The Orbit

The orbital cavity is schematically represented as a pyramid of four walls that converge posteriorly. The medial walls of the right and left orbit are parallel and are separated by the nose. (fig. 1&2)

The volume of the adult orbit is approximately (30 mL) and the eyeball occupies only about one-fifth of the space. Fat and muscles account for the bulk of the remainder.

The anterior limit of the orbital cavity is the orbital septum which acts as a barrier between the eyelids and orbit.

The orbits are related to the frontal sinus above ,the maxillary sinus below ,and the ethmoid and sphenoid sinuses medially.

The thin orbital floor is easily damaged by direct trauma to the globe resulting in a "blowout" fracture with herniation of orbit contents into the maxillary antrum.

Infection within the sphenoid and ethmoid sinuses can erode the paper-thin medial wall (lamina papyracea) and involve the contents of the orbit.

Defects in the roof (e.g. neurofibromatosis) may result in visible pulsations of the globe transmitted from the brain .

Orbital walls : (fig. 1)

I- The roof of the orbit is formed by the orbital plate of the **frontal bone** and the lesser wing of the **sphenoid bone** posteriorly.(The lacrimal gland is located in the lacrimal fossa in the anterior lateral aspect of the roof) .

II- The lateral wall is formed by the **zygomatic (malar) bone** this is the strongest part of the bony orbit and the greater wing of the **sphenoid bone** posteriorly .

III- The orbital floor is separated from the lateral wall by the inferior orbital fissure, the **orbital plate of the maxilla** forms the large central area of the floor (and is the region where blowout fractures most frequently occur), the frontal process of the **maxilla** medially and the **zygomatic** bone laterally complete the

inferior orbital rim, the orbital process of the **palatine** bone forms a small triangular area in the posterior floor.

IV-The medial wall is less distinct ; the **ethmoid** bone is paper-thin , the **lacrimal** bone, the body of the **sphenoid** forms the most posterior aspect of the medial wall and the angular process of the **frontal bone** forms a small part of it.

The eyeball

The normal adult globe is approximately spherical with an antero-posterior diameter averaging 24.5 mm. (fig 3,4,5)

The conjunctiva : fig. (4,10)

the conjunctive is the thin transparent mucous membrane that covers the posterior surface of the lids(palpebral conjunctiva) and the anterior surface of the sclera (bulbar conjunctiva).

it is continuous with the skin at the lid margin(a muco-cutaneous junction) and with the corneal epithelium at the limbus .

the palpebral conjunctiva lines the posterior surface of the lids and is firmly adherent to the tarsus the conjunctiva is reflected back (at the superior and inferior fornices) and covers the episcleral tissue to become the bulbar conjunctiva .

the bulbar conjunctive is loosely attached to the orbital septum in the fornices and is folded many times this allows the eye to move and enlarges the secretary conjunctival surface (the ducts of the lacrimal gland open into the superior temporal fornix) .

The sclera & episclera :

the sclera is the fibrous outer protective coating of the eye .

it is dense and white and continuous with the cornea anteriorly and the dural sheath of the optic nerve posteriorly, a few strands of scleral tissue pass across the anterior portion of the optic nerve as the lamina cribrosa .

the outer surface of the anterior sclera is covered by a thin layer of fine elastic tissue the episclera which contains numerous blood vessels that nourish the sclera.
at the insertion of the rectus muscles the sclera is about 0.3 mm thick; elsewhere it is about 1mm thick.
around the optic nerve the sclera is penetrated by the long and short posterior ciliary arteries and the long and short ciliary nerves , the four vortex veins draining the choroid exit through the sclera slightly posterior to the equator , usually one in each quadrant.
the nerve supply to the sclera is form the ciliary nerves.
histologically the sclera consists of many dense bands of parallel and interlacing **fibrous tissue** bundles , the histologic structure of the sclera is remarkably similar to that of the cornea.

The cornea :

The cornea is a transparent tissue comparable in size and structure to the crystal of a small wrist watch (fig. 3,4,5). it is inserted into the sclera at the limbus; the circumferential depression at this junction being known as the scleral sulcus .
the average adult cornea is 0.54mm thick in the center about 0.65mm thick at the periphery and about 11.5mm in diameter .
from anterior to posterior it has five distinct layers :

- **epithelium** (which is continuous with the epithelium of the bulbar conjunctiva) it has five or six layers of cells .
- **bowman's** layer is a clear acellular layer ; a modified portion of the stroma.
- **stroma** account for about 90% of the corneal thickness . it is composed of intertwining lamellae of collagen fibrils about 1µm wide that run almost the full diameter of the cornea. They run parallel to the surface of the cornea and by virtue of their size and periodicity are optically clear.
- **descemets membrane** is a clear elastic membrane that appears amorphous on electron microscopy and represents the basement membrane of the corneal endothelium

- **endothelium** is the inner most (and only one layer), it is cannot regenerate when damaged, by pumping action, it keeps the cornea in dehydrated state and hence optically clear.

sources of **nutrition** for the cornea are the vessels of the limbus , the aqueous and the tears . the superficial cornea also gets most of its oxygen from the atmosphere.

the **sensory** supply of the cornea is by the first (ophthalmic) division of the fifth (trigeminal) cranial nerve.

the **transparency** of the cornea is due to its uniform structure , avascularity and deturgescence.

The uveal tract :

The uveal tract is composed of the iris , the ciliary body and the choroid (fig. 3,4,5) . it is the middle vascular layer of the eye and is protected by the cornea and sclera.

Its structure is mainly vascular and hence nutrition to the adjacent structures is the main function.

I- The Iris :

The iris is the anterior extension of the ciliary body. it presents as a flat surface with a centrally situated round aperture "the pupil".

the iris lies in contiguity with the anterior surface of the lens dividing the anterior chamber from the posterior chamber each of which contains aqueous humor.

within the stroma of the iris are the sphincter and dilator muscles . the two heavily pigmented layers on the posterior surface of the iris represent anterior extensions of the neuro- retina and retinal pigment epithelium.

II- The ciliary body :

The ciliary body roughly triangular in cross section extends forward from the anterior end of the choroid to the root of the iris (about 6mm).

it consists of a corrugated anterior zone the pars plicata and a flattened posterior zone the pares plana , the ciliary processes arise from the pars plicata .

there are two layers of **ciliary epithelium**: an internal non pigmented layer representing the anterior extension of the neuro retina and external pigmented layer representing an extension of the retinal pigment epithelium. the cilliary processes and their covering ciliary epithelium are responsible for the formation of aqueous.

The ciliary muscle is composed of a combination of longitudinal , circular and radial fibers ; the function of the circular fibers is to contract and relax the zonular fibers which originate in the valleys between the ciliary processes (this alters the tension on the capsule of the lens giving the lens a variable focus for both near and distant objects . the longitudinal fibers of the ciliary muscle insert into the trabecular meshwork to influence its pore size.

III- The choroid :

The choroid is the posterior segment of the uveal tract (lies between the retina and the sclera). it is composed of three layers of choroidal blood vessels large, medium and small. the internal portion of the choroid vessels is known as the choriocapillaris.

blood from the choroid vessels drains via the four vortex veins one in each of the four posterior quadrants.

the choroidal blood vessels serves to nourish the outer portion of the underlying retina .

The lens : fig. (3,4,5)

The lens is a biconvex, a vascular ,colorless and almost completely transparent structure about 4mm thick and 9mm in diameter.

it is suspended behind the iris by the zonule which connects it with the ciliary body.

anterior to the lens is the aqueous while posterior to it, is the vitreous.

the lens capsule is a semi permeable membrane (slightly more permeable than a capillary wall)that will admit water and electrolytes.

The aqueous :

aqueous humor is produced by the ciliary body entering the posterior chamber. it passes through the pupil into the anterior chamber and then peripherally toward the anterior chamber angle . fig. 3

The anterior chamber angle : fig. 5

The anterior chamber angle lies at the junction of the peripheral cornea and the root of the iris . its main anatomic features are schwalbes line , the trabcular meshwork (which overlies schlemms canal) and the scleral spur.

- **Schwalbes line** marks the termination of the corneal endothelium .
- the **trabecular meshwork** is triangular in cross-section with its base directed toward the ciliary body, it is composed of perforated sheets of collagen and elastic tissue forming a filter with decreasing pore size as the cannel of schlemm is approached .
- the **scleral spur** is an inward extension of the sclera between the ciliary body and schlemms canal to which the iris and ciliary body are attached.

Efferent channels from schlemms canal (about 30 collector channels and 12 aqueous veins) communicate with the episcleral venous system.

The retina :

The retina is a thin semitransparent multilayered sheet of neural tissue that lines the inner aspect of the posterior two-thirds of the wall of the globe. it extends almost as far anteriorly as the ciliary body ending at the point in a ragged edge the ora serrate (fig. 4,6)

the outer surface of the sensory retina is apposed to the retinal pigment epithelium and thus related to bruchs membrane of the choroid and the sclera . in most areas the sensory retina and the retinal pigment epithelium are easily separated to from the sub retinal space such as occurs in retinal detachment but at the optic disk and the ora serrata the retina and retinal pigment epithelium are firmly bound together thus limiting the spread of sub retinal fluid in retinal detachment . the inner surface of the retina is apposed to the vitreous.

the epithelial layers of the inner surface of the ciliary body and the posterior surface of the iris represent anterior extension of sensory retina and retinal pigment epithelium.

The **layers of the retina** starting from its inner aspect are:

(1)internal limiting membrane.

(2) nerve fiber layer : containing the ganglion cell axons passing to the optic nerve.

(3) ganglion cell layer .

(4) inner plexifrom layer, containing the connections of the ganglion cells with the amacrine and bipolar cells.

(5) inner nuclear layer of bipolar , amacrina and horizontal cell bodies (6) outer plexifrom layer, containing the connections of the bipolar and horizontal cells with the photoreceptors.

(7) outer nuclear layer of photoreceptor cell nuclei.

(8) external limiting membrane .

(9) photoreceptor layer of rods and cones .

(10) retinal pigment epithelium .

The vitreous : fig. (3,4)

The vitreous is a clear avascular gelatinous body that comprises two-thirds of the volume and weight of the eye. it fills the space bounded by the lens retina and optic disk .

the outer surface of the vitreous (the hyaloid membrane) is normally in contact with the following structures: the posterior lens capsule , the zonular fibers , the pars plana epithelium ,the retina and the optic nerve head .

the base of the vitreous maintains a firm attachment through our life to the pars plana epithelium and the retina immediately behind the ora serrata.

the attachment to the lens capsule and the optic nerve head is firm in early life but soon disappears.

the vitreous is about 99% water; the remaining 1% includes two components collagen and hyaluronic acid which give the vitreous a gel-like from and consistency because of their ability to bind large volumes of water.

The ocular muscles

I-Rectus muscles : fig. (7,8)

The four rectus muscles originate at a common ring tendon (annulus of zinn) surrounding the optic nerve at the posterior apex of the orbit.

they are named according to their insertion into the sclera on the medial , lateral , inferior and superior surfaces of the eye.

the principal action of the respective muscles is thus to adduct , abduct , depress and elevate the globe accordingly.

the muscles are about (40)mm long becoming tendinous (4-9)mm from the point of insertion where they are about 10mm wide.

the approximate distance of the points of insertion from the corneal limbus are as follows : medial rectus 5mm, inferior rectus 6mm , lateral rectus 7mm and superior rectus 8mm .

II-Oblique muscles : fig. (7,8)

The two oblique muscles control primarily torsional movement and to a lesser extent upward and downward movement of the globe.

i- Sup. Oblique : (is the longest and thinnest of the ocular muscles).

- it originates above and medial to the optic foramen and partially overlaps the origin of the levator palpebrae superioris muscle .
- the superior oblique has a thin fusiform belly (40mm long) and passes anteriorly in the form of a tendon to its trochlea or pulley, it is then reflected backward and downward to attach in a fan shape to the sclera beneath the superior rectus.(the trochlea is a cartilaginous structure attached to the frontal bone 3mm behind the orbital rim).

ii- Inf. Oblique :

- it originates from the nasal side of the orbital wall just behind the inferior orbital rim and lateral to the nasolacrimal duct.

- it passes beneath the inferior rectus to insert onto the sclera with a short tendon at the postero-temporal segment of the globe just over the macular area.

Nerve supply :

1-The oculomotor nerve (III) innervates the medial, inferior and superior rectus muscles and the inferior oblique muscle.

2- The abducens nerve(VI) innervates the lateral rectus muscle.

3- The trochlear nerve (IV) innervates the superior oblique muscle.

III-Levator palpebrae superioris muscle:

- the levator palpebrae muscle arises with a short tendon from the undersurface of the lesser wing of the sphenoid above and ahead of the optic foramen.

- the two extremities of the levator aponeurosis are called its medial and lateral horns. The medial horn is thin and is attached into the medial palpebral ligament , the lateral horn inserts into the orbital tubercle and the lateral palpebral ligament.

- the levator belly passes forward forms an aponeurosis and spreads like a fan.

- the levator is supplied by the superior branch of the oculomotor nerve(III) .

- the muscle including its smooth muscle component (mullers muscle) and its aponeurosis form an important part of the upper lid retractor .
(the palpebral segment of the orbicularis oculi muscle acts as its antagonist).

IV-Orbicularis oculi muscle: see later

The ocular adnexia

I- Eye brows :

The eyebrows are folds of thickened skin covered with hair . the skin fold is supported by underlying muscle fibers. the glabella is the hairless prominence between the eyebrows. Fig. (9)

II- Eye lids :

The upper and lower eyelids (palpebrae) are modified folds of skin that can close to protect the anterior eyeball . fig. (10)
blinking helps spread the tear film which protects the cornea and conjunctiva from dehydration . the upper lid ends at the eyebrows; the lower lid merges into the cheek. the eyelids consist of five principal planes of tissues .

Structures of the eyelids :

1. skin layer: the skin of the eyelids is thin loose and elastic and possesses few hair follicles and no subcutaneous fat .

2. orbicularis oculi muscle: the function of the orbicularis oculi muscle is to close the lids. its muscle fibers surround the palpebral fissure in concentric fashion the segment outside the lids is called the orbital portion . the orbicularis oculi is supplied by the facial nerve.

3. areolar tissue: the submuscular areolar tissue that lies deep to the orbicularis oculi muscle communicates with the subaponeurotic layer of the scalp

4. tarsal plates: the main supporting structure of the eyelids is a dense (fibrous tissue layer) that- along with a small amount of elastic tissue- is called the tarsal plate. the lateral and medial angles and extensions of the tarsal plates are attached to the orbital margin by the lateral and medial palpebral ligaments .

5.palpebral conjunctiva: the lids are lined posteriorly by a layer of mucous membrane ,the palpebral conjunctiva, which adheres firmly to the tarsal plates . a surgical incision through the **gray line** of the lid margin splits the lid into an anterior lamella (of skin and orbicularis muscle) and a posterior lamella (of tarsal plate and palpebral conjunctiva).

Lid margins :

The free lid margin is 25-30 mm long and about 2 mm wide it is divided by the gary line (mucocutaneous junction) into anterior and posterior margins

A . anterior margin:

1. Eyelashes :- the eyelashes project from the margins of the eyelids and are arranged irregularly, the upper lashes are longer and more numerous than the lower lashes and turn upward ; the lower lashes turn downward.

2. glands of zeis :- these are small modified sebaceous glands that open into the hair follicles at the base of the eyelashes.

3. glands of moll :- these are modified sweat glands that open in a row near the base of the eye lashes.

B. posterior margin:

the posterior lid margin is in close contact with the globe and along this margin are the small orifices of modified sebaceous glands (meibomian or tarsal glands).

C. lacrimal punctum:

at the medial end of the posterior margin of each lid a small elevation with a central small opening can be seen on the upper and lower lids.
the puncta serve to carry the tears down through the corresponding canaliculus to the lacrimal sac.

Sensory nerve supply :

the sensory nerve supply to the eyelids is derived from the first and second divisions of the trigeminal nerve(V).

III- <u>the lacrimal apparatus</u> :

It consists of the lacrimal gland(with the accessory glands) and nasolacimal drainage system. (fig. 9)

The **lacrimal gland** consists of the following structures:

(1) the almond-shaped **orbital portion** located in the lacrimal fossa in the anterior upper temporal segment of the orbit .

(2) the smaller **palpebral portion** is located just above the temporal segment of the superior conjunctival fornix . lacrimal secretory ducts which open by approximately ten fine orifices connect the orbital and palpebral portions of the lacrimal gland to the superior conjunctival fornix. Removal of the

palpebral portion of the gland cuts off all of the connecting ducts and thus prevents secretion by the entire gland.

The **accessory lacrimal** glands (of Krause and wolfring) are located in the substance propria of the palpebral conjunctiva.

Tears **drain** from the lacrimal lake via the upper and lower puncta and canaliculi to the lacrimal sac which lies in the lacrimal fossa , the nasolacrimal duct continues outward and slightly backward from the sac and opens into the inferior meatus of the nasal cavity .

Tears are directed into the puncta by the combined forces of capillary attraction in the canaliculi, gravity and the pumping action of horners muscle (which is an extension of the orbicularis oculi muscle).

Nerve supply by lacrimal nerve(sensory) , great superficial petrosal nerve (secretory) and sympathetic fibers .

Ciliary ganglion

The parasympathetic ciliary ganglion is located about (1 cm) in front of the annulus of zinn on the lateral side of the ophthalmic artery, between the optic nerve and the lateral rectus muscle. Fig. (11)

It receives three roots :

I- a long **(sensory)** root from the nasociliary nerve . it contains sensory fibers from the cornea, the iris ,and the ciliary body.

II- a short **(motor)** root arises from the lower division of the oculomotor nerve (which also supplies the inferior oblique muscle).
the fibers of the motor root synapse in the ganglion and carry parasympathetic axons to supply the iris sphincter.

III- the **sympathetic** root comes from the plexus around the internal carotid artery, the fibers passes through the ganglion and innervates vessels of the eye and possibly the dilator fibers to the iris.

Branches of the ciliary ganglion : (short ciliary nerves)

The postganglionic short ciliary nerves are (6 to 10)and these arise from the ciliary ganglion .

each short ciliary nerve contains sympathetic, parasymbathetic and sensory fibers.

Only the parasympathetic fibers are thought to synapse in the ciliary ganglion ((sympathetic fibers from cell bodies in the superior cervical ganglion and sensory fibers from cell bodies in the trigeminal ganglion , all passing directly through the ciliary ganglion without synapsing)).

The short ciliary nerves travel on both sides of the optic nerve and together with the long ciliary nerves pierce the sclera around the optic nerve, they pass anteriorly to from a plexus in the ciliary muscle that supplies the cornea, the ciliary body, and the iris.

Visual pathway

The visual pathway transmitted neural stimuli(image) formed by the retina mainly to the visual centre in the occipital cortex. Fig. (12)

Some fibers conveys stimuli to the mid brain to serve the pupillary reaction or reflex.

I- Optic nerve : ((the second cranial nerve))

it is evident that the optic nerve not a nerve but actually a nerve fiber tract of the central nervous system formed by axons of the retinal ganglion cells, the macular projections are located centrally in the optic nerve and constitute 80% to 90% of the total volume of the optic nerve and the chiasmal fibers. it has three main parts :

a- Intraocular portion : the intraocular portion of the optic nerve can be divided into three parts: pre-laminar, laminar,and retro-laminar. the surface of the **prelaminar** portion is visible ophthalmoscopically. Fig. (6)

it is a 1.5 by 1.75 mm, oval ,with a disc shaped depression (the physiologic cup) . the main branches of the central retinal artery and vein pass through the center of the cup. Fig 6

b- orbital portion : this part extends from the globe to the apex of the orbit.

c- Intracranial portion : after passing through the optic foramen the optic nerves lie above the ophthalmic arteries and above and medial to the internal carotid arteries. the optic nerves then pass posteriorly over the cavernous sinus to join the optic chiasm.

****{lesion of the optic nerve causes ipsilateral field loss (and blindness) with ipsilateral afferent pupillary defect}.**

II- Optic chiasm :

the optic chiasm "makes up" part of the floor of the third ventricle. it is surrounded by pia and arachnoid and is richly vascularized.
it is approximately 12 mm wide, 8 mm in the anteropostrior direction and 4mm thick .
the nasal retinal fibers cross in the chiasm passing into the opposite optic tract while temporal fibers remain uncrossed in the chiasm and optic tract. approximately 53% of the optic nerve fibers are crossed and 47% are uncrossed.

****{ lesion of the central part of the chiasm causes "bitemporal heminopia while lesion of peripheral part of the chiasm causes binasal heminopia , pupillary fibers may be involved }.**

III - Optic tract :

each optic tract contains ipsilateral temporal and contralateral nasal fibers from the optic nerves fibers.(from the upper retinal projections, both crossed and uncrossed travel medially in the optic tract) while lower projections move laterally.
Pupillary fibers leaves the tract before entering the lateral geniculate body passing to the pretectal area then to the mid brain approaching the oculomotor nerve nucleus.

**{ optic tract lesion causes contralateral heminopia}.

IV - Lateral geniculate nucleus :

the lateral geniculate nucleus or body is the synaptic zone for the higher visual projections . it is an oval or cap-like structure which receives approximately 70% of the optic tract fibers.
within its six alternating layers of gray and white matter; layers 1,4 and 6 of the lateral geniculate body contain axons from the contralateral optic nerve while layers 2,3and 5 arise from the ipsilateral optic nerve.

**{ lesion of L.G.N. causes contralateral heminopia without pupillary reaction defect }.

V - Optic radiation :

the optic radiation connects the lateral geniculate body with the visual cortex of the occipital lobe. the fibers of the optic radiation leave the lateral geniculate body and run around the temporal horn of the lateral ventricle approaching the anterior tip of the temporal lobe (loop of meyer) they then sweep back ward toward the visual area of the occipital lobe.
**{ lesion causes visual defects similar to L.G.N. }

VI - Visual cortex :

the visual cortex has six cellular layers, is the thinnest area of the human cerebral cortex , and occupies the superior and inferior lips of the calcarine fissure on the posterior and medial surfaces of the occipital lobes.
macular function is extremely well represented in the visual cortex and occupies the most posterior position at the tip of the occipital lobe.

The posterior cerebral artery, a branch of the basilar artery supplies the visual cortex almost exclusively.

**{lesion causes visual defects similar to L.G.N. and radiation but with macular sparing }.