Lecture 7 The Eye د.أحمد جسام النقيب

The Eye

Movements of the Eyeball

Terms Used in Describing Eye Movements

The center of the cornea or the center of the pupil is used as the anatomic “anterior pole” of the eye. All movements of the eye are then related to the direction of the movement of the anterior pole as it rotates on any one of the three axes (horizontal, vertical, and sagittal). The terminology then becomes as follows: **Elevation** is the rotation of the eye upward, **depression** is the rotation of the eye downward, **abduction** is the rotation of the eye laterally, and **adduction** is the rotation of the eye medially. Rotatory movements of the eyeball use the upper rim of the cornea (or pupil) as the marker. The eye rotates either medially or laterally.

Extrinsic Muscles Producing Movement of the Eye

There are six voluntary muscles that run from the posterior wall of the orbital cavity to the eyeball. These are the **superior rectus,** the **inferior rectus,** the **medial rectus,** the **lateral rectus,** and the **superior** and **inferior oblique muscles.** Because the superior and the inferior recti are inserted on the medial side of the vertical axis of the eyeball, they not only raise and depress the cornea, respectively, but also **rotate it medially**.
For the superior rectus muscle to raise the cornea directly upward, the inferior oblique muscle must assist; for the inferior rectus to depress the cornea directly downward, the superior oblique muscle must assist. Note that the tendon of the superior oblique muscle passes through a fibrocartilaginous pulley (trochlea) attached to the frontal bone. The tendon now turns backward and laterally and is inserted into the sclera beneath the superior rectus muscle.

TABLE 11.2 Muscles of the Eyeball and Eyelids

Muscle	Origin	Insertion	Nerve Supply	Action
Extrinsic Muscles of Eyeball (Striated Skeletal Muscle)				
Superior rectus	Tendinous ring on posterior wall of orbital cavity	Superior surface of eyeball just posterior to corneoscleral junction	Oculomotor nerve (3rd cranial nerve)	Raises cornea upward and medially
Inferior rectus	Tendinous ring on posterior wall of orbital cavity	Inferior surface of eyeball just posterior to corneoscleral junction	Oculomotor nerve (3rd cranial nerve)	Depresses cornea downward and medially
Medial rectus	Tendinous ring on posterior wall of orbital cavity	Medial surface of eyeball just posterior to corneoscleral junction	Oculomotor nerve (3rd cranial nerve)	Rotates eyeball so that cornea looks medially
Lateral rectus	Tendinous ring on posterior wall of orbital cavity	Lateral surface of eyeball just posterior to corneoscleral junction	Abducent nerve (6th cranial nerve)	Rotates eyeball so that cornea looks laterally
Superior oblique	Posterior wall of orbital cavity	Passes through pulley and is attached to superior surface of eyeball beneath superior rectus	Trochlear nerve (4th cranial nerve)	Rotates eyeball so that cornea looks downward and laterally
Inferior oblique	Floor of orbital cavity	Lateral surface of eyeball deep to lateral rectus	Oculomotor nerve (3rd cranial nerve)	Rotates eyeball so that cornea looks upward and laterally
Intrinsic Muscles of Eyeball (Smooth Muscle)				
Sphincter pupillae of iris			Parasympathetic via oculomotor nerve	Constricts pupil
Dilator pupillae of iris			Sympathetic	Dilates pupil
Ciliary muscle			Parasympathetic via oculomotor nerve	Controls shape of lens; in accommodation, makes lens more globular

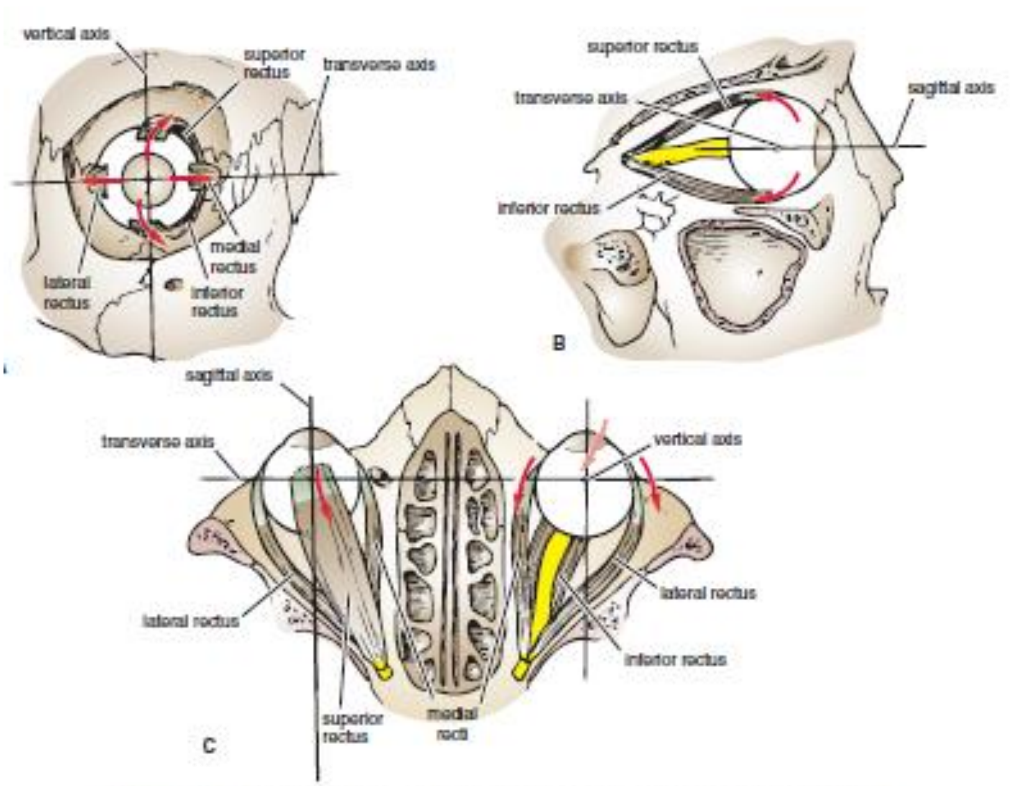


FIGURE 11.21 The actions of the four recti muscles in producing movements of the eyeball.

Clinical Testing for the Actions of the Superior and Inferior Recti and the Superior and Inferior Oblique Muscles

Because the actions of the superior and inferior recti and the superior and inferior oblique muscles are complicated when a patient is asked to look vertically upward or vertically downward, the physician tests the eye movements where the single action of each muscle predominates. The origins of the superior and inferior recti are situated about 23° medial to their insertions, and, therefore, when the patient is asked to turn the cornea laterally, these muscles are placed in the optimum position to raise (superior rectus) or lower (inferior rectus) the cornea. Using the same rationale, the superior and inferior oblique muscles can be tested. The pulley of the superior oblique and the origin of the inferior oblique muscles lie medial and anterior to their insertions. The physician tests the action of these muscles by asking the patient first to look medially, thus placing these muscles in the optimum position to lower (superior oblique) or raise (inferior oblique) the cornea. In other words, when you ask a patient to look medially and downward at the tip of his or her nose, you are testing the superior oblique at its best position. Conversely, by asking the patient to look medially and upward, you are testing the inferior oblique at its best position

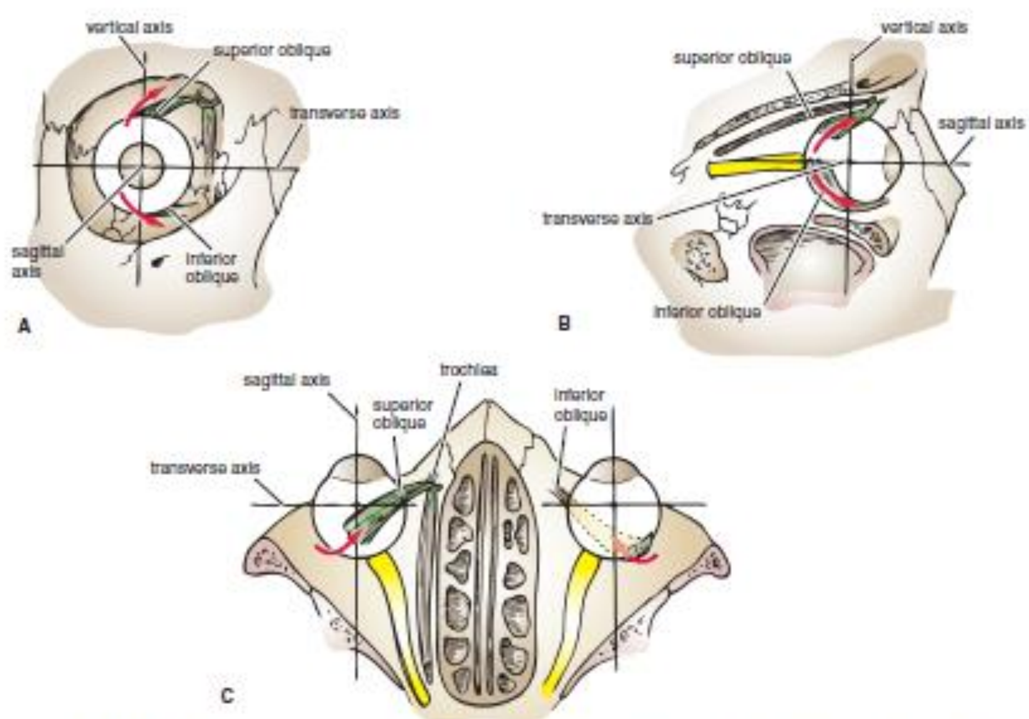


FIGURE 11.22 The actions of the superior and inferior oblique muscles in producing movements of the eyeball.

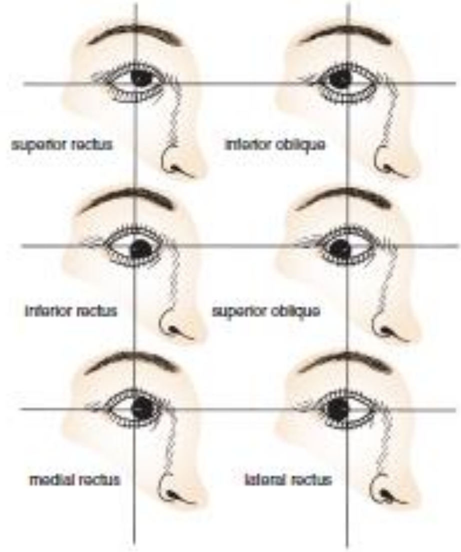


FIGURE 11.23 Actions of the four recti and two oblique muscles of the right orbit, assuming that each muscle is acting alone. The position of the pupil in relation to the vertical and horizontal planes should be noted in each case. The actions of the superior and inferior recti and the oblique muscles in the living intact eye are tested clinically, as described on page 557.

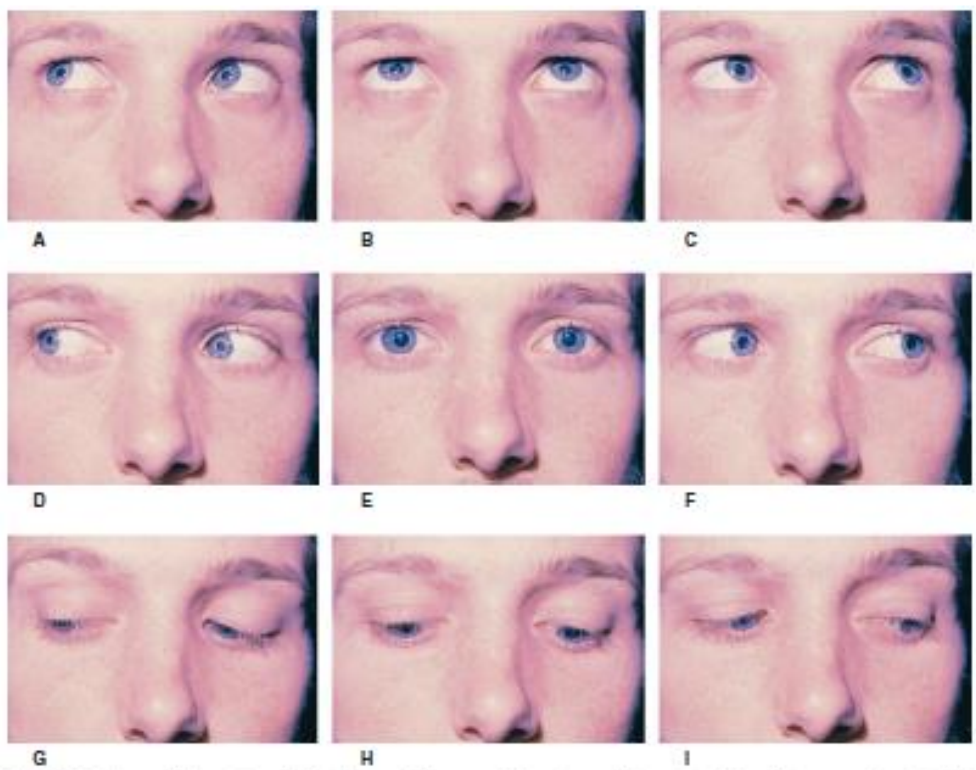


FIGURE 11.24 The cardinal positions of the right and left eyes and the actions of the recti and the oblique muscles principally responsible for the movements of the eyes. **A.** Right eye, superior rectus muscle; left eye, inferior oblique muscle. **B.** Both eyes, superior recti and inferior oblique muscles. **C.** Right eye, inferior oblique muscle; left eye, superior rectus muscle. **D.** Right eye, lateral rectus muscle; left eye, medial rectus muscle. **E.** Primary position, with the eyes fixed on a distant fixation point. **F.** Right eye, medial rectus muscle; left eye, lateral rectus muscle. **G.** Right eye, inferior rectus muscle; left eye, superior oblique muscle. **H.** Both eyes, inferior recti and superior oblique muscles. **I.** Right eye, superior oblique muscle; left eye, inferior rectus muscle.

Intrinsic Muscles

The involuntary intrinsic muscles are the **ciliary muscle** and the **constrictor,** and the **dilator pupillae of the iris** take no part in the movement of the eyeball and are discussed later.

Fascial Sheath of the Eyeball

The fascial sheath surrounds the eyeball from the optic nerve to the corneoscleral junction. It separates the eyeball from the orbital fat and provides it with a socket for free movement. It is perforated by the tendons of the orbital muscles and is reflected onto each of them as a tubular sheath. The sheaths for the tendons of the medial and lateral recti are attached to the medial and lateral walls of the orbit by triangular ligaments called the **medial** and **lateral check ligaments.** The lower part of the fascial sheath, which passes beneath the eyeball and connects the check ligaments, is thickened and serves to suspend the eyeball; it is called the **suspensory ligament of the eye.** By this means, the eye is suspended from the medial and lateral walls of the orbit, as if in a hammock.

Structure of the Eye

The eyeball is embedded in orbital fat but is separated from it by the fascial sheath of the eyeball. The eyeball consists of three coats, which, from without inward, are the fibrous coat, the vascular pigmented coat, and the nervous coat.

Coats of the Eyeball

Fibrous Coat

The fibrous coat is made up of a posterior opaque part, the sclera, and an anterior transparent part, the cornea. The Sclera The opaque sclera is composed of dense fibrous tissue and is white. Posteriorly, it is pierced by the optic nerve and is fused with the dural sheath of that nerve. The **lamina cribrosa** is the area of the sclera that is pierced by the nerve fibers of the optic nerve. The sclera is also pierced by the ciliary arteries and nerves and their associated veins, the venae vorticosae. The sclera is directly continuous in front with the cornea at the corneoscleral junction, or limbus.

The Cornea

The transparent **cornea** is largely responsible for the refraction of the light entering the eye. It is in contact posteriorly with the aqueous humor.

Blood Supply The cornea is avascular and devoid of lymphatic drainage. It is nourished by diffusion from the aqueous humor and from the capillaries at its edge.

Nerve Supply Long ciliary nerves from the ophthalmic division of the trigeminal nerve

Function of the Cornea

The cornea is the most important refractive medium of the eye. This refractive power occurs on the anterior surface of the cornea, where the refractive index of the cornea (1.38) differs greatly from that of the air. The importance of the tear film in maintaining the normal environment for the corneal epithelial cells should be stressed.

Vascular Pigmented Coat

The vascular pigmented coat consists, from behind forward, of the choroid, the ciliary body, and the iris.

The Choroid

The choroid is composed of an outer pigmented layer and an inner, highly vascular layer.

The Ciliary Body

The **ciliary body** is continuous posteriorly with the choroid, and anteriorly it lies behind the peripheral margin of the iris. It is composed of the ciliary ring, the ciliary processes, and the ciliary muscle.

The **ciliary ring** is the posterior part of the body, and its surface has shallow grooves, the **ciliary striae.**

The **ciliary processes** are radially arranged folds, or ridges, to the posterior surfaces of which are connected the suspensory ligaments of the lens.

The **ciliary muscle** is composed of meridianal and circular fibers of smooth muscle. The meridianal fibers run backward from the region of the corneoscleral junction to the ciliary processes. The circular fibers are fewer in number and lie internal to the meridianal fibers.

■ **Nerve supply:** The **ciliary muscle** is supplied by the parasympathetic fibers from the oculomotor nerve. After synapsing in the ciliary ganglion, the postganglionic fibers pass forward to the eyeball in the short ciliary nerves.

■ **Action:** Contraction of the ciliary muscle, especially the meridianal fibers, pulls the ciliary body forward. This relieves the tension in the suspensory ligament, and the elastic lens becomes more convex. This increases the refractive power of the lens.

The Iris and Pupil

The iris is a thin, contractile, pigmented diaphragm with a central aperture, the pupil. It is suspended in the aqueous humor between the cornea and the lens. The periphery of the iris is attached to the anterior surface of the ciliary body. It divides the space between the lens and the cornea into an **anterior** and a **posterior chamber.** The muscle fibers of the iris are involuntary and consist of circular and radiating fibers. The circular fibers form the **sphincter pupillae** and are arranged around the margin of the pupil. The radial fibers form the **dilator pupillae** and consist of a thin sheet of radial fibers that lie close to the posterior surface.

■ **Nerve supply:** The **sphincter pupillae** is supplied by parasympathetic fibers from the oculomotor nerve. After synapsing in the ciliary ganglion, the postganglionic fibers pass forward to the eyeball in the short ciliary nerves. The **dilator pupillae** is supplied by sympathetic fibers, which pass forward to the eyeball in the long ciliary nerves.

■ **Action:** The sphincter pupillae constricts the pupil in the presence of bright light and during accommodation.

The dilator pupillae dilates the pupil in the presence of light of low intensity or in the presence of excessive sympathetic activity such as occurs in fright.

Nervous Coat: The Retina

The retina consists of an **outer pigmented layer** and an **inner nervous layer.** Its outer surface is in contact with the choroid, and its inner surface is in contact with the vitreous body. The posterior three quarters of the retina is the receptor organ. Its anterior edge forms a wavy ring, the **ora serrata,** and the nervous tissues end here. The anterior part of the retina is nonreceptive and consists merely of pigment cells, with a deeper layer of columnar epithelium. This anterior part of the retina covers the ciliary processes and the back of the iris. At the center of the posterior part of the retina is an oval, yellowish area, the **macula lutea,** which is the area of the retina for the most distinct vision. It has a central depression, the **fovea centralis**.

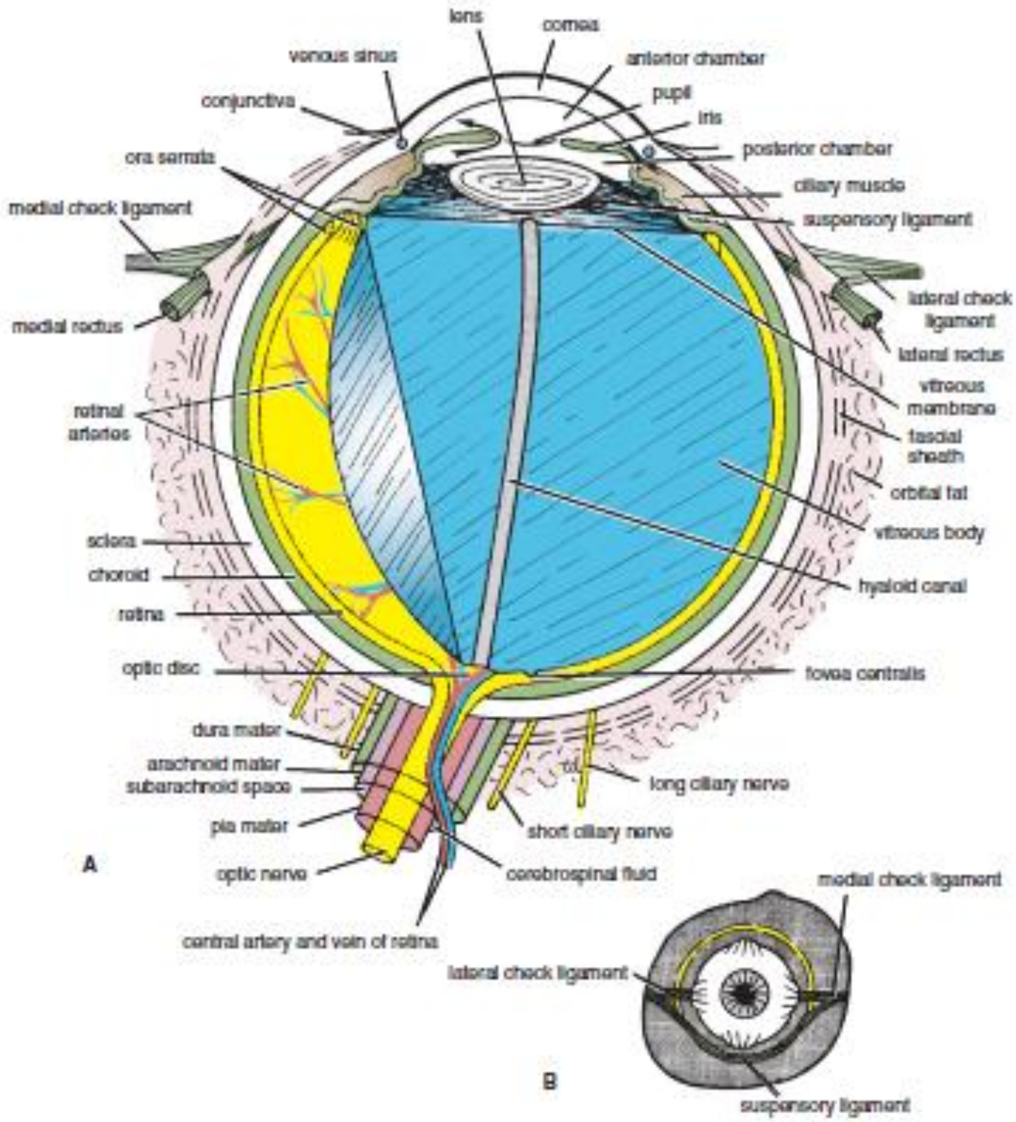
The optic nerve leaves the retina about 3 mm to the medial side of the macula lutea by the optic disc. The **optic disc** is slightly depressed at its center, where it is pierced by the **central artery of the retina.** At the optic disc is a complete absence of **rods** and **cones** so that it is insensitive to light and is referred to as the **"blind spot."** On ophthalmoscopic examination, the optic disc is seen to be pale pink in color, much paler than the surrounding retina.

Contents of the Eyeball

The contents of the eyeball consist of the refractive media, the aqueous humor, the vitreous body, and the lens.

Aqueous Humor

The aqueous humor is a clear fluid that fills the anterior and posterior chambers of the eyeball. It is believed to be a secretion from the ciliary processes, from which it enters the posterior chamber. It then flows into the anterior chamber through the pupil and is drained away through the spaces at the iridocorneal angle into the **canal of Schlemm.** Obstruction to the draining of the aqueous humor results in a rise in intraocular pressure called **glaucoma.** This can produce degenerative changes in the retina, with consequent blindness. The function of the aqueous humor is to support the wall of the eyeball by exerting internal pressure and thus maintaining its optical shape. It also nourishes the cornea and the lens and removes the products of metabolism; these functions are important because the cornea and the lens do not possess a blood supply.



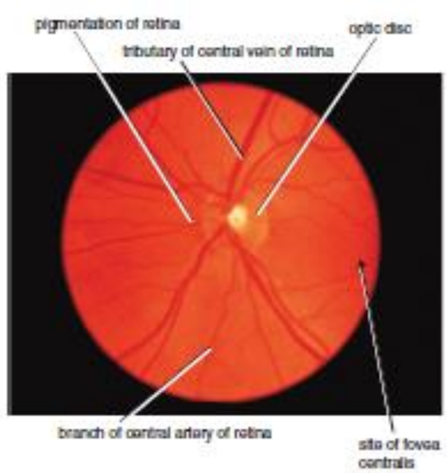


FIGURE 11.26 The left ocular fundus as seen with an ophthalmoscope.

Vitreous Body

The vitreous body fills the eyeball behind the lens and is a transparent gel. The **hyaloid canal** is a narrow channel that runs through the vitreous body from the optic disc to the posterior surface of the lens; in the fetus, it is filled by the hyaloid artery, which disappears before birth. The function of the vitreous body is to contribute slightly to the magnifying power of the eye. It supports the posterior surface of the lens and assists in holding the neural part of the retina against the pigmented part of the retina.

The Lens

The lens is a transparent, biconvex structure enclosed in a transparent capsule. It is situated behind the iris and in front of the vitreous body and is encircled by the ciliary processes. The lens consists of an elastic **capsule,** which envelops the structure; a **cuboidal epithelium,** which is confined to the anterior surface of the lens; and **lens fibers,** which are formed from the cuboidal epithelium at the equator of the lens. The lens fibers make up the bulk of the lens.

The elastic lens capsule is under tension, causing the lens constantly to endeavor to assume a globular rather than a disc shape. The equatorial region, or circumference, of the lens is attached to the ciliary processes of the ciliary body by the **suspensory ligament.** The pull of the radiating fibers of the suspensory ligament tends to keep the elastic lens flattened so that the eye can be focused on distant objects.

Accommodation of the Eye

To accommodate the eye for close objects, the ciliary muscle contracts and pulls the ciliary body forward and inward so that the radiating fibers of the suspensory ligament are relaxed. This allows the elastic lens to assume a more globular shape. With advancing age, the lens becomes denser and less elastic, and, as a result, the ability to accommodate is lessened (presbyopia). This disability can be overcome by the use of an additional lens in the form of glasses to assist the eye in focusing on nearby objects.

Constriction of the Pupil during Accommodation of the Eye

To ensure that the light rays pass through the central part of the lens so spherical aberration is diminished during accommodation for near objects, the sphincter pupillae muscle contracts so the pupil becomes smaller.

Convergence of the Eyes during Accommodation of the Lens

In humans, the retinae of both eyes focus on only one set of objects (single binocular vision). When an object moves from a distance toward an individual, the eyes converge so that a single object, not two, is seen. Convergence of the eyes results from the coordinated contraction of the medial rectus muscles.

References :

1- Snell, Richard S. Clinical anatomy by regions. Lippincott Williams & Wilkins, 2011.

2- Norton, Neil S. Netter's head and neck anatomy for dentistry e-book. Elsevier Health Sciences, 2016.