateral recti and ipsilateral upper eyelid. There was restriction on diffusion-
weighted imaging suggesting hypercellularity. The mass was low on ADC, characteristic of lymphoma.

![Imaging Images](image)

**Fig. 10:** Right orbital follicular lymphoma, typical case shows homogeneous well-defined lateral orbital mass which is dark on both T1 (A) and T2 FS images (B). Note restricted diffusion (D) and dark ADC (E) a hallmark of lymphoma. Homogeneous enhancement on post contrast study (F)

**References:** Gold Coast Health - QLD/AU

She had a right anterior orbitotomy and biopsy. Histopathology showed follicular lymphoma.

On PET-CT (**Fig. 11** on page 31), she had stage IV disease with an FDG-avid right orbital soft tissue mass, and lymphadenopathy above and below the diaphragm including right inguinal, right iliac, retrocaval, supraclavicular and submandibular lymphadenopathy. She was referred to Haematology for chemotherapy.
The literature reports that orbital lymphoma is associated with systemic lymphoma 35% of the time\textsuperscript{13}.

**Fig. 11**: CT FDG PET right orbital lymphoma shows homogeneous enhancement and avidity in the lateral orbital mass  

*References*: Gold Coast Health - QLD/AU

**Orbital Cellulitis**

Young girl presented with left eye pain and proptosis that came on within hours. The left eye looked cellulitic externally, very tense and difficult to examine.

CT orbit (Fig. 12 on page 35) showed soft-tissue thickening in the extraconal space between the lamina papyracea and medial rectus, which displaced the medial rectus temporally, associated with ethmoid air space opacification. There was soft tissue stranding anteriorly and left-sided proptosis. This was concerning for an early subperiosteal abscess formation.
Fig. 12: Left orbital cellulitis. A-C Preoperative baseline CT orbit study confirms left ethmoid opacification and a small left medial orbital subperiosteal phlegmon/abscess with pre and post septal involvement. D - Endoscopic sinus surgery and ethmoidectomy was performed to drain the medial orbital wall abscess. A lateral canthotomy was also necessary

References: Gold Coast Health - QLD/AU

The decision was made to operate due to the extent of cellulitis. The patient had a transconjunctival medial orbitotomy, and endoscopic sinus surgery. Pus was found in the supraperiosteal space of the medial wall and ethmoids. A lateral canthotomy was done to relieve pressure on the eye.

MR orbit day 5 post-op (Fig. 13 on page 32) showed improved proptosis and residual inflammation.

The patient's symptoms improved, her optic nerve function was intact.
**Fig. 13**: Post operative MRI confirms drainage of left medial orbital subperiosteal abscess with residual inflammatory change in the orbit and mild proptosis

**References**: Gold Coast Health - QLD/AU

Imaging is necessary to identify post-septal extension of infection, and identify a source (e.g. paranasal sinuses). The endoscopic approach may be used for collections that are nasal and inferonasal. Imaging is essential to plan the surgical approach.

**Meningioma**

A man in his 50s presented with left eye pain and proptosis. He had a background of recurrent left frontal meningioma that required multiple resections (Fig. 14 on page 33).

His visual acuity was R 6/5, L 6/36. There was no relative afferent pupil defect. Left ocular motility was severely restricted in all directions, particularly upgaze and he had severe proptosis of the left eye.
Fig. 14: Recurrent left frontal meningioma (WHO Grade II) with orbital invasion - Note the invasive mass involving the left middle cranial fossa (A,B,C) with invasion into the left orbit (D,E,F) causing significant proptosis and displacement of the globe.

References: Gold Coast Health - QLD/AU

He had an anterior pterional craniotomy to clear the tumour from the anterolateral wall, while preserving orbital structures. This was a joint case with both Neurosurgery and Ophthalmology.

Post op (Fig. 15 on page 34 ), his visual acuity improved to 6/12 in the left eye. Proptosis and motility also improved.
Fig. 15: Left frontal meningioma (post-operation)- marked improvement after tumor debulking with reduced proptosis

References: Gold Coast Health - QLD/AU
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Conclusion

Orbital masses frequently require multidisciplinary management. Multimodality imaging can delineate retrobulbar disease, aggressive mass lesions and identify 'don't touch lesions'. The position of the lesion within the orbit (anterior/mid orbit/apical) as well as which quadrant it is in, its relationship and effect on surrounding structures and intrinsic characteristics assist with preoperative diagnosis and surgical planning.

Imaging has a key role in diagnosis and management of orbital masses as it is pivotal in planning the surgical approach and treatment.
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