Anatomy of the Orbit and Periorbital Region

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Osteology of the Orbit

Dimensions

The orbits (Fig. 1.1) are the bony cavities that contain the globes, extraocular muscles, nerves, fat, and blood vessels. Each bony orbit is pear shaped, tapering posteriorly to the apex and the optic canal. Its volume in the average individual is approximately 25 cm^3, varying from a mean of 17.05 cm^3 to 29.30 cm^3 [1]. Within the orbit, the eye contributes about 7.2 cm^3 based on the average diameter of about 24 mm. A myopic eye is bigger than the standard eye and a hyperopic eye is smaller. The anterior entrance of the orbit forms a rough rectangle measuring approximately 43 mm (36–47 mm) wide by 34 mm (26–42 mm) high [2]. The orbit attains its widest dimensions at about 15 mm behind the bony rim. The human orbit is completely closed behind by the sphenoid bone, except for the superior and inferior orbital fissures. The two lateral orbital walls subtend a 90° angle between them. The four walls of each orbit converge posteriorly toward the orbital apex (Fig. 1.2) where the optic canal and superior orbital fissure pass into the middle cranial fossa. The orbital floor extends to approximately two-thirds the depth of the orbit; the other three sides extend to the apex. The orbital segment of the optic nerve is slightly curved and moves with the eye. This curve allows the eye to move forward with proptosis without damaging the nerve.

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https://doi.org/10.1007/978-3-030-46866-8_1

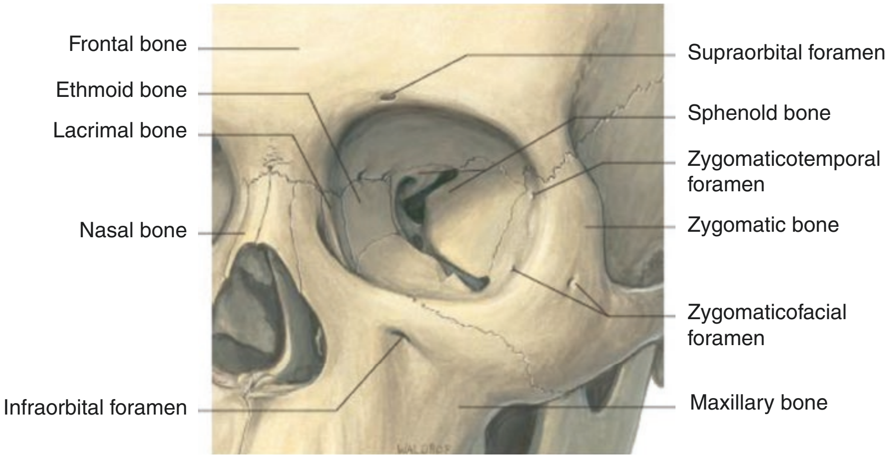

Fig. 1.1 Orbital bones, frontal view

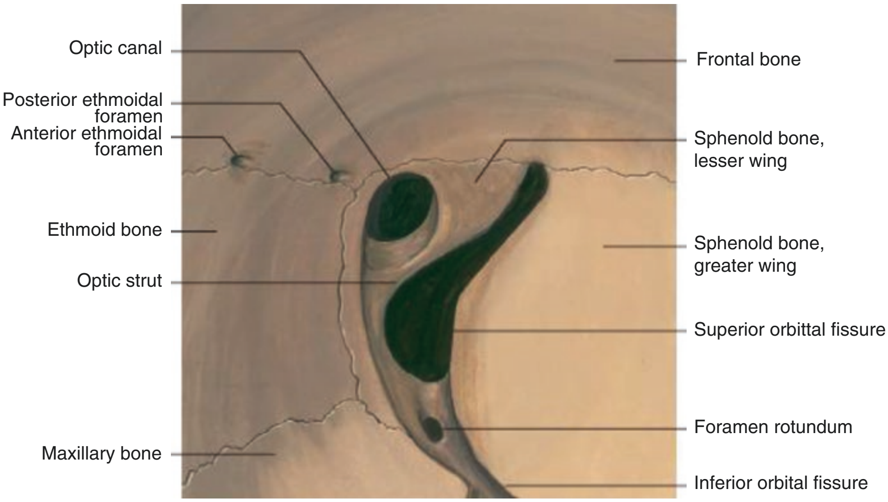

Fig. 1.2 Orbital bones, apex

Orbital Rim

The orbital rim is rounded and thickened, and serves to protect the eye from facial impacts. The superior rim is the most prominent due to expansion of the underlying frontal sinus. It is more protuberant in adult males. The medial third of the superior orbital rim is interrupted by a notch or foramen for passage of the supraorbital neurovascular bundle. One or both sides will have an open notch in 75% of all orbits. In 50% of individuals at least one side may be closed to form a foramen [3]. The notch is situated about 25–30 mm from the facial midline [4]. The location of this notch is an important guide in avoiding injury to the supraorbital nerve during brow and forehead surgery. The orbital rim is flatter and less prominent between the supraorbital notch and the medial canthal ligament. The supratrochlear and infratrochlear nerves, and the dorsal nasal artery emerge at this site. At the superomedial corner of the orbit lies the cartilaginous trochlea of the superior oblique tendon. Glabellar and forehead anesthesia can happen during surgical access to the medial wall through a frontoethmoidal as incision may interrupt these neural structures. If necessary for orbital access, the trochlea can be disinserted by elevating the periosteum. Medially, the orbital rim extends downward to the posterior lacrimal crest and ends at the inferior entrance to the nasolacrimal canal. The anterior lacrimal crest begins just above the medial canthal ligament, and passes downward into the inferior orbital rim. The medial rim is, therefore, discontinuous at the lacrimal sac fossa. Between the anterior and posterior lacrimal crests is the lacrimal sac fossa formed at the junction of the maxillary and lacrimal bones. The fossa measures about 16 mm in vertical length, 4–9 mm in width, and 2 mm in depth [5]. Just in front of and parallel to the anterior lacrimal crest is a vertical groove in the frontal process of the maxillary bone for a nutrient branch of the infraorbital artery. During dacryocystorhinostomy surgery this groove may be mistaken for the medial edge of anterior lacrimal crest. Brisk bleeding may occur from rupture of this vessel, but it is easily controlled. The inferior orbital rim is formed by the maxillary bone medially and the zygomatic bone laterally. The infraorbital foramen, conducting the infraorbital artery and nerve, is located 4–10 mm below the central portion of the inferior rim. During surgery on the orbital floor, care must be taken not to elevate periosteum anterior to the central rim for more than about 4 mm, since this may injure these neurovascular structures. The orbital rim is thickest laterally. Here it is formed by the frontal process of the zygomatic bone and the zygomatic process of the frontal bone. These two elements meet at the frontozygomatic suture line near the supratemporal corner of the orbit. This suture line is an important landmark for removing the lateral rim during orbital surgery, because the anterior cranial fossa lies 5–15 mm above this horizontal level. This is a weak suture and is frequently the site of separation following facial trauma. About 10 mm below the fronto-zygomatic suture line, about 4–5 mm inside the rim is a small mound, the lateral orbital tubercle of Whitnall. It serves for insertion of the posterior crus of the lateral canthal ligament, Lockwood's inferior suspensory ligament, the lateral horn of the levator aponeurosis, the lateral check ligament and pulley system of the lateral rectus muscle, and the deep layer of the orbital septum. Proper realignment of these structures after lateral orbital surgery or repair of rim fractures is essential for normal cosmetic and functional reconstruction. The entire orbital rim is buttressed by adjacent bones and is frequently involved in complex facial fractures. The surgeon must be alert to the normal anatomic and functional relationships between the orbital bones and the nasal cavity, paranasal sinuses, cranial vault, and the temporomandibular joint.

Topographic Relationships

The orbital septum arises from the orbital rims anteriorly. The paranasal sinuses lie adjacent to the floor, medial wall, and anterior portion of the orbital roof. There are four orbital walls composed of seven bones: ethmoid, frontal, lacrimal, maxillary, palatine, sphenoid, and zygomatic.

Roof of the Orbit

The orbital roof (Fig. 1.3) is triangular in shape. The orbital plate of the frontal bone forms most of the roof, with a small contribution by the lesser wing of the sphenoid bone posteriorly. It measures about 46 mm (range 35–59 mm) from the supraorbital foramen to the optic canal [6]. A concavity for the lacrimal gland lies in the anterior superolateral corner. A small depression in the superomedial corner, about 3–5 mm behind the rim, houses the fibrocartilaginous trochlea for the superior oblique tendon. This structure, along with its associated pulley system, can easily be separated from the adjacent bone along with periorbita if needed during surgery. Its precise repositioning is essential to avoid postoperative motility disturbance. The frontal sinus is located within the frontal bone in the anteromedial portion of the roof. The optic canal is located in the roof at the apex and communicates between the middle cranial fossa and the orbit. It is bounded by the body of the sphenoid bone medially, the lesser wing of the sphenoid superiorly, and the optic strut laterally and inferiorly. The strut arises from the body of the sphenoid and is directed slightly anteriorly, upward, and laterally at an angle of about 36° to the sagittal plane [7].

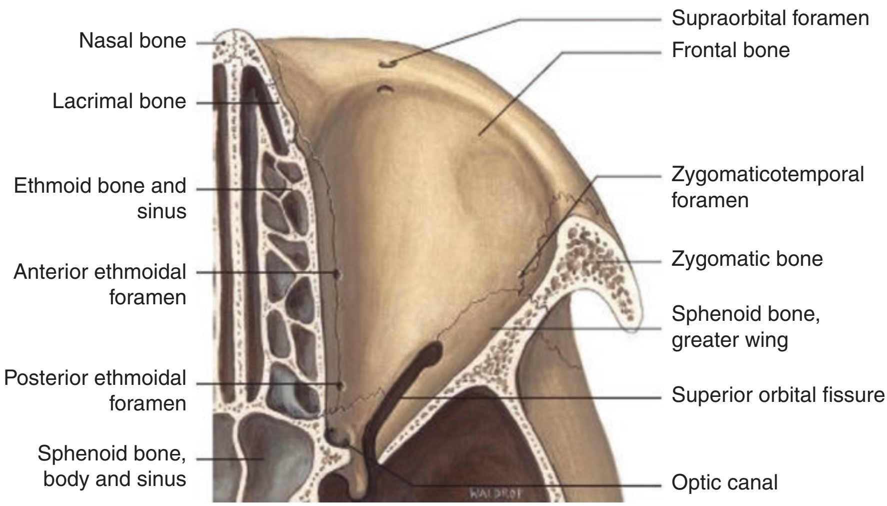

Fig. 1.3 Orbital bones, superior wall, intraorbital view

Lateral Wall of the Orbit

The lateral wall of the orbit (Fig. 1.4) is the thickest, and is composed of the zygomatic bone anteriorly and the greater wing of the sphenoid posteriorly. It is separated from the floor by the inferior orbital fissure, and from the roof, in part, by the superior orbital fissure. The lateral walls of the two orbits form an angle of approximately 90° with each other, and lie at 45° to the mid-sagittal plane. The lengths of the lateral and medial walls, from orbital rim to apex, are about the equal. Because of the oblique orientation of the lateral wall, the lateral rim lies about 10-mm posterior to the medial rim [8]. The length of the lateral wall from the lateral rim at the frontozygomatic suture to the optic canal is about 47 mm (range 39–55 mm). The thinnest part of the lateral wall is at the zygomatico-sphenoid suture, about 8–10 mm behind the orbital rim. Approximately 10 mm behind the zygomatic-sphenoid suture, the sphenoid bone thickens where it divides to form the anterior corner of the middle cranial fossa. In about 40% of individuals there are one or more openings within the fronto-sphenoid suture line, about 30 mm from the orbital rim. This is the cranio-orbital foramen (foramen meningo-orbitale) that transmits an anastomotic branch between the middle meningeal artery and the ophthalmic arterial system. This vessel is easily ruptured during lateral orbital surgery resulting in brisk bleeding. Compression for several minutes is usually sufficient to control it. At the junction of the lateral wall and roof is the superior orbital fissure (SOF). Several small foramina perforate the lateral orbital wall just behind the rim laterally and inferiorly near the anterior end of the inferior fissure. These transmit branches of the lacrimal artery and zygomatic nerve out of the orbit as the zygomaticotemporal and zygomaticofacial neurovascular bundles.

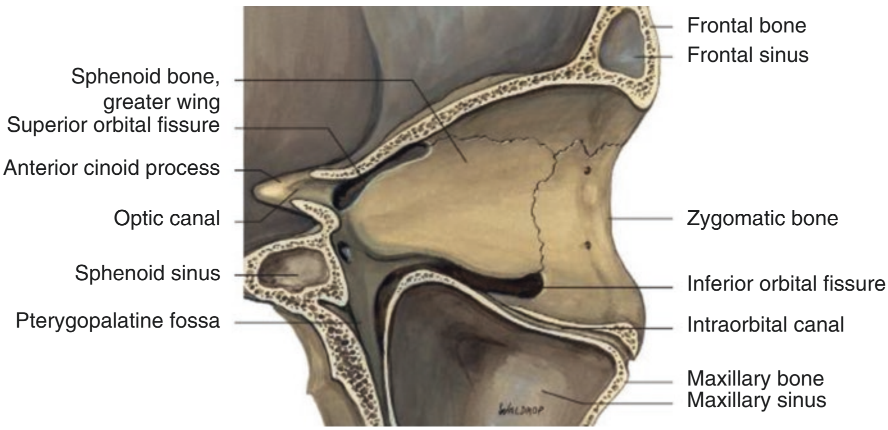

Fig. 1.4 Orbital bones, lateral wall, intraorbital view

Medial Wall of the Orbit

The medial walls (Fig. 1.5) of the orbits are approximately parallel to each other and to the mid-sagittal plane. The separation between the two orbits is approximately 24 mm from the medial wall of one to the medial wall of the other. The medial wall measures an average of 42 mm (range 32–53 mm) in horizontal length from the anterior lacrimal crest to the optic canal [6]. It is composed of the ethmoid, lacrimal, maxillary, and sphenoid bones. Anteriorly, the thick frontal process of the maxillary bone lies at the inferior medial rim. It contains the anterior lacrimal crest and forms the anterior portion of the lacrimal sac fossa. The lacrimal bone is a small, thin, and fragile plate situated just posterior to the maxillary process. It forms the posterior portion of the lacrimal sac fossa. Running vertically along its midpoint is the posterior lacrimal crest. The suture between the maxillary and the lacrimal bones generally lies along the mid-vertical line within the lacrimal sac fossa. Behind the posterior lacrimal crest is the lamina papyracea, which forms most of the lateral wall of the ethmoid labyrinth. It contributes 4–6 cm^2 to the orbital wall surface. It is fragile, measuring only 0.2–0.4 mm in thickness. However, it is made more rigid by the honeycombed bony laminae surrounding the ethmoid air cells, which usually number 3–8. Infections of the ethmoid sinuses may extend through the lamina papyracea to cause orbital cellulitis and proptosis [9]. Superiorly the ethmoid bone joins the orbital roof at the fronto-ethmoid suture line. The anterior and posterior ethmoidal foramina usually lie within the fronto-ethmoid suture line. Posterior to the ethmoid bone is the body of the sphenoid bone that forms the short posterior portion of the medial wall. The sphenoid body lies between the two orbital apices and contains the sphenoid sinus. The optic canal is situated in the superomedial portion of the orbital apex, enclosed by the body of the sphenoid medially, the lesser wing of the sphenoid superiorly, and the optic strut inferolaterally. The lacrimal sac fossa is a depression in the anterior inferomedial orbit [10]. It is bounded by the anterior and posterior lacrimal crests and measures about 4–9 mm in width and 16 mm in height.

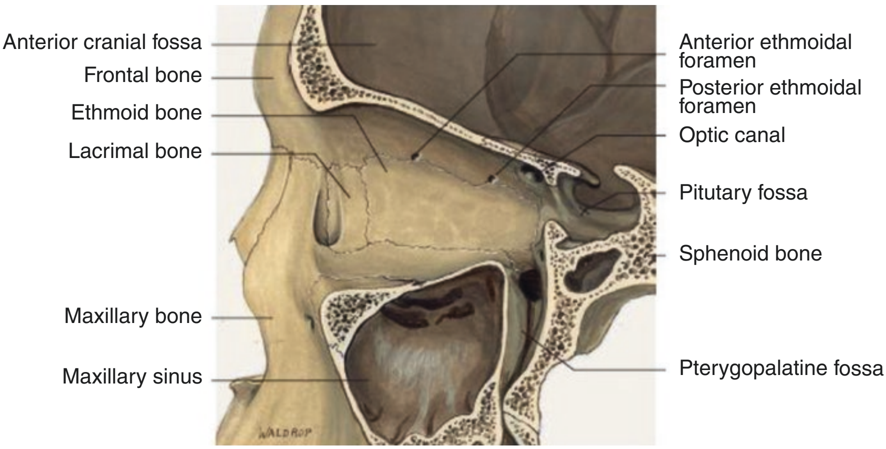

Fig. 1.5 Orbital bones, medial wall, intraorbital view

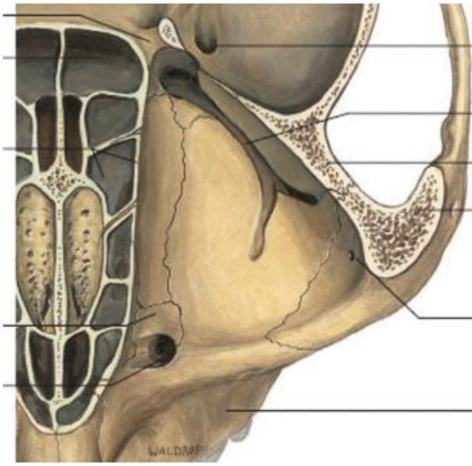

Fig. 1.6 Orbital bones, inferior wall, intraorbital view

The fossa is formed by the frontal process of the maxillary bone anteriorly and by the lacrimal bone posteriorly.

Floor of the Orbit

The orbital floor (Fig. 1.6) is a very thin plate composed of three bones (maxillary, zygomatic, and palatine). Its surface forms a triangular segment extending from the maxillary ethmoid buttress on the medial side, horizontally to the inferior orbital fissure on the lateral side, and from the inferior orbital rim back to the posterior wall of the maxillary sinus. The floor contributes 3–5 cm^2 to the overall orbital wall surface. It is strengthened by the infraorbital canal which runs anteroposteriorly through it near its midline or sometimes closer to its lateral border. The orbital floor shows the greatest degree of deformation with static loading of any of the orbital walls [11]. This explains the high rate of floor fractures associated with blunt trauma. A 3-mm downward displacement of the entire floor results in an increase of about 1.5 cm^3 (5%) to the orbital volume, and about 1.0–1.5 mm of enophthalmos. The major contribution to the floor is from the orbital plate of the maxillary bone, which also forms the roof of the maxillary sinus. Anterolaterally, the zygomatic bone contributes to the orbital rim and a small portion of the floor just in front of the anterior border of the inferior orbital fissure. The palatine bone lies at the extreme posterior end of the floor, near the orbital apex. The floor is bounded medially by the maxilla-ethmoid suture line, and anterolaterally by the zygomaticomaxillary suture. From the inferior orbital rim, the floor dips downward, where it reaches its lowest point. This is about 1.5–2.0 mm below the rim in children and young adults, but reaches 3.0 mm in older adults [12]. From here the floor slopes upward to the orbital apex. In the mid and posterior orbit, the floor ends at the inferior orbital fissure, and the posterior extent of the maxillary sinus. It is important to keep in mind that the orbital floor does not extend all the way to the apex, but rather ends at the pterygopalatine fossa. The floor is, therefore, the shortest of the orbital walls, extending only about 35–40 mm from the inferior rim to the posterior wall of the maxillary sinus. In the posterior portion of the orbital floor lies the infraorbital sulcus. This fissure runs approximately in the center of the floor from posterior to anterior, and carries the maxillary division of the trigeminal nerve and the associated infraorbital branch of the maxillary artery from the pterygopalatine fossa.

Apertures

The orbital walls are perforated by several important apertures.

Ethmoidal Foramina

The anterior and posterior ethmoidal foramina usually lie within the fronto-ethmoid suture line. These openings transmit branches from the ophthalmic artery and nasociliary nerve passing out of the orbit. The positions of these foramina are clinically important since they relate to important cranial structures such as the cribriform plate, and to the optic foramen. They are key landmarks during surgery along the medial orbital wall. Injury to the ethmoidal arteries can cause excessive orbital bleeding during surgery. Subperiosteal hematoma following trauma frequently results from rupture of one of these arteries, and management requires access to the medial wall with ligation or cautery of the bleeding vessel. These foramina provide a potential route of entry into the orbit for infections and neoplasms from the sinuses [13].

Superior Orbital Fissure

The superior orbital fissure (SOF) lies at the junction of the lateral wall and roof, between the greater and lesser wings of the sphenoid bone near the orbital apex. It is oriented from inferomedial at the apex to superotemporal distally. The anterior most edge of the SOF lies 37 mm (range 34–41 mm) from the lateral orbital rim. In size and shape this fissure shows considerable individual variability [14]. However, its comma-like shape is usually wider inferiorly, but then narrows more superiorly. The fissure measures about 20–25 mm in overall length. The narrow lesser wing of the sphenoid bone separates the medial edge of the superior orbital fissure from the lateral margin of the optic canal. The spinal recti lateralis is a small bony projection situated on the lateral edge of the fissure near its middle portion, at the junction of its wide and narrow portions. This projection serves as the origin for part of the lateral rectus muscle. It is formed primarily by a small groove in the sphenoid wing which lodges the superior ophthalmic vein as it passes through the fissure [7]. The superior orbital fissure transmits most of the vascular and neural structures from the middle cranial fossa into the orbit, with the major exception of the optic nerve and ophthalmic artery, which pass through the optic canal. The central portion of the fissure is anatomically divided by the annulus of Zinn, which serves as the tendinous origin for the rectus muscles. The central opening defined by the annulus, called the oculomotor foramen, transmits structures into the intraconal orbital space.

Most of these structures subserve ocular function and motility. These include the superior and inferior divisions of the oculomotor nerve, the abducens nerve, and the nasociliary nerve. Other structures passing through the superior orbital fissure but outside the annulus are mainly associated with the extraconal orbital space, or are toward extra orbital sites. These include the trochlear nerve, the frontal and lacrimal branches of the trigeminal nerve, and the superior ophthalmic vein above the annulus, and the inferior ophthalmic vein beneath the annulus. In 8–40% of individuals, a linear vertical groove is present lying along the greater wing of the sphenoid bone, between the superior and inferior orbital fissures. Most of the venous drainage from the orbit passes through this fissure by way of the superior ophthalmic vein to the cavernous sinus.

Inferior Orbital Fissure

The inferior orbital fissure is bounded by the sphenoid, maxillary, and palatine bones and lies between the lateral orbital wall and the orbital floor. It transmits the second (maxillary) division of CN V, including the zygomatic nerve, and branches of the inferior ophthalmic vein leading to the pterygoid plexus. The infraorbital nerve, which is a branch of the maxillary nerve, leaves the skull through the foramen rotundum and travels through the pterygopalatine fossa to enter the orbit at the infraorbital groove. This fossa extends laterally to become the infratemporal fossa. The nerve travels anteriorly in the floor of the orbit through the infraorbital canal, emerging on the face of the maxilla 1-cm below the inferior orbital rim. The infraorbital nerve carries sensation from the lower eyelid, cheek, upper lip, upper teeth, and gingiva. Numbness in this distribution often accompanies blowout fractures of the orbital floor and typically improves with time.

Zygomaticofacial and Zygomaticotemporal Canals

The zygomaticofacial canal and zygomaticotemporal canal transmit vessels and branches of the zygomatic nerve through the lateral orbital wall to the cheek and the temporal fossa, respectively.

Nasolacrimal Canal

The nasolacrimal canal is a bony tube extending from the lacrimal sac fossa to the inferior nasal meatus beneath the inferior turbinate in the nose, it runs inferolaterally and slightly posterior in the medial wall of the maxillary bone and it contains the membranous nasolacrimal duct. The canal measures about 5 mm in diameter and is bordered by three bones, the maxilla, the lacrimal, and the inferior turbinate bones. It measures about 12–15 mm in length.

Optic Canal

The optic canal is located in the roof at the apex and communicates between the middle cranial fossa and the orbit. It is bounded by the body of the sphenoid bone medially, the lesser wing of the sphenoid superiorly, and the optic strut laterally and inferiorly. The strut arises from the body of the sphenoid and is directed slightly anteriorly, upward, and laterally at an angle of about 36° to the sagittal plane [7].

The optic canal assumes a vertically oval shape at its orbital end, where it measures about 5–6 mm in horizontal diameter, and 6–8 mm vertically. In its central portion the canal is round in cross-section, and on the cranial end it is oval in the horizontal plane [15]. In about 4% of normal individuals the ophthalmic artery will notch the canal floor, forming a "keyhole" deformity [16]. The canal is 8–12 mm in length and is directed posteromedially at about 35° to the mid-sagittal plane, and upward about 38° to the horizontal. On the cranial side the optic canal measures 5–7 mm horizontally and 4–6 mm vertically. The tendinous annulus of Zinn encloses the orbital opening of the optic canal so that the optic nerve and ophthalmic artery pass into the intraconal space via the oculomotor foramen. Optic canal enlargement accompanies the expansion of the nerve, as seen with optic nerve gliomas. Blunt trauma may cause an optic canal fracture, hematoma at the orbital apex, or shearing of the nerve at the foramen, resulting in optic nerve damage.

Soft Tissues

Periorbita

The periorbita, also called the orbital periosteum or orbital fascia, covers the bones of the orbit. This dense connective tissue membrane serves as an attachment site for muscles, tendons, and ligaments and is a support structure for the blood supply to the orbital bones. The periorbita is attached only loosely to the underlying bone except at the orbital margins, the sutures, and the edges of fissures and foramina. At the orbital margins it is continuous with the periosteal covering of the bones of the face; at the edges of the superior orbital fissure, the optic canal, and the ethmoid canals, the periorbita is continuous with the periosteal layer of the dura mater. At the anterior portion of the optic canal, the periorbita splits such that a portion becomes continuous with the dura of the optic nerve and another portion reflects forward to take part in the formation of the common tendinous ring. At the inferior orbital fissure the periorbita is continuous with the periosteum of the skull. At the lacrimal crests a sheet of periorbita covers the lacrimal sac, and the periorbital is continuous with the tissue lining the nasolacrimal canal. Another portion of the periorbita covers the lacrimal gland.

Intraorbital Optic Nerve

Neural fibers of the optic nerve arise from primitive neuroblasts that become the ganglion cells in the retina, and grow toward the brain. Because the retina differentiates from the wall of the forebrain, the optic nerve is not a true peripheral nerve, but is an evaginated fiber tract of the diencephalon. Nevertheless, these fibers are customarily classified as a special somatic sensory cranial nerve. The fibers are myelinated, but lack a neurolemmal sheath. In the adult, the optic nerve is about 50 mm in length from the optic disc to the chiasm. Each nerve contains proximately 0.7–1.4

million axons, with a mean axon diameter of 0.85 mm. The highest axonal density is in the temporal inferior segment of the nerve, corresponding with the location of the major portion of the papillomacular bundle [17].

Within the orbit the nerve is invested with pia, arachnoid, and dural sheaths. The subarachnoid space is continuous from the middle cranial fossa, along the nerve, and into the posterior sclera. This space is partially interrupted at the orbital apex superiorly and medially where the pia and arachnoid are loosely adherent to the dura and annulus of Zinn. Clinically, this relationship may result in optic nerve compression and papilledema from increased intracranial cerebrospinal fluid pressure. The dura of the optic nerve becomes fused to periosteum within the optic canal superomedially. There are four anatomically important portions of the optic nerve; intraocular, Intraorbital (Fig. 1.7), intracanalicular, and intracranial. The center of the nerve leaves the globe 4 mm medial to, and 0.1 mm below the level of the macula [18]. The intraocular portion of the nerve lies within the limits of the posterior sclera, and measures approximately 1 mm in length. Here, it lies within the lamina cribrosa. The latter is a sieve-like connective tissue region of the posterior sclera through which pass the retinal ganglion cell axons and central retinal vessels. It preserves a pressure gradient between the intraocular and the extraocular spaces. The lamina cribrosa contains approximately 220–240 pores, each averaging 0.004 mm^2 in diameter [19]. As the retinal ganglion cell axons approach the lamina cribrosa they become crowded, forming the elevated papilla at the beginning of the intrascleral portion of the optic nerve. This is visible on funduscopic examination as the intraorbital portion of the optic nerve is approximately 30-mm long. The nerve is longer than the orbit, making an S-shaped curve to allow for movement with the eye.

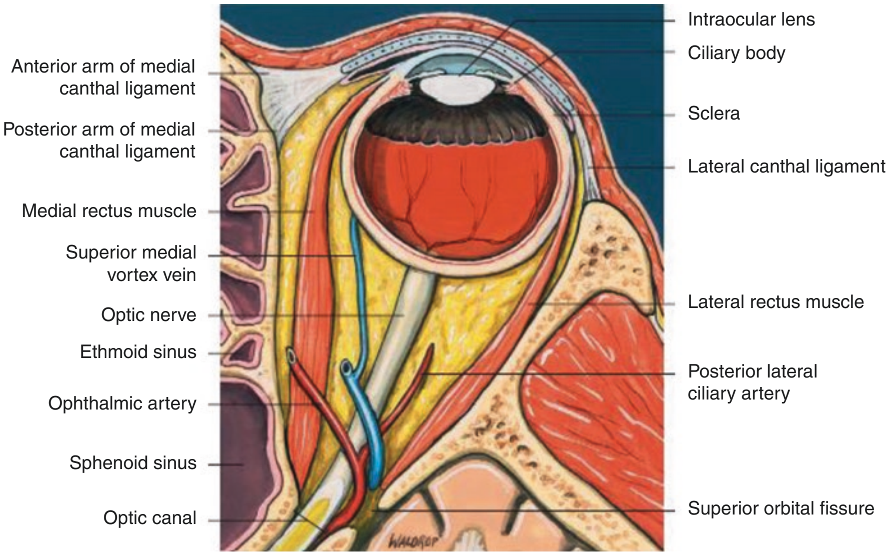

Fig. 1.7 Axial section through the mid-orbit at the level of the optic nerve

Extraocular Muscles and Orbital Fat

The extraocular muscles (Fig. 1.8) are responsible for the movement of the eye and for synchronous movements of the eyelids. All of the extraocular muscles, except the inferior oblique muscle, originate in the orbital apex and travel anteriorly to insert onto the eye or eyelid. The four rectus muscles (superior. medial, lateral, and inferior recti) originate in the annulus of Zinn. The levator muscle arises above the annulus on the lesser wing of the sphenoid. The superior oblique muscle originates slightly medial to the levator muscle and travels anteriorly through the trochlea on the superomedial orbital rim, where it turns posterolaterally toward the eye. The inferior oblique muscle originates in the anterior orbital floor lateral to the lacrimal sac and travels posterolaterally within the lower eyelid retractors to insert inferolateral to the macula. In the anterior portion of the orbit, the rectus muscles are connected by a membrane known as the intermuscular septum. When viewed in the coronal plane, this membrane forms a ring that divides the orbital fat into the intraconal fat (central surgical space) and the extraconal fat (peripheral surgical space). These anatomical designations on a magnetic resonance (MR) or computed tomographic (CT) scan are helpful for describing the location of a mass. A knowledge of these spaces helps direct the surgical dissection to the mass. The orbit is further divided by many fine fibrous septa that unite and support the globe, optic nerve, and extraocular muscles. Accidental or surgical orbital trauma can disrupt this supporting system and contribute to globe displacement and restriction. In many cases of diplopia after fracture, restriction of eye movement is caused by the entrapment of the orbital connective tissue rather than by the muscles themselves. The motor innervation of the extraocular muscles arises from cranial nerves Ill, IV, and VI. The superior rectus and levator muscles are supplied by the superior division of the 3rd

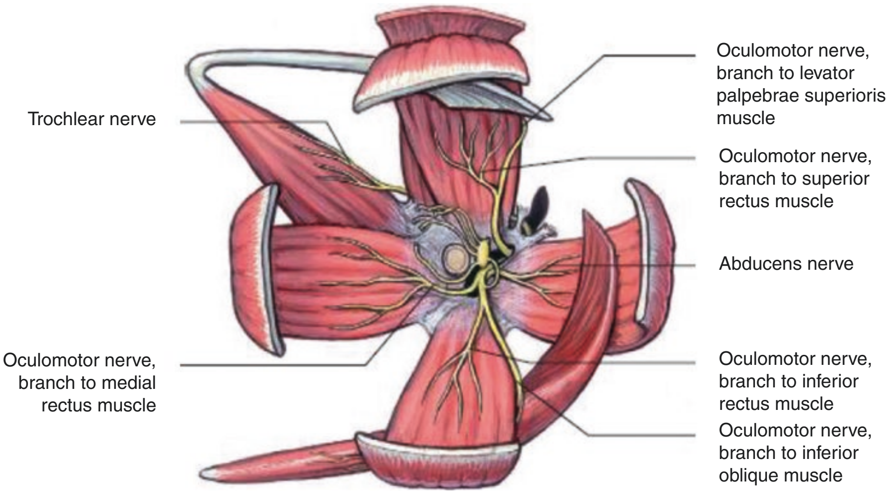

Fig. 1.8 Motor nerves, frontal view with extraocular muscles

nerve (oculomotor nerve). The inferior rectus, medial rectus, and inferior oblique muscles are supplied by the inferior division of the 3rd nerve. The lateral rectus is supplied by VI (abducent nerve). The cranial nerves to the rectus muscles enter the orbit posteriorly through the superior orbital fissure and travel through the intraconal fat to enter the muscles' intraconal surface at the junction of the posterior third and anterior two-thirds. Crania l nerve IV (trochlear nerve) crosses over the levator muscle and innervates the superior oblique on the superior surface at its posterior third. The nerve to the inferior oblique muscle travels anteriorly on the lateral aspect of the inferior rectus to enter the muscle on its posterior surface.

Annulus of Zinn

The annulus of Zinn (Fig. 1.9) is the fibrous ring formed by the common origin of the four rectus muscles. The ring encircles the optic foramen and the central portion of the superior orbital fissure. The superior origin of the lateral rectus muscle separates the superior orbital fissure into two compartments. The portion of the orbital apex enclosed by the annulus is called the oculomotor foramen. This opening transmits CN III (upper and lower divisions), CN VI, and the nasociliary branch of the ophthalmic division of CN V (trigeminal). The superior and lateral aspect of the superior orbital fissure external to the muscle cone transmits CN IV, as well as the frontal and lacrimal branches of the ophthalmic division of CN V. Cranial nerve IV is the only nerve that innervates an extraocular muscle and does not pass directly into the muscle cone when entering the orbit. Cranial nerves III and VI pass directly into the muscle cone through the oculomotor foramen. The superior ophthalmic vein passes through the superior and lateral portion of the superior orbital fissure outside the oculomotor foramen.

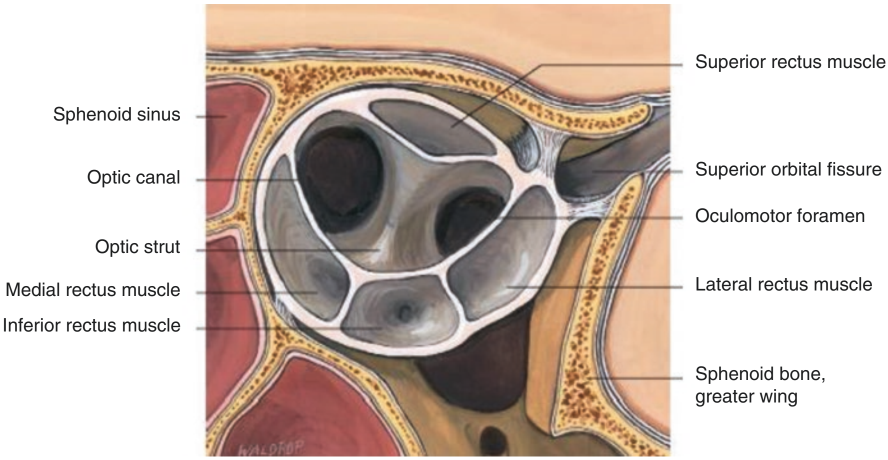

Fig. 1.9 Annulus of Zinn, anterior surface with origins of the extraocular muscles

Vasculature of the Orbit

The ophthalmic artery (Fig. 1.10) arises from the internal carotid artery just medial to the anterior clinoid process. It passes through the optic canal below the nerve and within its dural sheath and enters the orbit lateral to the nerve. It gives origin to the lacrimal artery lateral to the optic nerve and to the supraorbital artery as it crosses the optic nerve to reach the medial wall. It terminates by dividing into the dorsal nasal and supratrochlear arteries. It may give origin to the two medial palpebral arteries before it terminates. The lacrimal artery passes forward on the upper border of the lateral rectus muscle accompanied by the lacrimal nerve. It supplies the lacrimal gland, then pierces the septum, and divides into two lateral palpebral arteries in the lids. The supraorbital artery joins the supraorbital nerve in the roof of the orbit and accompanies it through the supraorbital notch. It passes upwards deep to the brow fat pad and then pierces the frontalis muscle. Its branches contribute to the supply of the forehead, scalp, and upper lid. The dorsal nasal artery pierces the septum above the medial canthal tendon to supply the skin of the root of the nose and the lacrimal sac. It gives origin to the medial palpebral arteries if these have not arisen separately from the ophthalmic artery. The two medial palpebral arteries enter the lids above and below the medial canthal tendon. The superior ophthalmic vein provides the main venous drainage of the orbit. This vein originates in the superonasal quadrant of the orbit and extends posteriorly through the superior orbital fissure into the cavernous sinus.

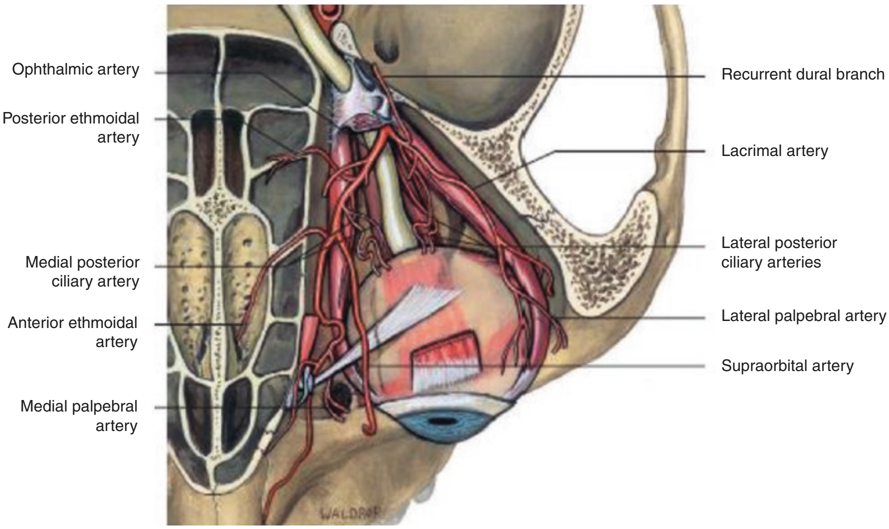

Fig. 1.10 Arterial supply to the ocular adnexa and globe

Nerves

Sensory innervation to the periorbital area is provided by the ophthalmic and maxillary divisions of CN V. The ophthalmic division (Fig. 1.11) of CN V travels anteriorly from the ganglion in the lateral wall of the cavernous sinus, where it divides into three main branches: frontal, lacrimal, and nasociliary. The frontal and lacrimal nerves enter the orbit through the superior orbital fissure above the annulus of Zinn and travel anteriorly in the extraconal fat to innervate the medial canthus (supratrochlear branch), upper eyelid (lacrimal and supratrochlear branches), and forehead (supraorbital branch). The nasociliary branch enters the orbit through the superior orbital fissure within the annulus of Zinn, entering the intraconal space and traveling anteriorly to innervate the eye via the ciliary branches. The short ciliary nerves penetrate the sclera after passing through the ciliary ganglion without synapse. The long ciliary nerves pass by the ciliary ganglion and enter the sclera, where they extend anteriorly to supply the iris, cornea, and ciliary muscle. The muscles of facial expression, including the orbicularis oculi, procerus, corrugator superciliaris, and frontalis muscles, receive their motor supply by way of branches of CN VII (the facial nerve) that penetrate the undersurface of each muscle. Parasympathetic Innervations enters the eye as the short posterior ciliary nerves after synapsing within the ciliary ganglion, parasympathetic innervation to the lacrimal gland originates in the lacrimal nucleus of the pons and eventually joins the lacrimal nerve to enter the lacrimal gland. The nerve fibers follow the arterial supply to the pupil, eyelids, and orbit and travel anteriorly in association with the long ciliary nerves. Interruption of this innervation results in the familiar signs of Horner syndrome:

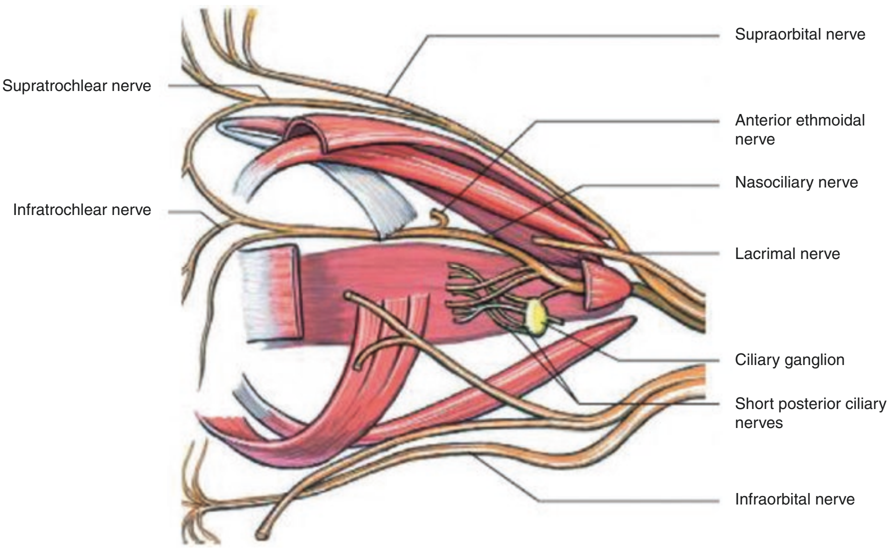

Fig. 1.11 Sensory nerves, lateral view with extraocular muscles

ptosis of the upper eyelid, elevation of the lower eyelid, miosis, anhidrosis, and vasodilation.

The motor innervation (Fig. 1.8) of the extraocular muscles arises from cranial nerves (N) lll. IV. and VI. The superior rectus and levator muscles are supplied by the superior division of nerve lll (oculomotor nerve). The inferior rectus, medial rectus, and inferior oblique muscles are supplied by the inferior division of N lll. The lateral rectus is supplied by N VI (Abducent nerve). The cranial nerves to the rectus muscles enter the orbit posteriorly through the superior orbital fissure and travel through the intraconal fat to enter the muscles' intraconal surface at the junction of the posterior third and anterior two-thirds. Crania l nerve IV (trochlear nerve) crosses over the levator muscle and innervates the superior oblique on the superior surface at its posterior third. The nerve to the inferior oblique muscle travels anteriorly on the lateral aspect of the inferior rectus to enter the muscle on its posterior surface.

Lacrimal Apparatus

The lacrimal gland (Fig. 1.12) is wrapped around the posterior border of the lateral horn of the levator aponeurosis. The superior, orbital part of the gland lies in the lacrimal gland fossa. Anteriorly, it is in contact with the septum and posteriorly, with orbital fat. Inferiorly, the lateral rectus muscle lies laterally and the levator lies medially. Its secretory ducts pass down into the inferior, palpebral part of the gland which is one-third the size of the orbital part. The anterior border of the palpebral

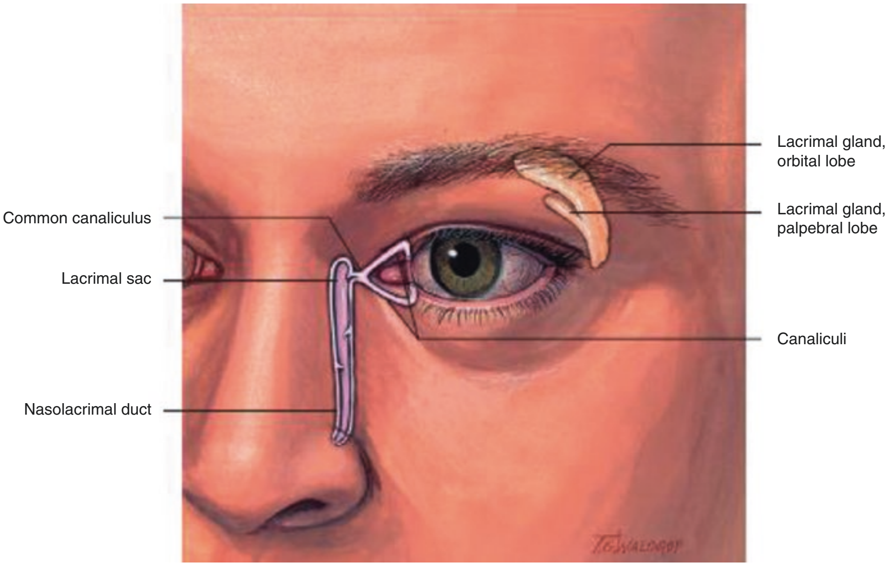

Fig. 1.12 The lacrimal secretory and drainage systems

part can be seen laterally in the upper fornix and its secretory ducts emerge there. With age, the orbital lobe of the lacrimal gland may prolapse inferiorly out of the fossa and present as a mass in the lateral upper eyelid.

The lacrimal canaliculi, surrounded by the orbicularis muscle immediately medial to the puncta, pass medially and posteriorly between the limbs of the medial canthal tendon to pierce the fascia overlying the lacrimal sac. They usually join to form a common canaliculus before entering the sac. The sac lies in the lacrimal sac fossa which is bounded anteriorly and posteriorly by the anterior and posterior lacrimal crests. Periosteum at the posterior lacrimal crest splits to enclose the sac and reunites at the anterior lacrimal crest. The lateral leaf is the stronger and it is reinforced further by the posterior limb of the medial canthal tendon. The anterior part of the tendon crosses the upper part of the sac and the septum covers the lower part. The inferior oblique muscle arises just behind and lateral to the orifice of the nasolacrimal canal. Anterior to the medial canthal tendon, about 8-mm medial to the medial canthus, is the angular vein.

Periorbital Structures

Nose and Paranasal Sinuses

The bones forming the medial, inferior, and superior orbital walls are close to the nasal cavity and are pneumatized by the paranasal sinuses, which arise from and drain into the nasal cavity. The sinuses may serve to decrease the weight of the skull, or they may function as resonators for the voice. The sinuses may also support the nasal passages in trapping irritants and in warming and humidifying the air. Pathophysiologic processes in these spaces that secondarily affect the orbit include sinonasal carcinomas, inverted papillomas, zygomycoses, Wegener granulomatosis, and mucoceles as well as sinusitis, which may cause orbital cellulitis or abscess. The nasal cavity is divided into two nasal fossae by the nasal septum. The lateral wall of the nose has three bony projections: the superior, middle, and inferior conchae (turbinates). The conchae are covered by nasal mucosa, and they overhang the corresponding meatuses. The frontal sinus and the anterior and middle ethmoid air cells drain into the middle meatus. The nasolacrimal duct opens into the inferior meatus. The nasal cavity is lined by a pseudostratified, ciliated columnar epithelium with copious goblet cells. The mucous membrane overlying the lateral alar cartilage is hair bearing and therefore less suitable for use as a composite graft in eyelid reconstruction than the mucoperichondrium over the nasal septum, which is devoid of hair. The frontal sinuses develop from evaginations of the frontal recess and cannot be seen radiographically until the sixth year of life. Pneumatization of the frontal bone continues through childhood and is complete by early adulthood. The sinuses can develop asymmetrically and vary greatly in size and shape. The frontal sinuses are almost always separated by the midline intersinus septum. Each sinus drains through separate frontonasal ducts and empties into the anterior portion of the middle meatus. The ethmoid air cells are thin-walled cavities that lie between the medial orbital wall and the lateral wall of the nose. They are present at birth and expand as the child grows. Ethmoid air cells can extend into the frontal, lacrimal, and maxillary bones and may extend into the orbital roof (supraorbital ethmoids). The numerous small, thin-walled air cells of the ethmoid sinus are divided into anterior, middle, and posterior. The anterior and middle air cells drain into the middle meatus; the posterior air cells, into the superior meatus. Orbital cellulitis develops most frequently from the spread of ethmoidal sinusitis through the lamina papyracea into the orbit. The sphenoid sinus evaginates from the posterior nasal roof to pneumatize the sphenoid bone. It is rudimentary at birth and reaches full size after puberty. This sinus is divided into two cavities by a bony septum. Occasionally, pneumatization extends into the pterygoid and occipital bones. The sinus drains into the sphenoethmoidal recess of each nasal fossa. The optic canal is located immediately superolateral to the sinus wall. Visual loss and visual field abnormalities can be direct sequelae of pathologic processes involving the sphenoid sinus. The maxillary sinuses are the largest of the paranasal sinuses. Together, the roofs of each maxillary sinus form the floor of the orbits. The maxillary sinuses extend posteriorly in the maxillary bone to the inferior orbital fissure. The infraorbital nerve and artery travel along the roof of the sinus from posterior to anterior. The bony nasolacrimal canal lies within the medial wall. The sinus drains into the middle meatus of the nose by way of the maxillary ostium. Orbital blowout fractures commonly disrupt the floor of the orbit medial to the infraorbital canal. The infraorbital nerve is often damaged, causing hypoesthesia of the cheek.

Eyelid Anatomy

The eyelids form a soft-tissue protection to the globe and the anterior entrance to the orbit. The orbital septum separates the bony orbit from the eyelid and represents the anterior most orbital structure. All structures anterior to the orbital septum are technically in the eyelid. The eyelid provides important components of the precorneal tear film, and help its distribution on the surface of the eye. Together with the lacrimal drainage apparatus, the eyelids collect and propel tears to the medial canthus, where they pass to the nose. The face and scalp are arranged in concentric tissue layers, which more or less, follow a single basic pattern [20]. This pattern consists of five basic layers: skin, subcutaneous tissue, superficial musculoaponeurotic layer, loose areolar tissue, and the deep fascia and periosteum.

The Adult Eyebrow

The eyebrows mobility is part of the system of facial expression, they are situated over the bony superior orbital rims, at the junction between the upper eyelid and the forehead. They extend from just above the trochlear fossa medially, nearly to the frontozygomatic suture line laterally. The flattened and generally hairless glabellar region separates the two eyebrows in the midline. The eyebrow consists of thickened skin overlying the supraorbital torus, from which it is separated by a prominent fat pad. The eyebrow is capable of a wide range of movement, averaging 1-cm downward and 2.5-cm or greater upward [21]. Excursion is more extensive in the medial portion of the brow. These complex movements are provided by the interdigitation of five striated muscles that insert partially along the brow namely; the frontalis, procerus, depressor supercilii, corrugator supercilii, and orbicularis oculi muscles. All are innervated by the seventh cranial, or facial, nerve. The frontalis muscle fibers are oriented vertically on the forehead and form the anterior belly of the occipitofrontalis musculofascial complex that forms the epicranius. The latter includes two flat muscle masses, the frontalis muscle anteriorly and the occipitalis muscle posteriorly.

Frontalis Muscle

The frontalis muscle is usually considered to be part of the epicranius, or occipitofrontalis muscle that includes the occipitalis muscle posteriorly and the frontalis muscle anteriorly, with the galea aponeurotica joining the two portions. The frontalis muscle has no bony attachments. Rather, its proximal fibers originate from the galea aponeurotica at about the level of the coronal suture line and extend toward the supraorbital rim. On the lateral side, frontalis muscle fibers extend slightly more than on the medial border [22]. The muscle belly is surrounded by layers of the galea, anteriorly by the thin superficial layer and posteriorly by the thicker deep layer. The frontalis muscle is paired with a distinct midline separation. Its medial fibers blend with those of the procerus muscle. More laterally, under the brow, frontalis fibers interdigitate with the corrugator and orbital portion of the orbicularis muscles. The frontalis muscle does not extend laterally beyond the junction of the middle and lateral thirds of the brow, so that the lateral brow lacks an elevator. Because of this the lateral brow is under the depressor influence of the lateral orbicularis muscle [23]. The frontalis muscle is separated from the periosteum by a fat pocket in the deep fascia of the forehead. This has been referred to as the sub-brow fat pad or the superior retro-orbicularis oculi fat pocket (ROOF) [24]. The frontalis muscle elevates the brow, and together with the occipitalis belly, tightens the scalp and provides mobility of the skin along the temples. Brow elevation may be transmitted through other tissues to serve as an accessory retractor of the eyelid. This function is the basis for the frontalis suspension operations used to repair poor-function upper eyelid ptosis. Because of this contribution to eyelid elevation it is essential to mechanically immobilize the frontalis muscle during preoperative evaluation of levator muscle function in ptosis patients.

Eye Lid

The interpalpebral fissure measures 10–11 mm in vertical height, but with advancing years the upper eyelid assumes a more ptotic position, resulting in a fissure of only about 8–10 mm. The horizontal length of the fissure is 30–31 mm, and is achieved by the age of about 15 years [25]. The upper and lower eyelids meet medially and laterally at an angle of approximately 60°. Laterally, this canthal angle rests against the globe, but medially it is displaced away from the globe about 5–6 mm. Within this medial space, called the lacus lacrimalis, are a fleshy mound, the caruncle, and a fold of conjunctiva lateral to it called the plica semilunaris. The interpalpebral fissure is usually inclined slightly upward at its lateral end, such that the lateral canthal angle is about 2–3 mm higher than the medial canthal angle. In the primary position of gaze, the upper eyelid margin usually lies at the superior corneal limbus in children and 1.5–2.0 mm below it in the adult. To be kept in mind during ptosis repair or eyelid reconstructions is that the lower eyelid margin rests at the inferior corneal limbus and the upper eyelid marginal contour reaches its highest point just nasal to the pupil. The margin of each eyelid is about 2-mm thick. Posteriorly, the marginal tarsal surface is covered with conjunctival epithelium, interrupted by the Meibomian gland orifices. Anteriorly, the margin is covered with cutaneous epidermis from which emerge the eyelashes. Separating these two regions is a faint linear zone, sometimes forming a slight sulcus. This is the gray line, which is the marginal projection of the pars ciliaris of Riolan's muscle. Eyelid skin is the thinnest of the body and is unique in having no subcutaneous fat layer. The upper eyelid crease is a horizontal indentation caused by attachments of superficial levator aponeurotic fibers into orbicularis intermuscular septa and subcutaneous tissue. It lies about 8–11 mm above the eyelid margin centrally. Medially, the crease is generally lower, about 4–5 mm from the lid margin. Laterally, it lies about 5–6 mm above the margin. This crease should be reformed during ptosis or blepharoplasty surgery to maintain normal cosmetic appearance, and to prevent downward displacement of preaponeurotic fat or overhang of eyelid skin.

Protractors

The orbicularis oculi (Fig. 1.13) is a complex periocular striated muscle sheet that lies just below the skin and is an integral component of the superficial musculoaponeurotic system (SMAS). The SMAS is that part of the superficial fascia of the head and neck which covers the midface. A fibroadipose layer separates the orbicularis muscle from the overlying dermis [20]. The orbicularis muscle consists of striated

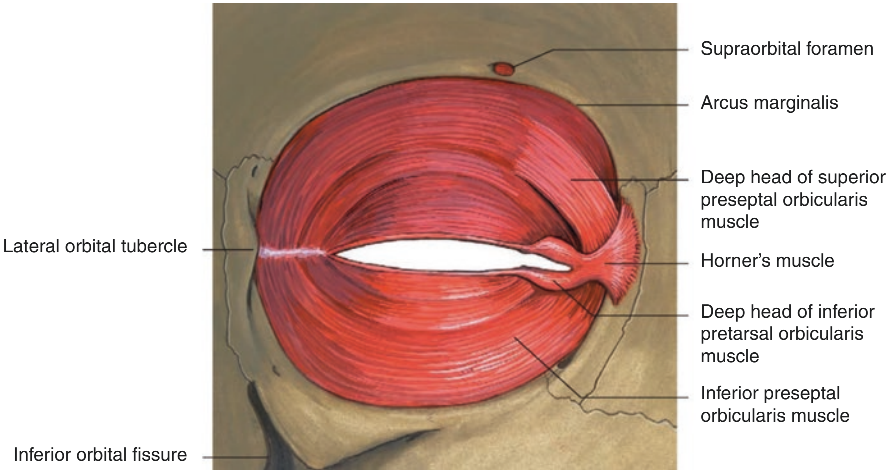

Fig. 1.13 Orbicularis oculi muscle

fibers that run parallel to the eyelid margins. The orbicularis muscle is divided anatomically into four segments, three contiguous and one separate. The contiguous parts are the orbital, preseptal, and pretarsal portions of the orbicularis, and the separate part is the muscle of Riolan. The orbital portion of the orbicularis muscle overlies the bony orbital rims. It arises from insertions on the frontal process of the maxillary bone in front of the anterior lacrimal crest, from the orbital process of the frontal bone, and from the common medial canthal ligament. A medial slip of this muscle passes superficial to the depressor supercilii and the origin of the corrugator supercilii, and inserts onto the dermis at the medial brow [26]. The major bundle of fibers passes around the orbital rim to form a continuous ellipse without interruption at the lateral palpebral commissure. These fibers insert medially just below their points of origin. They are innervated by the temporal and zygomatic branches of the facial nerve, and serve as a sphincter of the eyelids. The palpebral portion of the orbicularis muscle overlies the mobile eyelid from the orbital rims to the eyelid margins. The muscle fibers sweep circumferentially around each eyelid as a half ellipse, fixed medially and laterally at the canthal ligaments. Although this portion forms a single anatomic unit in each eyelid, it is customarily further divided topographically into two parts, the preseptal and the pretarsal orbicularis. The preseptal part is positioned over the orbital septum in both upper and lower eyelids, and its fibers originate perpendicularly along the upper and lower borders of the medial canthal ligament. The inferior preseptal muscle arises as a single head from the entire length of the common ligament. Posterior muscle fibers may be seen to attach to dense collagen fibers that insert onto the upper portion of the lacrimal sac [27]. The preseptal muscle arises by two heads in the upper lid. The anterior or superficial head is the more prominent, arising as a broadsheet from the upper surface of the common canthal ligament. The posterior head arises from the superior limb, and to a lesser extent from the posterior limb of the canthal ligament. The superior limb of the medial canthal ligament (Fig. 1.14) is fused to the fundus of the lacrimal sac by

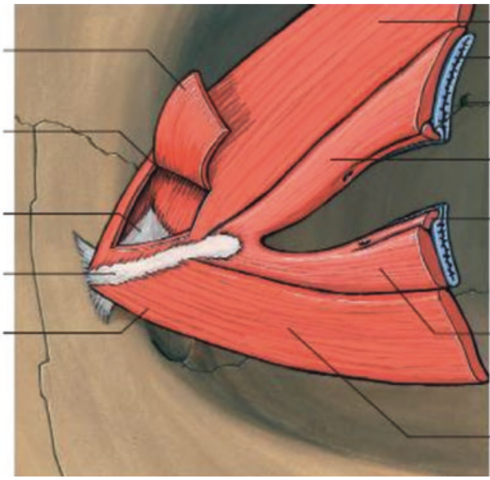

Fig. 1.14 The medial canthus

a layer of fibrovascular fascia so that on contraction, this deep head of the preseptal muscle pulls the sac laterally, thus contributing to the lacrimal pump mechanism. Fibers of the upper and lower preseptal muscles arc around the eyelids and interdigitate laterally along the lateral horizontal raphe. From its orientation, the preseptal orbicularis muscle appears to function largely in counteracting opposing tone in the retractors of the eyelids by distally displacing the levator aponeurosis and capsulopalpebral fascia. Secondarily, it likely contributes to the lacrimal pump mechanism at the level of the lacrimal sac. The pretarsal muscles, firmly attached to the tarsal plates, insert medially by a superficial head and a deep head. The superficial head from each lid blends with a fibrous component to form the anterior part of the medial canthal tendon. The deep head from each lid is also known as the pars lacrimalis, or Horner's muscle. Its fibers begin at the medial ends of the tarsal plates and insert into the posterior lacrimal crest a few millimeters behind the lacrimal sac. Contraction of the deep head pulls the lid medially and posteriorly. At the lateral canthus the pretarsal muscles join and insert by a common tendon into Whitnall's tubercle. The preseptal muscles join laterally to form a lateral raphe, which is connected to the underlying tendon. Deep to the muscle insertions a Y-shaped fibrous thickening in the orbital septum joins the lateral ends of the tarsal plates to Whitnall's tubercle. These muscular and fibrous structures together form the lateral canthal tendon. The medial canthal tendon also has a fibrous and a muscular component. The fibrous component is attached laterally to the medial ends of the tarsal plates as two limbs of a Y. It has a superficial and a deep component. The superficial component inserts medially on the frontal process of the maxilla just anterior to the anterior lacrimal crest, level with the upper part of the lacrimal sac. It has a definite inferior border but the superior border blends with the periosteum. The deep component leaves the deep surface just lateral to the anterior lacrimal crest and inserts into the posterior lacrimal crest behind the lacrimal sac. This deep component of the tendon is the main medial anchor of the lids. During blinking the deep heads of the pretarsal muscles (Horner's muscle) pull the medial ends of the eyelids medially, shortening the canaliculi, while the lacrimal fascia and sac wall are pulled laterally by contraction of the deep heads of the preseptal muscle. The puncta close and the tears in the ampullae of the canaliculi are forced medially and are sucked into the sac. As the deep insertions of the orbicularis muscle relax at the end of the blink the lacrimal fascia and sac wall move medially again, the medial ends of the lids move laterally, the puncta reopen and the ampullae refill with tears. Drainage of tears from the lacrimal sac into the nasolacrimal duct is not influenced directly by the lacrimal pump mechanism and is mainly due to gravity. Near the eyelid margin, a specialized bundle of striated muscle, the muscle of Riolan, lies more posterior than the main portion of the orbicularis and creates the gray line. The muscle of Riolan may play a role in Meibomian glandular discharge, blinking, and the position of the eyelashes.

Orbital Septum

The orbital septum (Fig. 1.15) is a fibrous, multilayered membrane beginning at the arcus marginalis along the orbital rim. The septum is continuous with other layers on the forehead and within the orbit. The orbital septum is the anterior most

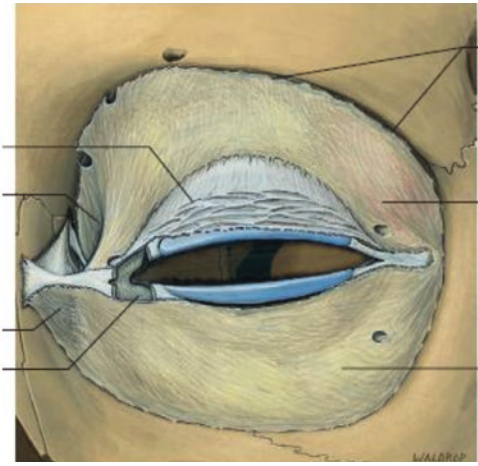

Fig. 1.15 Orbital septum

septal sheet of the orbital fascial system, and defines the anterior limit of the orbit. Within the upper eyelid, the septum forms a nearly continuous layer that separates the anterior eyelid lamellae from the posterior lamellae and from the deeper orbital structures. From the superior arcus marginalis the septum passes inferiorly between the orbicularis muscle and the preaponeurotic fat pockets. Distally, the septum is loosely joined to the levator aponeurosis. The point of insertion is usually about 3–5 mm above the tarsal plate. The more anterior layers of the septum gradually interdigitate distally with those of the levator aponeurosis [28]. After fusing with the aponeurosis, the anterior layer of the septum continues to extend downward over the distal aponeurosis and along the anterior tarsal surface [29]. The septum fuses with the anterior layer of the capsule-palpebral fascia 3–5 mm below the inferior border of the tarsus. The common fascial sheet then inserts onto the inferior tarsal edge [30]. Medially the septum divides into several layers and has an intimate relationship with the lacrimal drainage system. In the lower eyelid the anterior septal layer inserts onto the anterior lacrimal crest, and onto the inferior border of the fibrous medial canthal ligament. A posterior layer separates and passes posteriorly around the lacrimal sac. It is fused to periorbita along the orbital opening of the nasolacrimal duct, and also to the fascia of the lower lacrimal sac. In the upper eyelid an anterior layer of the orbital septum inserts onto the superior limb of the medial canthal ligament and onto the orbital process of the maxillary bone. Here it encloses the lacrimal sac fossa anteriorly, and is interrupted along the canthal ligament for penetration of Horner's muscle. Thus, the anterior layer of the septum forms an anterior fibrous wall to the lacrimal sac fossa. The anterior and intermediate layers of the orbital septum effectively isolate the lacrimal sac and duct within their own fascial compartment, separate from the eyelid and orbit. Laterally, the orbital septum passes slightly behind the bony orbital rim where it inserts onto the lateral canthal ligament, and the lateral retinaculum at the orbital tubercle in company with the lateral horn of the levator aponeurosis [31].

Orbital Fat

Sub-orbicularis Oculi Fat Pad (SOOF) (Fig. 1.16)

This fat pad lies just below the lateral half of the inferior orbital rim and extends over the lower part of the body of the zygoma. It is in contact with the periosteum deep to the lower part of the orbicularis oculi muscle in the upper cheek. It is posterior to the deep layer of the SMAS lining the deep surface of the orbicularis muscle. As the SMAS descends from the lower lid tissues, it is thickened into a supporting sheet, the orbitomalar ligament (also known as the orbicularis retaining ligament), which has attachment also to the inferior orbital rim periosteum.

The Retro-Orbicularis Oculi Fat Pad (ROOF)

This fat pad, lies deep to the skin and thin subcutaneous fat layer of the brow, the orbital part of the orbicularis muscle and the lower fibers of the frontalis muscle. It is enclosed between the superficial and deep layers of the deep galea aponeurotica as these descend into the upper lid. An additional deep attachment of the row fat to the supraorbital periosteum is more secure medially than laterally. The brow fat may extend inferiorly on the anterior surface of the orbital septum. The SOOF and ROOF pads communicate at their lateral ends through fat overlying the lateral orbital rim and the lateral canthal tendon. These fat pads are separated from the orbital fat pads by the orbital septum and, in the lower lid, also by the layers of the SMAS (orbitomalar ligament) at the orbital rim.

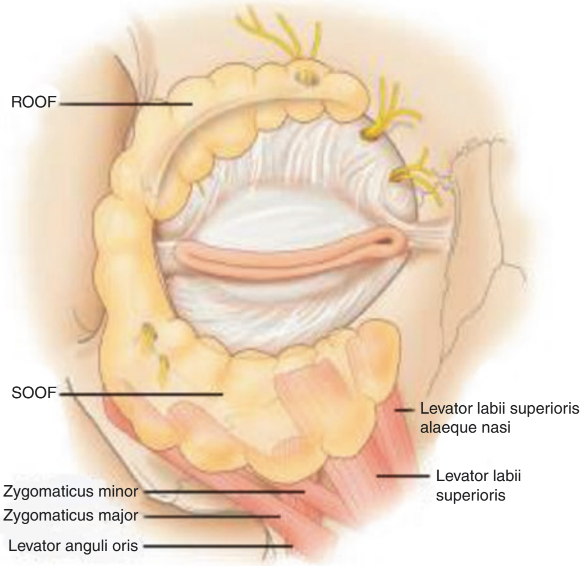

Fig. 1.16 Soof fat layers

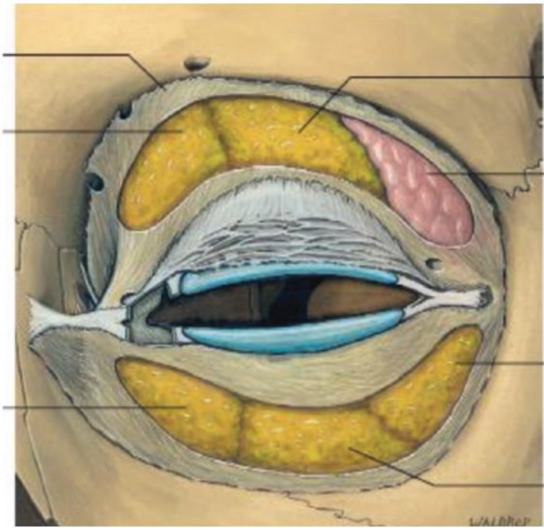

Fig. 1.17 Eyelid preaponeurotic fat pockets

The Post Orbicular Fascia (Fig. 1.17)
This plane is an avascular loose areolar layer between the orbicularis muscle and the orbital septum-levator aponeurosis fascial complex (upper lid) or the capsulopalpebral fascia (lower lid). It extends to the eyelid margin where blends with the gray line. Within the lid it allows bloodless dissection and identification of the underlying orbital septum. On the eyelid margin, the gray line marks the approximate anatomic separation of the anterior skin–muscle lamella from the posterior tarso-conjunctiva lamella. This fascial space is also responsible for the easy accumulation of fluid and blood in the eyelid following surgery or trauma. The post-orbicular fascial plane is best defined beneath the pretarsal portion of the orbicularis muscle. Under the preseptal portion, this plane becomes more complex and contains a thin layer of fibroadipose tissue continuous with the deep brow fat pad [32]. In the upper eyelid there are two fat pockets: nasal and central. In the lower eyelid, there are three fat pockets: nasal, central, and temporal. The central orbital fat pad is an important landmark in both elective eyelid surgery and lid laceration repair because it lies directly behind the orbital septum and in front of the levator aponeurosis.

Retractors
The retractors of the upper eyelid are the levator muscle with its aponeurosis and the superior tarsal muscle (Müller muscle). In the lower eyelid, the retractors are the capsulopalpebral fascia and the inferior tarsal muscle.

Upper Eyelid Retractors
The lesser sphenoid wing just above the annulus of Zinn, superolateral to the optic canal gives the origin of the levator palpebrae superioris muscle (Fig. 1.18). The

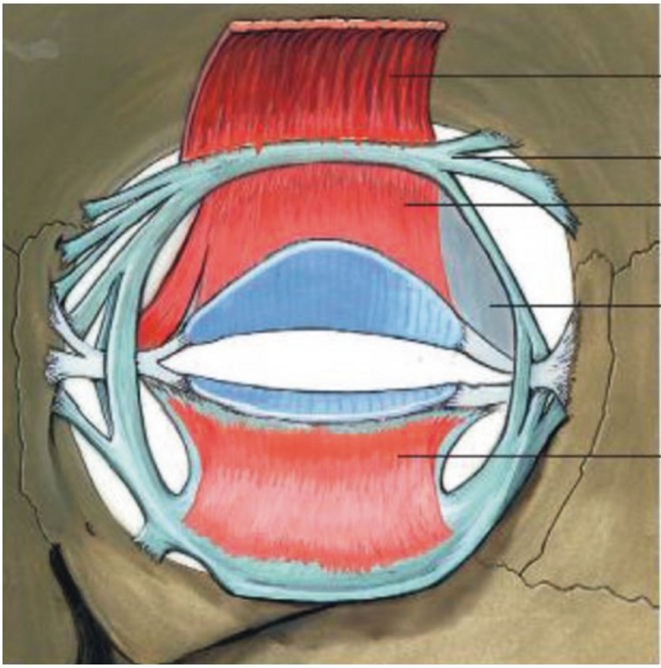

Fig. 1.18 Levator aponeurosis and Müller's tarsal muscles, interior orbital view

muscle is about 36 mm in length, measuring 4 mm in width at its origin, widening to 8 mm in the mid-orbit [33]. Along the anterior third of the levator muscle, posterior to Whitnall's ligament, a thin sheet of fibrous tissue separates and interconnects the levator muscle sheath with the superior rectus muscle. More anteriorly this becomes thicker until it completely envelopes the levator, fusing with a similar covering around the superior rectus muscle it is referred to this as the "conjoint fascial sheath" [34]. The forniceal suspensory ligaments are a fibrous attachment that run downward about 2 mm from the conjoint fascial sheet to the superior conjunctival fornix. Just behind the superior orbital rim the levator muscle widens to about 18 mm and is divided into two layers, superior and inferior, separated by connective tissue. The superior layer continued into the levator aponeurosis, and the inferior layer passed into Müller's smooth muscle [35]. Here a thickened condensation is seen within the muscle sheath around the levator muscle. This structure runs horizontally across the superior orbit and attaches medially to the fascia around the trochlea, and laterally onto the capsule of the lacrimal gland and periosteum of the frontal bone. This condensation is firmly adherent to the levator muscle sheath along its medial and lateral surfaces, but is only loosely attached centrally. It forms the superior transverse orbital ligament of Whitnall. The levator muscle is innervated by the superior division of CN III, which also supplies the superior rectus muscle. A superior division palsy, resulting in ptosis and decreased up gaze, implies an infraorbital disruption of CN III. The peripheral arterial arcade is found between the levator aponeurosis and the Müller muscle, just above the superior tarsal border. This vascular arcade serves as a useful surgical landmark to identify the Müller muscle.

Lower Eyelid Retractors

The retractors of the lower lid are equivalent to the retractors of the upper lid (the levator and Müller's muscles). They develop from the capsulopalpebral head of the inferior rectus muscle. But unlike the upper lid retractors, they are vestigial, containing little muscle. They arise from the sheath of the inferior rectus muscle and consist of the capsulopalpebral fascia (equivalent to the levator) and the inferior tarsal muscle (equivalent to Müller's muscle). As they pass forward the lower lid, retractors split to enclose the inferior oblique muscle, and where they reunite, they blend with thickened fascia on their inferior aspect. This is Lockwood's suspensory ligament that inserts into the orbital walls close to the canthal tendons. The septum fuses with the lower lid retractors about 2–3 mm below their insertion into the lower tarsal border. The angle between the posterior aspect of the septum and the lower lid retractors contains a pad of orbital fat—the medial fat pad—similar to the preaponeurotic fat in the upper lid. The pull of the lower lid retractors depresses the lid in downgaze and helps to maintain the upright position of the tarsal plate.

Tarsus

The tarsal plates (Fig. 1.19) form the skeleton of the eyelids. They are made of dense fibrous tissue with some elastic tissue. The upper eyelid tarsal plates measure 10–12 mm vertically in the center of the eyelid; the maximum lower eyelid tarsal plate measurement is 4 mm. The tarsal plates have rigid attachments to the periosteum through the canthal tendons medially and laterally. The tarsal plates may become horizontally displaced with age as a result of stretching of the medial and lateral supporting tendons. Both tarsal plates are usually 1-mm thick and taper at the

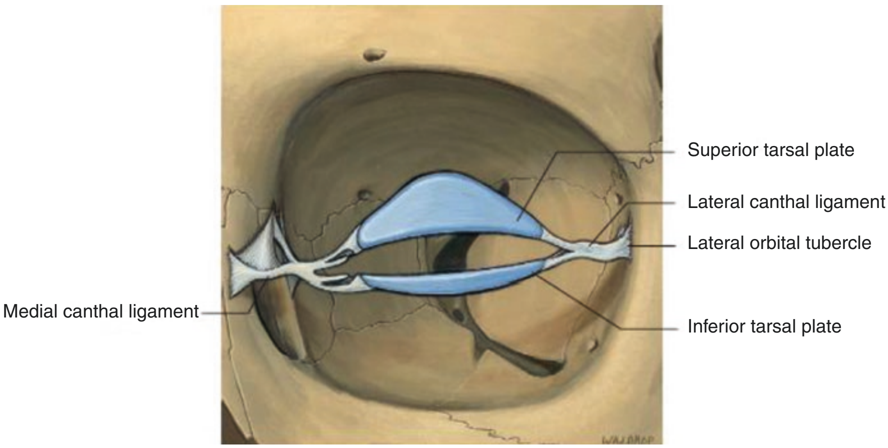

Fig. 1.19 Tarsal plates with medial and lateral canthal ligaments

medial and lateral ends as they approach the canthal tendons. Holocrine sebaceous glands, the Meibomian glands lie within the substance of the tarsal plates. In the upper lid the lower fibers of the levator aponeurosis insert into the lower part of the tarsal plate and Müller's muscle is attached to the proximal border. In the lower lid, the lower lid retractors insert into the proximal border. The tarsal conjunctiva is firmly attached to its posterior surfaces.

Conjunctiva

The conjunctiva is composed of non-keratinizing squamous epithelium. It forms the posterior layer of the eyelids and contains mucin-secreting goblet cells and the accessory lacrimal glands of Wolfring and Krause that are found mainly between the upper tarsal border and the upper fornix, especially laterally. The lacrimal gland ducts empty into the lateral part of the upper fornix. The superior and inferior fornices extend almost to the orbital rims. The lateral fornix extends to approximately 14 mm from the limbus but the medial fornix is shallower. Fibrous tissue support reaches the fornices and in the superior and inferior fornices "suspensory ligaments" can be identified. They are extensions of the common sheaths between the upper or lower lid retractors and the superior or inferior rectus muscles.

Blood Supply of the Eye Lid (Fig. 1.20)

The dorsal nasal artery pierces the septum above the medial canthal tendon to supply the skin of the root of the nose and the lacrimal sac. It gives origin to the medial palpebral arteries if these have not arisen separately from the ophthalmic artery. The two medial palpebral arteries enter the lids above and below the medial canthal

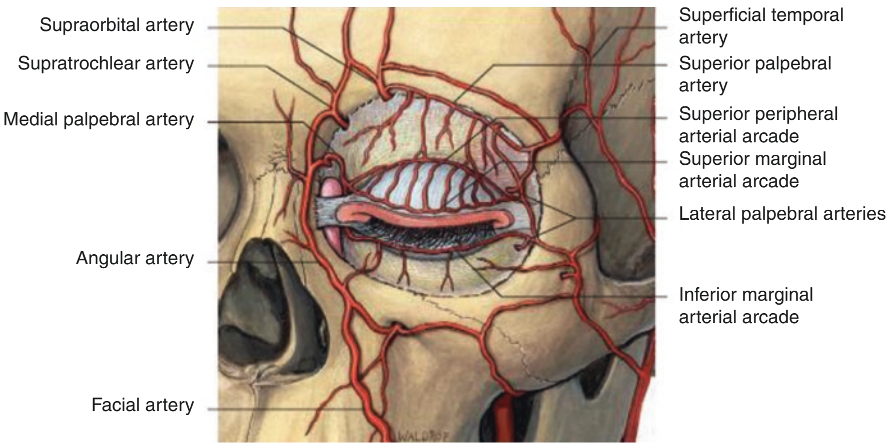

Fig. 1.20 Eyelid arterial supply

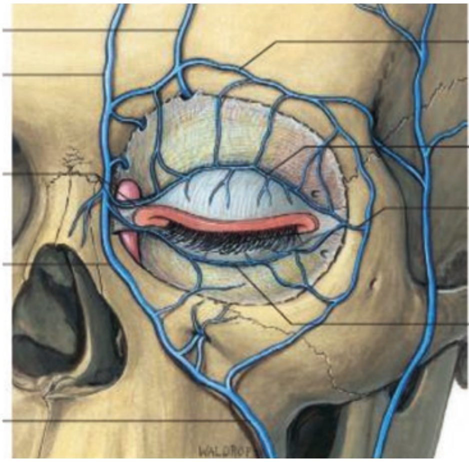

Fig. 1.21 Eyelid venous drainage

tendon. In the lids the medial and lateral palpebral arteries anastomose to form arcades within the submuscular connective tissue on the surface of the upper and lower tarsal plates 2–4 mm from the lid margins. In the upper lid, a second arcade is formed at the upper border of the tarsal plate. The supratrochlear artery pierces the septum with the supratrochlear nerve, winds upwards into the mid-forehead and supplies it. It anastomoses with the supraorbital artery. Blood from the external carotid system reaches the lids through anastomoses with the infraorbital and facial arteries, mainly via the angular artery, and the superficial temporal artery.

Venous Drainage (Fig. 1.21)

The veins of the lids are found mainly in the region of the fornices. They drain to the venous network of the middle third of the face. The angular vein is formed by the anastomosis of the supraorbital and supratrochlear or frontal veins at the upper inner angle of the orbit. It drains posteriorly into the superior orbital vein and inferiorly into the facial vein. It lies about 8-mm medial to the inner canthus where it can often be seen through the skin. Venous blood also drains to the inferior ophthalmic vein.

Lymphatic Drainage of the Lids (Fig. 1.22)

The preauricular and parotid lymph nodes drain the lateral two-thirds of the upper lid and the lateral third of the lower lid. The submandibular nodes drain the medial third of the upper lid and the medial two-thirds of the lower lid.

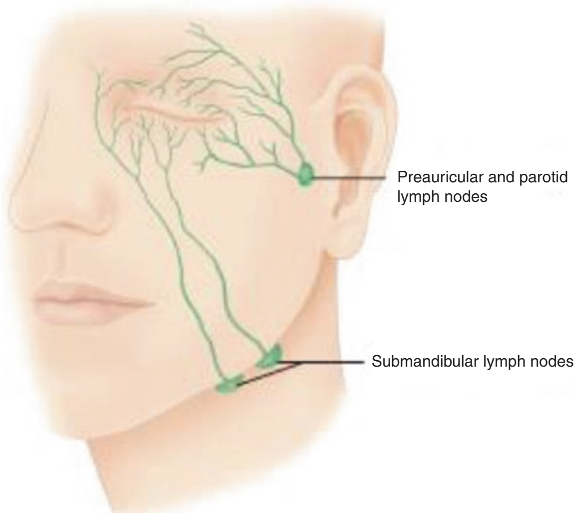

Fig. 1.22 Lymphatic drainage of the eyelids

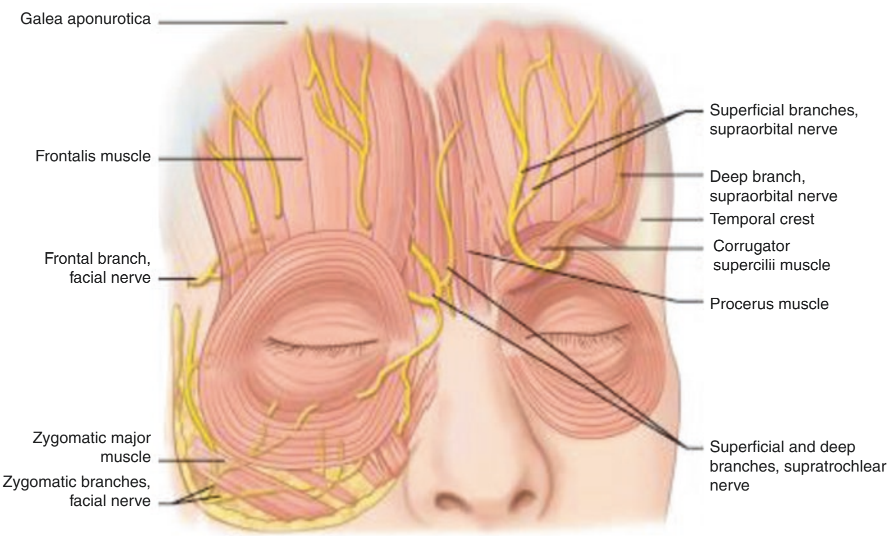

Fig. 1.23 Nerve supply of the lid

Nerve Supply to the Lids and Face

Motor Supply (Fig. 1.23)

The muscles of facial expression are supplied by branches of the facial nerve. Within the face the branches lie deep to the muscles of facial expression then penetrate the deep layer of the superficial musculo-aponeurotic system (SMAS) to innervate the orbicularis muscle and the other muscles of facial expression. After emerging from the stylo-mastoid foramen the facial nerve gives origin to the posterior auricular branch which passes upwards and posteriorly to supply the occipitalis muscle and posterior auricular muscles. The trunk passes forward and enters the substance of the parotid gland where it divides into branches that emerge from the anterior border of the gland to supply the muscles of facial expression, including the frontalis and platysma muscles. Two of these branches, sometimes known as the upper and lower zygomatic branches, are of particular importance in the periocular region. The upper branch crosses the zygoma approximately at its midpoint, halfway between the outer canthus and the tragus, and enters the temporoparietal (superficial temporal) fascia and travels within it into the forehead, passing about 1.5 cm above the tail of the brow. Here it is known as the frontal branch of the facial nerve. Its surface marking is important during surgery in the forehead. It innervates the frontalis and orbicularis muscles, also the corrugator and procerus muscles, just above the superior orbital rim. The lower branch crosses the zygomatic bone to supply the orbicularis fibers of the lower lid and the upper fibers of the elevators of the upper lip. Having reached the lids, the terminal branches of the nerve turn at right angles to the muscle bundle to approach the lid margins, except medially where they run in the line of the muscles. There is extensive cross innervation between the branches of the facial nerve. The levator palpebrae superioris muscle is supplied by the third cranial nerve. It enters the orbit from the lateral wall of the cavernous sinus. It passes through the tendon ring lateral to the optic nerve and divides into superior and inferior branches. The superior division of the nerve traverses and supplies the superior rectus muscle before supplying the levator at the junction of its middle and posterior thirds. Müller's muscle is supplied by sympathetic nerves. Cranial preganglionic sympathetic fibers leave the CNS in the anterior spinal nerve roots of the intermediate region of the spinal cord, T1 to L1, and ascend the sympathetic chain to the superior cervical ganglion level with the second and third cervical vertebrae. Cranial postganglionic sympathetic fibers originate in the superior cervical ganglion and travel with the internal carotid artery and its branches to supply the structures of the cranial cavity and the orbit. The ciliary ganglion is attached anatomically to the nasociliary nerve lateral to the optic nerve near the back of the orbit. Preganglionic parasympathetic fibers originate in the Edinger Westphal nucleus in the midbrain and travel to the orbit with branches of cranial nerve III. They synapse in the ciliary ganglion and the postganglionic fibers travel in the multiple short ciliary nerves to pierce the sclera around the optic nerve and supply the sphincter muscle of the iris. Sympathetic postganglionic fibers from the superior cervical ganglion pass through the ciliary ganglion without further synapse and travel in the long and short ciliary nerves to enter the eye and supply the dilator muscle of the iris.

Sensory Supply

The lids and the contents of the orbit are supplied by the ophthalmic and the maxillary divisions of the trigeminal (fifth cranial) nerve. The ophthalmic division of the trigeminal nerve divides into the lateral wall of the cavernous sinus into the lacrimal, frontal, and nasociliary nerves. These pass through the superior orbital fissure into the orbit. The lacrimal nerve runs forward along the superior border of the lateral rectus muscle to supply the lacrimal gland in its anterior two-thirds, it is accompanied by the lacrimal artery. It pierces the septum and supplies sensation to the lateral part of the upper lid and conjunctiva. The parasympathetic innervation of the lacrimal gland travels with the zygomatic nerve from the sphenopalatine ganglion and joins the lacrimal nerve just posterior to the gland. The frontal nerve is the largest of the three branches. It passes forward between the periosteum of the orbital roof and the levator muscle. Anteriorly, it divides into the supratrochlear and supraorbital nerves. The supratrochlear nerve ascends over the medial orbital rim with the artery, deep to the orbicularis muscle, to supply the medial part of the lid and conjunctiva and the skin of the forehead. The supraorbital nerve continues to the supraorbital notch which it passes through with the artery medial to it. It divides into superficial and deep branches. The superficial branch winds around the corrugator muscle and ascends more medially, superficial to the frontalis. The deep branch remains deep to the corrugator and ascends more laterally, deep to or through the frontalis. These branches supply the upper lid and conjunctiva, and the forehead and scalp as far as the vertex. The nasociliary nerve crosses medially above the optic nerve with the ophthalmic artery. It gives origin to several branches and then divides into the anterior ethmoidal nerve and the infratrochlear nerve. The anterior ethmoidal nerve passes via the anterior cranial fossa to terminate as nasal nerves. These supply the tip of the nose including the anterior part of the nasal septum. The infratrochlear nerve passes below the trochlea to supply the medial ends of the lids and conjunctiva, the lacrimal sac, and the root of the nose. There are several communications between the terminal branches of the ophthalmic nerve around the eye. They also communicate with the infraorbital nerve, a branch of the maxillary division of the fifth cranial nerve. The maxillary division of the trigeminal nerve passes forward from the trigeminal ganglion to the foramen rotundum through which it enters the pterygopalatine fossa. The infraorbital nerve branches forward and travels in a groove, then a canal, in the floor of the orbit to reach the infraorbital foramen. It branches to supply the skin and conjunctiva of the lower lid, the lower part of the side of the nose and the upper lip. The zygomatic nerve, a branch of the maxillary nerve, enters the orbit through the inferior orbital fissure. It follows the lower part of the lateral orbital wall where, after communicating with the lacrimal nerve, it divides into the zygomaticofacial and zygomaticotemporal nerves. The zygomaticofacial nerve exits anteriorly on the zygomatic bone to supply sensation to the malar area of the cheek. The zygomaticotemporal nerve exits in the temporal fossa and supplies sensation to the anterior temporal region.

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