Ocular anatomy and physiology relevant to anaesthesia

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Abstract

The orbit contains many delicate and vulnerable structures, but with a solid knowledge of the anatomy one can minimize the chance of complications and better understand how regional blocks work. This article discusses anatomy of the orbit and eye, and includes rudimentary ocular physiology.

Keywords Aqueous humor; iris; pupil; retina; Tenon's fascia; vitreous body

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Learning objectives

After reading this article, you should be able to:

- describe the fundamental anatomy of the orbit and understand its relevance to eye blocks
- draw a labelled schematic diagram of the eyeball and anterior segment
- understand basic optics, common visual defects and optic neural pathways

Orbital blowout fractures

Blunt trauma to the eyeball may result in a blowout fracture. This occurs most commonly on the relatively thin orbital floor. Inferior rectus sometimes becomes incarcerated with inferior blowout fractures and this may cause diplopia or (especially in children) fainting due to activation of the oculocardiac reflex.

The bony orbit

Shape and structure: the best way to understand the three-dimensional shape of the orbit is to look at a skull. It can be thought of as a socket in the skull that would accommodate a short ice-cream cone, with the tip innermost. How each orbit relates to the other can be seen by placing two ice-cream cones side by side. The volume of each orbit is around 30 ml, but varies between individuals. Medial to each orbital cavity lies the nasal cavity. The angle described by the medial and lateral walls from the posteriorly situated optic foramen is roughly 45 degrees, but can vary between about 40 and 60 degrees (Figure 1).

The orbit has a roof, a floor, medial and lateral walls. It is made up of frontal, zygomatic, sphenoid, ethmoid, lacrimal and maxillary bones (Figure 2). Superiorly, the orbital margin has a notch (which can be palpated at about 2.0–2.5 cm from the medial wall) that carries the supraorbital nerve. On the lateral orbital margin the notch formed by the suture line of the frontal and zygomatic bones can be palpated.

Periosteum and foramina: there are a number of holes in the orbit, the biggest of which is at the front where the eyeball sits. At the back of the orbit the holes (fissures and foramina) allow the passage of nerves and blood vessels between the cranial fossae and the orbital cavity (Figure 3).

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The inside of the orbital cavity is lined with a loosely attached fascial layer of periosteum. This layer is continuous anteriorly with the external periosteum of the skull and within the cranium with the dura mater.

Orbital contents

Muscles and their nerve supply: there are four rectus muscles, two oblique muscles and a levator palpebrae superioris muscle situated within each orbit.

The recti (superior, inferior, medial and lateral) arise from a ring-shaped thickening of periosteum surrounding the optic canal. They pass forward, getting wider as they do so, to attach onto the surface of the globe anterior to the coronal equator of the eyeball (Figure 1). These four muscles form the 'muscle cone' (or simply 'the cone'). The distinction between intraconal and extraconal is important to anaesthetists when performing regional blocks (Table 1).

A retrobulbar block aims to deliver local anaesthetic within the muscle cone and close to the nerves, and works instantly. A peribulbar block delivers local anaesthetic outside the cone and relies on spread of anaesthetic to within the cone. Hence, the block takes several minutes to develop fully and requires a greater injectate volume. A sub-Tenon's block achieves anaesthesia within the sub-Tenon's space (described below), but local anaesthetic often spills into the cone.

The superior, inferior and medial recti, and the inferior oblique muscle are all supplied by the oculomotor nerve (III cranial nerve). The lateral rectus is supplied by the abducent nerve (VI cranial nerve). These nerves all reside within the cone.

The inferior oblique muscle arises close to the nasolacrimal canal on the floor of the orbit. It passes backwards and laterally beneath the inferior rectus and rises to insert below the belly of the lateral rectus in a broad tendon behind the coronal equator of the eyeball.

The superior oblique muscle arises from the body of the sphenoid, close to the origin of the recti. As it passes forward it

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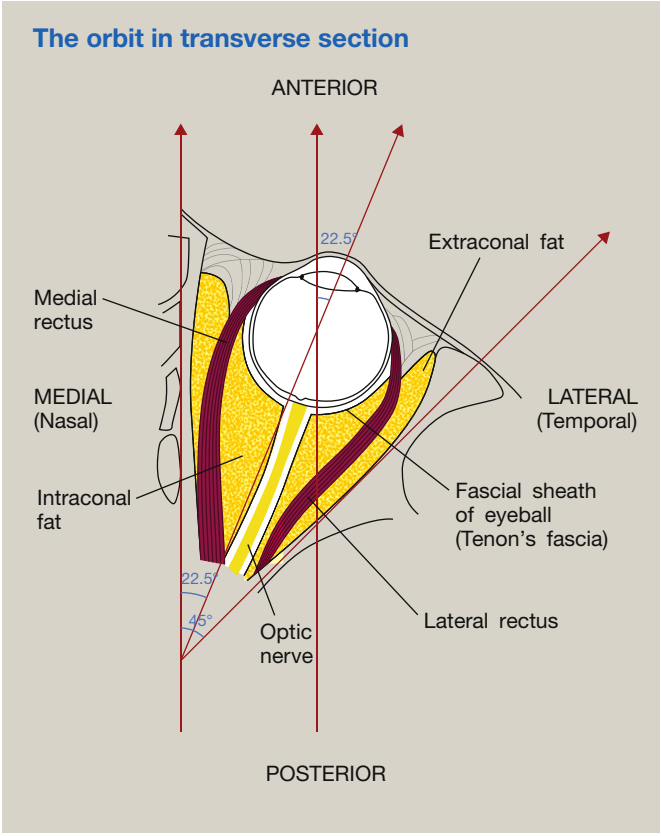

Figure 1

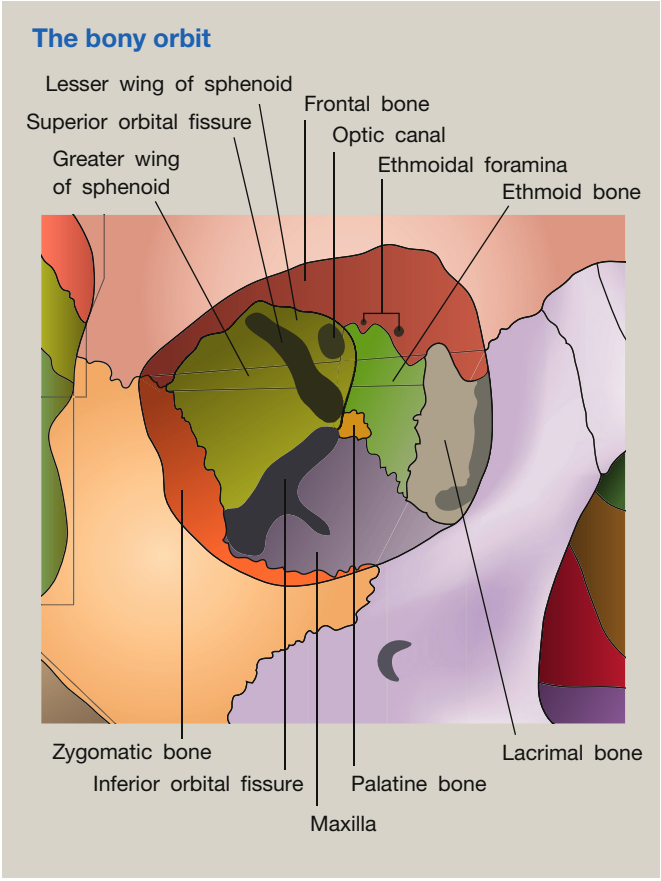

Figure 2

becomes rounded and tendinous and loops through the fibrocartilaginous trochlea, which is medial to the supraorbital notch just inside the orbital rim. It then passes backwards and laterally and inserts onto the sclera beneath the superior rectus muscle and behind the coronal equator of the eyeball. The superior oblique muscle is supplied by the trochlear nerve (IV cranial nerve) which is situated outside the muscle cone.

Commonly with retrobulbar and sub-Tenon's blocks the trochlear nerve is spared, leading to some remaining rotational movement of the eyeball.

Ocular movement: the long axis of the muscle cone (and orbit) is approximately 22.5 degrees (45/2) from the sagittal plane. It is useful to remember this when thinking about the action of the muscles (Figure 1).

Medial and lateral rectus muscles move the eye to the left and right. The superior and inferior recti do not move the eye 'straight' up and down, owing to the 22.5 degree angle of the long axis of the cone. The action of looking straight up and down is a complex interaction of the recti and other extraocular muscles.

Tenon's fascia and the conjunctiva: Tenon's fascia is a layer of connective tissue that envelops the eyeball, and is pierced by the muscles and nerves that penetrate and attach to it. It is not present over the cornea but arises from the sclera at the corneoscleral junction (limbus). From its origin, Tenon's fascia is adherent to the overlying conjunctiva but as it passes backwards and continues closely overlying the sclera, the two layers separate. The conjunctiva also arises at the limbus but is reflected onto the inner surface of the eyelids and does not continue posteriorly within the orbit. Between Tenon's fascia and the sclera is a potential space, called the sub-Tenon's space.

The eyeball

The eyeball is made up of three main layers: a fibrous exterior layer, a vascular/muscular layer and a neural layer (Figure 4). The outermost fibrous layer comprises the sclera (or white of the eye) and the clear cornea. This layer is made up of collagen and elastin. The composition of the sclera and cornea is identical; however, one layer is clear and the other opaque. This is because of the structural organization of the collagen fibres: in the cornea, collagen fibres are arranged in highly regular laminae; in the sclera, the fibres appear interwoven and extend in all directions. If the fibrous layer of the eye is broken, there is said to be a penetrating eye injury (Table 2). There is a high risk of subsequent visual loss through expulsion of the contents of the eye, retinal detachment or infection.

Inside the fibrous layer is the vascular/muscular layer. Posteriorly is the choroid (Figure 4). Richly vascular, the choroid supplies oxygen and nutrients to outer layers of the retina and the structures of the anterior chamber. It is loosely adherent to the sclera. Anteriorly the choroid becomes continuous with the ciliary body, which, in turn, is continuous with the iris.

The ciliary body is made up of ciliary muscle, which controls the shape of the lens (accommodation, discussed below), and the ciliary processes, which produce aqueous humor (Figure 5).

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