Orbital bone lesions: CT and MR imaging findings

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Learning objectives

To illustrate the anatomy of the bony orbit.

To discuss radiological findings of both common and uncommon orbital bone lesions.

Background

CT and MRI are often used in the detection and differential diagnosis of orbital pathology. We show some key facts to help us to detect usual orbital bony diseases and to recognize unusual lesions.

Findings and procedure details

A simple definition of the orbits would be 2 symmetrical structures located on either side craniofacial. Its function is support the different optical structures. However their anatomy is complex, with 7 bones: frontal, sphenoid, zygomatic, palatine, ethmoid, lacrimal and maxilla. Fig. 1 on page 10  Fig. 2 on page 10

A cranial cavity

- Optic foramen: Optic nerve, ophthalmic artery
- Superior orbital fissure: V1(Nerves cleft nasal sphenoid, frontal and lacrimal)
- Inferior orbital fissure: Oculomotor nerve (cranial nerve III), Abducens nerve (cranial nerve VI), Pathetic nerve (cranial nerve IV), ophthalmic vein superior

- Inferior orbital fissure: Sympathetic root of ciliary ganglion

- Anterior ethmoid canal: Anterior ethmoid artery

- Posterior ethmoid canal: Internal nasal nerve

- Posterior ethmoid canal: Posterior ethmoid artery
Orbital pathology is very diverse depending on the affected structure, whether the eyeball, optic pathway or the orbit itself. In turn it could be classified according to the etiologic process as congenital anomalies, inflammatory-infectious disorders, vascular disorders and neoplastic processes. In the following lines we will try to classify and discuss the most important bone lesions.

**CLASSIFICATION OF LESIONS IN THE ORBIT**

1. **Congenital Abnormalities**
   - Dermoid cyst
   - Epydermoid cist
   - Neurofibromatosis

2. **Fibro-osseous lesions**
   - Osteoma
   - Fibrous dysplasia
   - Ossifying fibroma

3. **Malignant bone tumors:**
   - Osteosarcoma
   - Haemangiomata of bone
   - Aneurysmal Bone Cyst
   - Histiocytosis

4. **Benign lesions:**
   - Meningioma
   - Lymphoma
   - Metastasis

5. **Other Malignant Tumors**
   - Myeloma
   - Mucocele
The technique of choice is going to be in most cases the multislice CT Fig. 3 on page 11, which will study the different planes the affected structures, especially those that have calcium. In most situations, the administration of intravenous contrast allows us a better delimitation of the lesions and affected adjacent organs. Although MRI has a leading role in the study of the eyeball and visual pathways, in the bony orbit, it has a complementary role to CT, emphasizing more on the malignant tumor lesions, where medullary involvement is frequent.

CLASSIFICATION OF LESIONS IN THE ORBIT

1. Congenital Abnormalities
   Dermoid cyst
   Epydermoid cyst
   Neurofibromatosis

Dermoid Cyst Epydermoid Cyst

These lesions are typically located near the superoexternal orbital periostium and produce local erosion and remodeling in majority of cases 85%.

The epidermoid cyst is a rounded lesion of desquamated keratinaceous and cholesterol.

CT shows an hypodense lesion, without captation of contrast, well-circumscribed and with smooth edges. It is very rarely the presence of calcifications. Fig. 4 on page 12
At MR, it has low signal intensity on T1 sequences and T2 and high signal in diffusion sequences. A thin capsular enhancement can be seen after IVC. Fig. 5 on page 13

The dermoid cyst is the most frequent congenital lesion in the orbit. Appears generally before 10 years of life.
In CT evidenced an hypodense lesion, not reinforced after administration iodinated contrast. Often exist small calcium images inside, the principal difference with the epydermoid cyst.
In MRI, usually identified fat-fluid levels, that´s a pathognomonic finding. It presents with low signal intensity in sequences T1-weighted and hyperintense on T2 and FLAIR. However, if the fat content is higher, will show high signal intensity on T1 and T2. Fig. 25 on page 28

Neurofibromatosis
Neurofibromatosis type 1 may affect the iris, retina, optic nerve, and the bony or soft tissue of the orbit. Fig. 6 on page

Sphenoid bone dysplasia is a distinctive, although uncommon, manifestation of NF1. This abnormality is a defect in the greater sphenoid wing and enlargement of the middle cranial fossa and was well. Sphenoid dysplasia can be seen isolated or associated with an underlying plexiform neurofibroma (PNF). The neurofibromas are frequently present near facial bone changes and have suggested that the origin of sphenoid bone dysplasia may be multifactorial. There’s an interaction between neurofibromas and sphenoid bone during skull development has been proposed.

2. Fibro-osseous lesions

Osteoma

Fibrous dysplasia

Ossifying fibroma

Osteoma

A true osteoma is a tumor-like mass of bony tissue that is histologically similar to the normal bone. The osteomas arise exclusively at the junction of bones of cartilaginous and membranous origin. This lesion usually arise from the sinus secondarily invading the orbit. The imaging characteristic depend on the relative proportions of the two densities may vary with the size of the lesion. The most common sites of origin are the paranasal sinuses (frontal 80%), skull, and facial bone. CT appearances depende on the degree of the calcification of the bone matrix, so the lesion can be high dense ("ivory-type") or mixed type with less density areas. Fig. 8 on page 14

Fibrous dysplasia

Is a benign tumour-like congenital process, manifested as a defect in osteoblastic differentiation and maturation, with progressive replacement of normal bone with immature woven bone.

Fibrous dysplasia can affect any bone, and can divided into 3 sub types:

- Monoostotic: single bone Fig. 9 on page 16
- Polyostotic: multiple bones Fig. 11 on page 17
- Craniofacial fibrous displasia: skull and facial bones alone
In the craniofacial bones, fibrous dysplasia tends to expand the bone, with thinning of the overlying cortex. The margins are poorly defined, and the dysplasia transgresses suture lines; the proportion of mineralized to fibrous tissue determines the degree of radiolucency. Most cases demonstrate a relatively equal mixture, resulting in a pagetoid appearance. Where the fibrous element is predominant, there may be cystlike areas; a preponderance of mineralized tissue, however, results in a homogeneous, sclerotic, "ground-glass" picture Fig. 10 on page 16.

The primary differential is hyperostotic meningioma, Paget’s disease, Langerhans cell histiocytosis (eosinophilic granuloma). Fibrous dysplasia, in contrast, tends to have a lower intensity on T1- and a heterogeneous signal on T2 images. It can enhance with gadollinium.

**Ossifying fibroma**

Ossifying fibroma occurs most commonly in the mandible (75%) in the first or two decades of life, with a proclivity for females. 20 arise from maxilla.

Ossifying fibroma is a monostotic lesion that expands the bone of origin in a well-circumscribed manner. However, with growth it may spread to involve adjacent bones and may even extend across the midline to involve both orbits. The characteristic CT appearance is of a round or ovoid mass with a well-defined, thin sclerotic margin, and low attenuation fibrous center. Fig. 12 on page 18

**3. Malignant bone tumors:**

**Osteosarcoma**

Osteosarcoma (osteogenic sarcoma) is the most common primary neoplasm of bone. The most common site are long bones. Orbital involvement is rare and usually from a maxillary focus. Osteosarcomas are also seen as a second tumor in patients with familiar retinoblastoma, even in the absence of radiation therapy.

The usual CT appearance is destructive aggressive lesion, with "sunburst" periostical reaction. Fig. 13 on page

**4. Benign lesions:**
Meningioma
Haemangioma of bone
Aneurysmal Bone Cyst
Histiocytosis
Mucocele

Meningioma

Meningiomas are the most frequently occurring benign intracranial neoplasms. Compared with other intracranial neoplasms they grow slowly, and they are potentially amenable to a complete surgical cure.

A very common site is the wing of the sphenoid with direct expansion into orbit. Fig. 15 on page 27

Haemangioma of bone

It has a variable incidence, in the range of 10 - 50 age.

In CT presents a multiple spiculations "on bicycle wheel", associated with a lytic halo. The arteriography is often used to analyse its vasculature and origin.

In the differential diagnosis should consider osteosarcoma, metastasis and meningioma. Fig. 14 on page 20

Aneurysmal Bone Cyst

The orbital aneurysmal bone cyst is an uncommon pathologic finding, usually diagnosed in young patients. This is defined as a benign lesion and cavities formed by hematic giant osteoclast-like cells. It occurs rarely in the skull and orbit; of those with orbital involvement, the frontal bone appears to be the most common location.

The term 'aneurysmal' refers to its characteristic radiographic appearance in "bubble" lytic lesion.

Conventional radiograph findings are not specific and consists with destruction and important expansion of the orbital bones with thin cortical margin.

On CT images the lesion is heterogeneus with characteristic fluid-fluid levels (Fig. 17 on page 21) better demonstrate on MRI that may shows recent hemorrhage in cases with
an acute onset. After gadolinium peripheral and septal components can enhance. Fig. 18 on page 22

**Histiocytosis**

Is an uncommon multisystem disorder of unknown etiology, characterized by accumulation of histiocytes in various tissues. Unifocal eosinophilic granuloma can affect long bones, skull, skull-base and temporal bone. The age of onset is about 5 years. In his facial involvement, can reach orbit affecting upper outer quadrant, causing focal lysis. CT usually shows a solid hypodense lytic mass. It may have sharply defined "punched out" or irregular but sclerotic margins appearance. . Fig. 19 on page 23. On MRI a marked heterogeneous-enhancing mass is common.

Hand-Schuller-Christian disease is a more severe form in children under 1-5 years old. The classic triad include diabetes insipidus, proptosis and skeletal involvement. Fig. 26 on page 29 Fig. 27 on page 30

In the differential diagnosis should include lacrimal gland tumors, rhabdomyosarcoma, metastasis or lymphoma.

**Mucocele** Fig. 20 on page 24 Fig. 21 on page 24

Mucoceles are cysts originating in the paranasal sinuses. They most commonly arise in the frontal or ethmoid sinus associated with chronic inflammation or mechanical obstruction to drainage. As mucus and inflammatory debris accumulate, the cyst slowly enlarges and may displace or erode through bone into the orbit or the intracranial cavity. Mucoceles represent 4% of all orbital mass lesions. Occasionally the mucocele becomes infected to form a mucopyocele filled with purulent material. Most cases involve adults, but young children with cystic fibrosis are prone to develop mucoceles. Patients frequently have a history of chronic sinusitis, often with headache and visual complaints. Abaxial proptosis is common, with displacement of the globe downwards and laterally. A non-tender, fluctuant mass may be palpable at the superomedial orbital rim. Occasionally a frontoethmoidal mucocele can erode through an ethmoidal artery presenting as a subperiosteal hemorrhage.

5. **Other Malignant Tumors**

Myeloma
Lymphoma
Metastasis

Myeloma

Multiple myeloma and more rarely solitary plasmacytoma may involve orbital bone. These tumors affect patients older than 50 years and present with a subacute onset of pain and proptosis. In the case of multiple myeloma, there are usually systemic manifestations such as bone pain, fever, and fatigue, as well as urinary and serum protein abnormalities.

Radiologically, an osteolytic area with a contiguous soft tissue mass is the rule. Fig. 23 on page 26 Fig. 24 on page 27

Lymphoma

This is the most common type of neoplasy of the orbit in adults. The vast majority of orbital lymphomas are of the non-Hodgkin's variety. Most are low-grade proliferations of small monoclonal B-lymphocytes. Lymphomas represent 5-10% of orbital mass lesions and 40-60% of lymphoproliferative disease in the orbit. They tend to occur in the superior and anterior orbit with a predilection for the lacrimal gland. Lymphomas are seen primarily among older patients between 50 and 70 years of age. Both orbits may be involved in some cases. Fig. 28 on page 31 Fig. 29 on page 32 A significant percentage of primary orbital adnexal lymphomas are MALT-type (mucosa-associated lymphoid tissue) arising from extranodal mucosal tissues. Primary lymphoma has also been associated with acquired immune deficiency syndrome (AIDS). Fig. 30 on page 33 About 5% of patients with systemic lymphoma will develop orbital or adnexal metastases. The clinical onset is typically insidious. Painless proptosis is the most frequent symptom, often with downward displacement of the globe.

In the last time, the lymphoma has been related with Chlamydia Psittaci (this infection is usually the result of exposure to infected birds and household pets). This possible infective etiology may explain the probably increase in incidence of orbital lymphomas.

In CT, the lymphomatous mass is homogeneous, iso / slightly hyperdense. Following administration of iodinated contrast has a slight enhancement. In MR, usually identified one mass of intermediate signal intensity on T1. In enhanced sequences for T2 has varying intensity. It has a moderate catchment in postgadolininium's sequence. Differential diagnosis with inflammatory pseudotumor (lymphoid hyperplasia) is complex as to be equal both at T1 as T2 sequences.
Metastases affecting the orbital region are caused by breast neoplasia in women and lung, kidney or prostate cancer in men. In children, they come from neuroblastoma metastases, Ewing’s sarcoma, and Wilms’s tumor.

The imaging appearance of metastasis is variable and depends mainly on the type and location of the primary tumor.

**Images for this section:**

![Bony orbit. Oblique view.](image)

**Fig. 1:** Bony orbit. Oblique review.
**Fig. 2:** 1: frontal sinus 2: maxilar sinus 3: Ethmoidal cells E: Ethmoidal and sphenoidal sinus P: Palantine C: Cornethe T: Septum nasal Shorts arrows: Innominate line Longs arrows: orbital roof Arrow head: orbital floor (*) orbital fissure
**Fig. 3:** CT allows 3D reconstructions of high quality and can be highly suggestive of clinical findings such as proptosis.
**Fig. 4:** A two coronal CT reconstruction in soft tissue and bone window respectively. Exists an expansive intraosseous lesion with irregular margins in the superoexternal quadrant of the right orbit. This lesion comes from the frontomalar fissure and produces ipsilateral proptosis. It’s hypodense and doesn’t have calcium.

**Fig. 5:** Images of MR in T2(axial and coronal), T1(sagital) and T1 postcontrast(axial and sagital). Lesion in quadrant superoexternal of the left orbit. It’s heterogeneous and presents high signal in T1 and T2. In postcontrast sequences exist minimal peripheral enhancement. The lesion causes erosion of the bone. It also produces proptosis and lower deviation of the eye. This lesion is compatible with epidermoid cyst.
Fig. 7: Axial CT in soft tissue window. There is a left sphenoorbital wing dysplasia, that’s causing proptosis and deformity of the orbit and sphenoid wing.
Fig. 8: Axial soft tissue and bone window orbital CT. A homogeneous lesion, well-defined, densely calcified lobular mass. Its origin is the right sphenoethmoid recess. No sphenoid mucocele is present. In coronal radiography classic appearance of an ethmoidal ivory osteoma. Differential diagnosis are fibrous dysplasia or ossifying fibroma and bony exostosis.
**Fig. 9:** Axial and Coronal CT: There is a thickening of frontal left bone with "ground glass" pattern due to fibrous displasia type monoostotic.
Fig. 10: Coronal and axial bone CT reveals diffuse osseous thickening due fibrous dysplasia of the frontal bones and greater wing of the sphenoid bones.
Fig. 11: Coronal radiography and axial bone CT. Extensive facial bone involvement with lion facies due to a leontiasis ossea.
Fig. 12: Axial soft tissue and bone CT reveal a mixed lesion of the ethmoid sinus with an ossific outer margin surrounding a fibrous areas center. On MR, there is an extensive mass inside of the ethmoid sinus which is hyperintense on T1 and heterogeneous on T2 (hypointense on the periphery and isointense on the center).
Fig. 16: Sagital, Coronal and Axial NCCT of the orbit. An ill-defined bone expansive lytic lesion of the orbit floor, with an characteristic heavily calcified osteoid matrix.
Fig. 14: A expansible lesion of orbital roof. Presents multiple spiculations "on bicycle wheel", associated with a lytic halo, suggestive of haemangioma of bone. Sometimes an arteriogram is performed to visualize the vascular tree and rule out other possibilities (the arteriography is showing another haemangioma of the orbital floor with small multiple foci of contrast pooling). The differential diagnosis should consider osteosarcoma and metastasis.
Fig. 17: Axial CT soft tissue. A big expansive lesion of the greater wing of the sphenoid, with a thin cortex and internal trabeculations.(see next figure 18)
Fig. 18: Magnetic resonance imaging of the lesion described in Figure 16. Axial T2 on the left. Coronal T1 with contrast on the right. Sagittal T1 below. Cystic lesion with different stage of blood products with typical fluid-fluid levels. After gadollinium, there´s a enhancement of the peripheral and septal components of the lesion.
Fig. 19: Coronal radiography shows a characteristic well defined lytic lesion of the superoexternal orbital margin. Coronal MRI T1-weighted image with contrast demonstrates a solid mass with heterogeneous enhancement inferiorly displacing the eyeball. Coronal CT shows invasion and destruction of the orbital roof. This appearance can simulate a more aggressive lesion as rhabdomyosarcoma.

Fig. 20: Coronal and sagittal NECT shows a low-density, expansile left frontal mucocele. Note the thinning of the orbital roof and the remodeling of the frontal bone. There is mass effect on the eyeball (inferior dystopia).
Fig. 21: Coronal CT in soft and bone window: A hypodense and homogeneous lesion of superointernal quadrant of the right orbit, which came from anterior ethmoidal cells and expanding of the "lamina orbitalis".
Fig. 22: 2 cases of metastasis. In the left image exists a lytic mass in the greater wing of sphenoid, that it remodels the zygomatic bone, with important calcification associated in "sun rays”. Initial diagnosis was ostesarcoma. Another possibilities was haemangioma of bone. The biopsy demonstrate a thyroid metastasis. In the right another extraconal lesion of the superexternal cuadrant with mass effect and bone destruction. It was a lung metastasis.
**Fig. 23:** On the left axial NCCT: Multiples homogeneous solid masses with bone destruction in both orbits and skull base. On the right Sagittal MRI T1-weighted image: Solitary plasmacytoma on the orbital roof. The lytic mass is very homogeneous in the sagittal T1 sequence, this finding help us to differentiate from metastasis.

**Fig. 24:** Multiple atypical bone lesions in both zygomatic bones, lateral orbital wall and nasal bones. Note the atypical perosteal reaction simulating osteosarcoma or metastasis.
**Fig. 15:** Upper: axial and coronal bone CT: Invasive sclerotic meningioma of the greater wing of the left sphenoid. Diffuse osseous thickening involve both lateral wall of the left orbit and sphenoid sinus. MR shows homogeneous enhancement of the extraosseous soft tissue component of the meningioma. In the T2 sequence is observed an extensive temporal lobe edema.
Fig. 25: There is a hipointense mass in the superoexternal quadrant on the left orbit, that´s expanding the orbital roof without erosion. It´s compatible with dermoid cyst.
Fig. 26: AxialICT and 3D reconstructions. Diffuse bony involvement of the skull with several orbital erosions, multiple lytic skull lesions and marked hypoplasia of the mandible.
**Fig. 27:** Axial CT shows a multiple solid masses affecting orbital and petrous bones with visceral involvement. These findings are almost pathognomical of Hand-Schuller-Christian syndrome.
**Fig. 28:** Axial MRI T1 and T2-weighted images show a bilateral soft-tissue masses affecting lateral wall. There wasn’t bone anomalies in the greater wings of sphenoids on CT, but MRI demonstrate temporal fossa involvement, this permeative pattern is characteristic of lymphoproliferative disorders. In this case multiples chloromas in the acute lymphocytic leukemia.
**Fig. 29:** Axial and coronal CT: A solid homogeneous mass arising from right nasal fossa with orbital invasion. Note the aggressive bone involvement with medial orbital bone destruction similar to primary sinus carcinoma.
Fig. 30: Axial bone CT: Left orbital proptosis secondary to extraconal infiltrative mass with ethmoidal component. Note the infiltrative pattern without significant bone involvement. This pattern is characteristic of aggressive form of lymphoma associated with HIV.
Fig. 32: Coronal CT and Coronal MRI sequences. Multiple lytic lesions affecting orbital bones with lytic expansive pattern. On MRI the masses are hiperintensity in T1 and T2-weighted. This is a children had proved metastasis of neuroblastoma.
**Fig. 34:** Axial CT: An extensive masses affecting the lateral walls of the orbits with subperiosteal reaction. This is a children had proved metastasis of retinoblastoma. The metastasic lesions in childrens always should be include retinoblastoma as a differential diagnosis of neuroblastoma.

**Fig. 33:** Sagital X-RAY and axial CT: Diffuse infiltrative pattern of bone secondary of breast´metastasis.
Fig. 35: Axial and coronal CT: Sclerotical and blastic lesion in the superoexternal cuadrant on the left orbit with mass of soft-tissue in relation with metastasic lesion of prostatic carcinoma.
Conclusion

Multiple pathological conditions can involve the bony orbit. The location, imaging features and clinical history can help narrow the differential diagnosis.

Personal information

References