CONTINUING EDUCATION PROGRAM: FOCUS . . .

A wander through the land of the orbit

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KEYWORDS
CT scan; Orbit; Trauma; Enophthalmos; Myopia

Abstract This article shows the pathological and physiological images of the orbit, which each radiologist will commonly see in his or her everyday CT scan practice. It explains the images, following the course of the patient’s trajectory through imaging as complications develop or in the post-treatment monitoring of some common disorders (orbital trauma, retinal detachment, postoperative appearances).

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This article takes an unconventional approach to illustrate the path, which any radiologist can follow in his or her everyday practice, based on orbital abnormalities. These are seen on specific orbital imaging or following brain or facial sinus investigations and may reflect the presence of disease, a normal variant or post-treatment appearances. Some of these may worry the non-specialist and lead to unnecessary investigations or follow-up and others, which may be a warning sign requiring further assessment can be missed.

The orbit can be investigated in various ways. Ultrasound, CT scanning and MRI can be used depending on the disease. Ultrasound requires specific training and is only performed in specialist centres. It has many indications for examining the globe of the eye: measuring axial length, which is essential to calculate the power of an implant in cataract surgery, studying masses seen on fundoscopy or in the assessment of leucocoria (white pupil), investigating behind a haemorrhage which prevents ophthalmological examination and looking for retinal detachment, a bleeding lesion, locating a foreign body. It allows a detailed examination of the ciliary bodies and anterior chamber in neoplasia and glaucoma.

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http://dx.doi.org/10.1016/j.diii.2012.10.015
Ultrasound combined with Doppler provides important diagnostic evidence for cavernous sinus dural fistulae (reversal or even arterialisation of superior ophthalmic venous flow), in characterising anterior masses (differentiating between lymphoma and inflammation) and for lachrymal gland tumours.

The CT scan is the fundamental investigation for exophthalmos, trauma and acute infection. MRI allows orbital tissue mass, which is sometimes detected on CT scan, and neuro-ophthalmological disease to be examined.

As ultrasound is reserved for specialist use, we will only consider here the orbital abnormalities which are commonly seen, mostly on a CT scan.

Things begin with a minor event, an injury to the face [1]. Swelling of the peri-orbital soft tissue, pain, impact site and occasionally ocular motor problems will guide the investigator towards a possible orbital fracture. A CT scan without injection is the investigation of choice here. Helicoidal acquisition studying the orbits and facial sinuses must always be reconstructed in the axial coronal and sagittal bone and parenchymal, windows parallel to the axis of the orbit and confirms the diagnosis of fracture. This diagnosis varies in difficulty as shown on the following images. It is very easy in the case of a large bone dehiscence (Fig. 1) and less straightforward if the fracture site is small. Intra-orbital air is an excellent pointer towards this (Fig. 2a and b). The site of the fracture(s), particularly with respect to the apex of the orbit in orbital floor damage (hence the merits of sagittal sections) is recorded on the report.

If there is severe, immediate, post-traumatic visual loss, the patient must be investigated for a bone fragment which may have damaged the optic nerve, particularly at the apex (Fig. 3). This finding may lead to an immediate decompression procedure. If the clinician has found diplopia because of impaired elevation in an orbital floor fracture, patients must always be investigated for muscle incarceration, which is an absolute surgical emergency. The incarcerated muscle is very rapidly damaged by ischemic necrosis and the injury and becomes hypo or non-functional, leading to diplopia which can be very difficult to manage. The fracture site may be "closed", when the diagnosis is made from the misleading appearance of absence of fracture by seeing a muscle fragment beneath the orbital floor (Fig. 4).

The diagnosis is made. How the fracture is then treated? [2,3]. The surgeon will treat any compressive haematoma [4], remove bone fragments and occasionally reinsert a muscle. In some cases he/she will close the bone dehiscence, the main complications of which are infection and later, if large and untreated, enophthalmos which often requires surgical treatment [5] to reincorporate the orbital material (predominantly fatty tissue) which protrudes towards the adjacent sinus cavity (maxillary sinus or more rarely the ethmoid sinus) into the orbital cavity and keep it in place.

Several types of material are used to fill the dehiscence [3]. A strip of biocoral, for example, may be sutured to the orbital rim and is responsible for its specific morphology (Fig. 5) and the small holes visible anterior to the new orbital floor.

The prosthetic silicone strip is seen as a reduced signal on MRI and dense on a CT scan.
MRI is more useful than a CT scan to detect complications if the diplopia persists or if oculomotor problems develop after surgery. These may involve migration of the strip, fracture of the biocoral (Fig. 6a), or inflammation around the fracture site (Fig. 6b–c). Treatment is then either surgical (revision) or medical (anti-inflammatories, orbital rehabilitation).

The other complications of orbital fracture or trauma include repeated orbital infections. We always need to think about foreign bodies (FB) and repeat the imaging as the FB is generally more visible distant to the accident because of changes in its structure, for example due to dehydration (plant FB in particular) (Fig. 7) [6].

Foreign bodies can be of all types. These must be thought about before considering MRI which is strongly advised against with metallic FB. A standard film or particularly a CT scan without injection before the MRI is very useful to detect these [7,8]. Orbital changes (pain, exophthalmos) several years after the injury also raise the possibility of an FB-related complication, particularly an inflammatory...
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Figure 6. Fractured, displaced, biocoral strip in the maxillary cavity (a). Another patient: difficulty with elevation after insertion of a silicate strip for a left orbital floor fracture. The strip is in position (b) but surrounded by an inflamed layer (c) which surrounds the inferior rectus muscle and hinders its movements. Medical treatment.

Figure 7. Right orbital trauma three months ago (marital dispute). Two episodes of infection since. Repeat imaging. Fragment of wood contained in the lateral rectus on CT scan (a) and MRI (b).
Figure 8. CT scan (a) and MRI (b) hypotropia (ocular globe positioned too low) and exophthalmos 13 years after right orbital trauma. FB granuloma.

Figure 9. Pre-operative photograph. Ball covered with sclera before repositioning in the orbit and suturing the oculomotor muscles (A). Different types of prosthesis on CT scan. Cup (a), hollow ball (b), full ball (c). Epithesis insertion area (d: arrow) and on MRI (e).
granuloma which may produce a liquid appearance of gradually increasing volume (Fig. 8).

Ocular globe ruptures are exceedingly rare thanks to the blow-out out effect (immediate rupture of the orbital walls in the event of a sudden increase in pressure). On the other hand, a globe injury may be associated with the bone damage. This can be suspected if the CT scan shows air within the globe, a sign which is invariably pathological in the absence of recent surgery. The globe may retain its normal morphology or may be more or less deformed and sunken. The outcome of these injuries varies, one of the major prognostic indicators for vision being the presence or absence of retinal damage.

In cases which deteriorate the globe becomes involuted and gradually retracts. This serious complication causes aesthetic problems, pain and infection and like other destruction of the globe (following surgery or infection, etc.) requires replacement with a prosthetic eye.
The most widely used prostheses are made of biomaterial. At best the procedure involves enucleating the globe preserving the sclera and replacing it with a ball (generally made of hydroxyapatite), recovering it with the sclera and reinserting the oculomotor muscles which have been temporarily detached from the sclera (Fig. 9a). The porous ball is colonised with vessels and becomes integrated into the orbit. Secondarily an epithestis (simple tenon and mortar system) can be positioned on the prosthesis. The assembly then reproduces the appearance of the controlateral eye, preserving conjugate motility of the eyes. It is sometimes not possible to use this technique: usually a removable complete prosthesis (ball and epithestis) is then implanted. These prosthetic eyes are easy to identify on imaging (Fig. 9b–e).

The complications which may occur after prosthesis insertion are infection and inflammation. One of the most common features is an inclusion cyst, an inflammatory reaction which may occur late after implanting the prosthesis.
Figure 17. Normal lens (a). Lens implant to treat cataract (b).

Figure 18. Partial dislocation (a) and complete dislocation (b) of the lens.
Imaging should be requested for patients who have pain and shows a cystic structure lying between the epithesis and the prosthesis (Fig. 10a). Another problem is that prosthesis may migrate towards the floor of the orbit and cause enophthalmos of the prosthesis (Fig. 10b), with troublesome aesthetic consequences. This complication can be treated by increasing the volume of the orbital content, either surgically or by inserting fragments of hydroxyapatite (Fig. 11), or fat (lipostructure) into the orbit or by injecting gelatinous substances containing hyaluronic acid into the orbit through a transpalpebral approach under local anaesthesia. This produces liquid appearances which are very easy to identify on T2 with abolition of the fat signal (Fig. 12), which is less easy to see on a CT scan. Soluble calcium hydroxyapatite can also be injected [9].

Untreated globe injuries may progress and become complicated by infection or inflammation. The commonest of these which must be recognised are physis or “melting” of the globe. The globe volume decreases and scleral calcifications develop (Fig. 13). Physis is not the only cause of orbital calcifications which may be seen physiologically on the reflection pulley of the superior oblique muscle (Fig. 14), and with drusen of the papilla. These involve a yellowish peripapillary collection which may calcify. It causes papillary protrusion which may be taken for papilloedema. In all CT scans requested to assess suspected raised intracranial pressure because of papilloedema, practitioners should remember to look at the globes of the eye to reveal any drusen (Fig. 15) (the best investigation to identify these still being ultrasound as CT scan will not reveal uncalcified drusen) [10]. Calcifications can also be found at the insertion of the lateral rectus muscle (Fig. 16a) and is not be confused with the calcifications associated with insertion an implant in cataract surgery (Fig. 16b).

Figure 19. Coloboma.

Figure 20. Right microglobe.

Figure 21. Right myopia (a) and examples of myopic staphylomas (b).
In order to differentiate between these two causes of calcification, we only need to examine the appearance of the lens. This is normally biconvex in shape, dense on CT scanning with reduced signal on T2 (Fig. 17a). The diagnosis of cataract cannot be made by imaging apart from cataracts associated with calcifications. On the other hand it is very easy to identify an implant as it is far thinner than the lens (Fig. 17b).

Other lens abnormalities include partial or complete post-traumatic dislocations (Fig. 18) and deformities due to coloboma (Fig. 19) [11,12].

In considering artefactual images, we return to the position of the globe described in prosthesis enophthamlos. Some morphological abnormalities of the globe clinically suggest exophthalmos or enophthalmos when the globe is in position. This may be a small ocular globe: congenital, post-traumatic or after treatment for retinoblastoma (Fig. 20). Conversely, the globe may be too large: whilst this abnormality is described in NF1 (buphthalmos), the commonest cause is myopia which is an association of increased axial length combined with an ovoidal deformity of the posterior pole (staphyloma) (Fig. 21). In highly progressive myopia the globe axis of the globe gradually deviates inwards (esotropia) and produces a clinically artefactual appearance of damage to VI (Fig. 22).

One of the most serious complications of severe myopia is retinal detachment caused by a minimal tear allowing a liquid vitreous fluid to pass into the space between the two layers of the retina [13]. The distended, poorly supplied retina is more fragile in myopic patients than in the general population. Laser treatment is needed to identify the tear and photocoagulate the neighbouring tissues.

When overt detachment is present vision is lost and therefore requires treatment to reapply the detached retina onto the wall of the globe.

Guided ocular cerclage or indentation can be used to reapply the retina using external compression of the ocular globe without opening it. Miragel sponges used for this purpose: use a piece of Miragel inside the eye and use an applicator to push it through the sclera and press it against the retina. When applied properly under anesthesia the retina will stick and prevent further detachment. It is possible to do this several times in as many as 20 applications if necessary. The best result occurs when the detachment is immature and is therefore still mobile. When the detached retina is very tight and fixed it may be impossible to reattach it using percutaneous means alone, but open surgical techniques are usually sufficient to achieve this goal.

compression tend to displace and cause forced tumours (palpable protrusion) (Fig. 23) [14–16].
These are being replaced with other materials such as silicone rails.

Surgery can also be used instead of this technique. The usual treatment is carried out in several stages: vitrectomy and injection of Per Fluoro Carbone Liquid (PFCL), identification of the tear (laser, cryotherapy), application of the retina and in order to promote healing, aspiration of the PFCL and injection of gas [17] (Figs. 24–25). The gas used may be air which remains visible for three days, sulphur hexafluorure (SF6) which is visible for 1 to 5 days, or octafluoropropane (C3F8) which can be detected for a month. Silicone can also be used (Fig. 26). After intraocular injection this may remain for life but is removed 1 to 3 years after the procedure because of the potential risks of toxicity. It is transparent for the patient and it does not interfere with vision. On imaging it is dense on CT scanning and displays an increased signal on T1 and T2. Occasional cases of intracerebral silicone migration have been published in the literature [18]. The complications of these treatment are recurrence of the RD which often requires revision surgery (and the superposition of several techniques by imaging figure), complication of treatment such as migration of silicone beneath the detachment (Fig. 27), or as we have seen, migration of a sponge used for indentation.

Silicone left in place can cause problems if the patient subsequently needs cataract surgery. This produces incorrect calculations of axial eye length based on the echogenicity of the natural media present in the globe (very little silicone is required) or the calculation may be impossible to perform. CT scanning is then used in these patients to obtain this measurement. The calculation method has to be understood in order that the values can be used to calculate the power of the implant. This measurement is taken from a section passing through the lens, papilla and apex of the orbit. These three structures are aligned theoretically by taking the acquisition (a series of sections examining the orbit without injection) while the patient is looking straight in front of him/her. The distance is then calculated between

Figure 25. Gas and indentation (silicone rail).

Figure 26. Silicone on the right, gas on the left.

Figure 27. Silicone migrated beneath the RD (black arrow). Sponge (white arrow).

Figure 28. Measurement of axial length. Dense intraocular silicone.
the central point of the surface of the cornea and the macula, represented by the point on the posterior wall located 3 mm outside of the centre of the papilla (Fig. 28).

Apart from materials inserted during ophthalmological treatments, some others, notably makeup, produce artefactual images on MRI. Any radiologist who performs orbital MRI must have makeup remover and cotton wool pads to hand and should not be remotely reticent about asking patients to use them before the investigation in order that image quality is not compromised by feminine beauty.

We finish this promenade through the orbit with a few examples of dental artefacts or those due to mascara (Figs. 28 and 29).

Conclusion

A conclusion? Interpreting unusual orbital appearances means not forgetting that the ophthalmologist may have inserted material, that patients use makeup and that they have materials in their teeth or even in their orbit. Dialogue with a patient and knowledge of the patient's history are the best means of understanding the appearances, untangling physiology from disease, and avoiding unnecessary distress and superfluous further investigations.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


