Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 4 Issue 1 Janauary 2022

Review Article

The Animal Eye Anatomy and Development

Mohammed Khaled Hassaan*

Student at Faculty of Veterinary Medicine, Kafr Elsheikh University, Egypt

***Corresponding Author:** Mohammed Khaled Hassaan, Student at Faculty of Veterinary Medicine, Kafr Elsheikh University, Egypt.

Received: November 05, 2021

Published: December 08, 2021

Abstract

The eye structure divided into three main parts are accessory structure around the eye, eyeball and the eye chamber & refractive media. The orbit is a bony cavity around the eye. There are three eyelids: upper, lower and third. Structure of upper and lower eyelid is skin and subcutaneous tissues, muscular layer, fibrous layer, The third eyelid is located at the medial canthus of the eye and consists of nictitating membrane, hyaline cartilage and lymph glands. Lacrimal apparatus consists of lacrimal gland, excretory ducts, puncta lacrimalis, lacrimal canaliculi, lacrimal sac and nasolacrimal duct. Lacrimal gland produces tears whereas nasolacrimal apparatus transmission it. The eye ball consists of three concentric coats are the fibrous coat, vascular pigmented coat (uvea) and nervous coat. The corneal structure is fibrous and cellular parts whereas sclera is fibrous only. The limbus is the junction between cornea and sclera and contains circular venous plexus that drain the aqueous humor of the anterior chamber. Vascular tunic consists of choroid, ciliary body and iris. The retina is a double layer: outer pigmented layer and inner neural layer and consists of two parts: pars optica and pars ceca. The eye chambers are three which arranged according to the size from biggest to smallest as the following; vitreous, anterior and posterior chamber. Refractive media is a cornea, aqueous humor, vitreous body and lens. The major eye development occurs between week 3 and week 10, involving ectoderm, neural crest cells, and mesenchyme. The vertebrate eye comprises tissues of various embryonic origins: the lens and cornea are derived from the ectoderm surface, while the iris and ciliary body retina and epithelial layers are derived from the anterior neural plate. Retinal ganglion cells develop towards the optic stalk which forms the optic nerve.

Keywords: Food; Vision; Cornea; Anterior Chamber

Introduction

The vision is that animals can see the world around them, animals need vision to survive, find food, defend themselves from predators, seek shelter, etc. The main organ of the vision is eye, the eye along with its various parts and generating vision in tandem with the brain. As well as allowing many view- independent photo-response functions. The eyes senses light inside nerves and converts it into electro-chemical impulses.

In higher species, the eye is a complex optical system that collects light from the outside world, Focuses it to shape an image by means of an adjustable lens assembly, transforms this image into a series of electrical signals and transmits these signals to the brain via complex neural pathways that link the eye to the optic nerve to the visual cortex and other areas of the brain.

Many domestic mammals' visual systems have evolved to enhance efficiency under a wide variety of lighting conditions so that they can exploit particular ecological niches. Of domestic animals, cats are possibly the most highly suited to night vision, with a minimum threshold for light detection up to seven times lower than that of humans.

The eye is located within the head Orbital. The bony orbit is a cavity, containing parts of the lacrimal bone (including nasolacri-

mal duct fossa) and the maxilla (including infraorbital canal caudal foramen). It is caudally continuous with the temporal bone and the pterygopalatine fossa. The bony orbit is laterally in herbivores yet is positioned forward in hunting animals. The eye consists of various components which allow it to receive light stimuli from the environment and deliver these stimuli in the form of an electrical signal to the brain. Vision covers all eye components.

These components include: The Conjunctiva, Sclera, Cornea, Anterior Chamber, Posterior Chamber, Iris, Pupil, Lens, Vitreous Humor, Retina and Optic Nerves.

Anatomy of the eye

Accesssory structure of the eye:

- Orbit
- Eye lid " Palpebrae "
- Conjunctiva
- Lacrima apparatus
- Extraocular muscles
- Periorbita
- Orbital fascia
- Retro-orbital fat.

Figure 1: Cross section of dog eye.

Eye ball "eye bulb or globe"

- Fibrous tunica
- Vascular tunica
- Nervous tunica.

Eye chambers and refractive media

- Chambers
- Refractive media

Accesssory structure of the eye

Orbit

It's a bony cavity or socket surrounding the eye that contains the eye ball, formed by several bones, also contains Muscles, nerves, blood nerves and the structure that produce and drain tears, The orbit location inside the skull varies according to the species. The eye orbits are laterally located in cattle, goats, And horses, providing panoramic vision, while the eyes are more anterior in dogs and cats, which underlines binocular similarity between the two eyes.

Figure 2: Eye orbit.

Eye lids (palpebrae)

There are three eye lids: upper, lower and third: the upper and lower eye lids meet an lateral palperal commissures that enclose medial and lateral angle (canthus) of the eye. The lateral canthus is round and small while median one is larger and has inverted U or V shape. The lacrimal lake is inverted U or V shape recess which present in the medial canthus whereas the lacrimal caruncle is a small, reddish yellow elevation (aggregated lymph nodules) pres-

ents in the center of the lacrimal lake (well developed in equine). The palpebral fissure is the elliptical opening between the upper and lower eye lids and the eyelashes (cilia) are short, curved hairs (more in upper eyelid) on the free edges of the eye lids. There are animal types that don't need eyelids. Fish, for instance, haven't true eyelids so they live in water that keeps their eyes moist. Fish can not shut their eyes and neither can snakes. Several lizards have two eyelids to cover their eyes - a small, white one to guard the open eye - and another pigmented eyelid.

Figure 3: External anatomy of left.

Structure of upper and lower eyelids

The eyelids consist of a fibrous tarsal plate and muscle, bounded on the outersurface by the skin and on the inner surface by the conjunctiva. Additionally, adnexal specializations such as cilia (eyelashes) and glands occur. These components differ by species; but there may be some general comments. The skin on the outer eyelid surface is thinner, more flexible and more pliable on the body than skin elsewhere. Cilia occur in dogs, horses, goats, pigs, and sheep on the outer surface of the upper eyelid margin. On the lower eyelids of horses, cattle, and sheep are also a few cilia present.

Figure 4: Cross section of eyelid.

Note that Cats have no cilia but have an essentially identical line of modified hairs. Modified sweat glands - Moll's glands - open onto the eyelid margin near the cilia base. The Zeis glands are rudimentary sebaceous glands opening up into the follicles generating the cilia. The tarsal or meibomian glands are modified sebaceous glands embedded in the tarsal plate, a layer of fibrous tissue that gives the eyelid a certain structural rigidity. At the eyelid margin posterior to the cilia the meibomian glands open right. Their orifices are clearly noticeable, and they can transmit a greyish white secretion rich in phospholipids. This secretion has two functions: It coats the eyelid margins to reduce tears overflow and it forms the precorneal tear film's superficial lipid layer. This lipid layer has high surface tension and thus adds stability to the tear film's aqueous layer and decreases its evaporation. The second structure of the eyelid which follow the skin is a muscular layer which consists of

- **Orbicularis occuli muscle (sphincter muscle of the eye)**: It surrounds the two eye lid completely and is innervated by auriclopalpebral nerve of facia (VII).
- **Levator palpebrae superioris Muscle**: It presents only in the upper eye lid, dorsolaterally and inside the orbit and is innervated by dorsal branch of the oculomotor nerve (III).
- **Corrugator super cilii Muscle (Levator anguli oculi medialis)**: Similar to levator palpebrae superioris Muscle, but present out side the orbit and is innervated by auriclopalpebral nerve of facia (VII).

The third structure of eye lids is fibrous layer (tarsus) that is a connective tissue layer in which the the tarsal gland is embedded. The tarsal glands are a sebaceous glands that spill their oily secretion (sebum) behind the eyelashes onto the edge of the lip.

The forth structure of the eye lids is the mucous membrane of the palpebral conjunctiva.

Conjunctive is a thin mucous membrane consisting of two Parts. The first part is palpebral conjunctiva which lines the eyelids whereas the second part is bulbar conjunctiva which lines the sclera. The dorsal and ventral conjunctival fornices are the lines of reflection of the two parts of the conjunctiva.

The third eyelids

is a mobile, protective, and glandular structure lying between the cornea and the lower eyelid in the medial portion of the inferior conjunctival sac that is the space between the bulbar and palpebral

conjunctiva. The third eyelids is ill developed in human and domestic animals except camel because of protection of cornea from sand but well developed in birds because of protection of cornea from dust. It consists of:

- Nictitating membrane; Semilunar fold of mucus membrane
- Hyaline cartilage; T shape - curved triangular - with its superficial part is wide and covered by the nictitating membrane, which the deep part is narrow and isn't covered by the membrane.

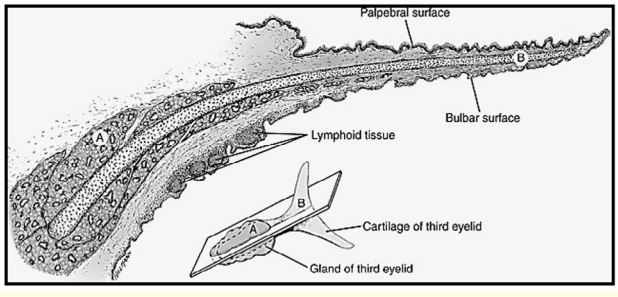

Figure 5: The third eyelid structure.

Lymph glands (nodules); There're two glands. The superficial glands that present around the middle part of the cartilage and the deep (Harderian) glands in which deep part of the cartilage in pig and ruminants.

Lacrimal apparatus

Produce tears that moisturize the eye surface, preventing the delicate ocular cells and tissues from being desiccated and facilitating the non-friction-bearing movement of the lids on the globe. So tears are necessary for preserving the eye's functional integrity.

Lacrimal apparatus consists of:

- Lacrimal gland: It's situated above the eye ball in the dorsolateral part of the orbit and secrete the tears.

It has two surfaces: Dorsal (Superficial surface) surface and Ventral (Deep) surface. as follows

- Dorsal (Superficial surface) surface; convex and adapt to the concave part of the lacrimal gland fossa of supraorbital (zygomatic) process of frontal bone.
- Ventral (Deep) surface; concave and adapt to the convex part of the eye ball.

Excretory ducts

There are 12 - 16 ducts opening into the conjunctiva dorsal fornix.

Figure 6: Lacrimal Apparatus of Dog.

Puncta lacrimalis

There are two puncta; dorsal (upper or superior) and ventral (lower and inferior), each one is a slit like opening situated behind the edge of lid near medial angle of the eye. except in the rabbit and pig, that have one punctum only.

Lacrimal canaliculi (canal)

The upper and lower lacrimal canals begin at the puncta and converge medially to open in the lacrimal sac.

The tears circulate through the cornea and accumulate in the lacrimal lake. From here, the tears enter the lacrimal canaliculi thought the puncta lacrimalis.

Lacrimal sac

It's the dilated origin of the nasolacrimal duct which lies in the lacrimal sac fossa of the lacrimal bone.

Nasolacrimal duct

25 - 30cm tube which extend (in a rostroventral direction) from the lower part of the lacrimal sac at medial canthus of eye into the floor of nasal vestibule.

Consists of

- First part; passes inside the lacrimal canal (osseus).
- Second part; passes inside the nasolacrimal groove which covered firstly by cartilage and then by mucosa of the middle nasal meatus.
- Terminal part (nasolacrimal opening); open in the floor of the nasal vestibule at the junction between the middle meatus and skin.

Note that: Produce tears whereas the lacrimal system allow tears to drain from the eye.

Extraocular muscle consists of the dorsal rectus, ventral rectus, Medialrectus, lateral rectus, dorsal oblique, ventral oblique, retractor oculi and levator palpebrae superioris muscle.

Note that: The dorsal oblique muscle's tendon turns around a piece of cartilage to change the direction of pulling. Levator palpebrae superioris muscle is eye muscle lid but considered as extraocular muscle.

Periorbital and orbital fat

The eyeball is embedded in orbital fat but is separated from it by a tough sheath of connective tissue, the periorbital consists of: apex (attached around the optic foramen) and base (attached to orbit bones).

Eye ball (eye bulb or globe) consists of

Fibrous tunica

The fibrous tunic consists of 2 components, the clear cornea and the opaque sclera. They vary mainly with this accounting in the arrangement or organization of their collagen and water content, for the difference in their transparency.

Figure 7: Eye ball structure.

Cornea

The Mammalian cornea is a transparent, avascular structure that transmits and refracts light and acts as a protective barrier to the internal ocular content whereas the cornea is avascular, it have nerve fibers. These are branches of the ophthalmic branch of cranial nerve 5, and are located mainly in the anterior third of the cornea.

Generally species cornea is fairly similar, differing only in thickness, curvature, and shape. Anterior part of cornea is convex with vertex in its center whereas the posterior part is concave. In general, the cornea of various species is remarkably similar, differing in thickness, curvature, and shape only.

The cornea is thickest peripherally. The Cornea structure (Fibrous and cellular part), from the outside in, are the corneal epithelium, Bowman's capsule, the corneal stroma, Descemet's membrane and the endothelium of anterior chamber.

Note that: Descemet's (Limiting membrane) joins to iris through pectinate ligament.

Sclera is the main component of the fibrous tunic, and joins the limbus cornea. Previously it is covered by a bulbar conjunctiva beneath which is the episclera, the scleral stroma and the fusca lamina. The episclera consists of loose bundles of collagen and elastic fibers, blood vessels, nerves, fibroblasts and melanocytes, depending on the species and pattern of colour. Has two surface ; external surface that attached cranially to bulbar conjunctiva and give insertion to extra- ocular muscles and internal surface which attached to the choroid by connective tissue called lamina fusca. The scleral structure is only fibrous part.

Corneoscleral junction (Limbus) is the junction between cornea and sclera that is composed of (a) small groove in the anterior part of the sclera and (b) caudal margin of cornea which envelops a small groove (a) in away similar to watch covers. contains circular venous plexus that drain the aqueous humor of the anterior chamber.

Vascular tunica (Uvea)

It's the middle layer of tissue surrounding the eye, is formed - from behind forward - by the choroid, the ciliary body, and the iris.

Choroid takes up the posterior five-sixths of the bulb and is mainly comprised of blood vessels. Its major functions are oxygen supply and nutrition for the eye. A dark pigment, melanin, occurs in

the choroid to help reduce uncontrolled reflection throughout the eye which could contribute to confusion. The anterior part of the choroid crosses through the ciliary body, and one of its functions is to fix the lens in place.

Ciliary body

T contains a muscle (Ciliary muscle) that can change the shape of the lens for adjustment to the distance or near sight, controlling the so- called lens refractive power (accommodation). Additional functions of the ciliary body are the production, secretion and outflow of aqueous humor (the latter via the so-called 'Schlemm's canal'), a watery fluid that fills both the anterior and the posterior chambers of the eye.

The Iris is connected to the anterior part of the ciliary body, covers the top of the lens. Similar to the aperture of a camera, it controls how much light is let into the eye. The iris forms a circular, thin structure within the eyeballthat regulates the size and the diameter of the pupil. It also contains pigments, the amount of which determines a person's eye colour. For example, in children with blue eyes, the iris contains less pigment than in brown-eyed kids.

Nervous tunic (neural)

The third and inner coat of the eye is the retina, which is responsible for the perception of images - vision.

The retina: It has a cup form with double layers; The outer pigment layer closely applied to the inner portion of the choroid and the inner neural layer slightly adherent to the vitreous body. See figure 8.

Figure 8: Retinal Layer.

It consists of two parts: Pars optica (the large posterior part that about 4/5 of neural retina) contains both pigmented and neural layers connected at ora ciliaris with the pars ceca (the second part of retina that smaller anterior fifth and contains only the pigment layer) divided into, pars iridica at iris and pars ciliaris at ciliary boy.

Eye chambers and refractive media

Eye chambers

There're three chambers that arranged according to the size from biggest to smallest as the following; vitreous chamber, anterior chamber and posterior chamber.

- **Anterior chamber**: Presents between the endothelium of the cornea (anteriorly) and the anterior epithelium of the iris (posteriorly), it contains aqueous humor and it communicates with the posterior chamber through the eye pupil.
- **Posterior chamber**: Small annular space lies between the posterior surface of the iris (anteriorly) and the both lens and suspensory ligaments (posteriorly).
- **Vitreous chamber:** It lies between the lens (anteriorly) and the retina (posteriorly) and contains vitreous body.

Figure 9: Eye chambers.

Refractive media

Actually, light is refracted across Four media. The first is the cornea (the transparent layer on the outside of the eye), then the aqueous humor (liquid), then the lens (which can slightly change shape to allow objects close and far to focus), and then there is the vitreous humor (liquid filling most of the inside of the eye) all of which light needs to pass through before it enters the retina. The aqueous

humor occupies both anterior and posterior chamber of the eye and the vitreous body occupies the vitreous chamber whereas the lens bathes anteriorly by aqueous humor of the posterior chamber and posteriorly by the vitreous body. The lens is completely cellular, the anterior cells forming a thin epithelium and the posterior cells much elongated, forming an onion like structure called lens fibers which forms the outer softer cortex and the inner firm nucleus [1-15].

Conclusion

Development of the eye

The main eye development occurs between week 3 and week 10, including ectoderm, neural crest cells, and mesenchyme. The neural tube ectoderm gives rise to the epithelial retina, iris and ciliary body in addition to optic nerve, smooth iris muscles, and some of the vitreous humor. Surface ectoderm is gives rise the lens, the conjunctival and epithelial cornea, the eyelids and the lacrimal apparatus. The remaining ocular structures form from mesenchyme.

The vertebrate eye comprises tissues of various embryonic origins: the lens and cornea are derived from the ectoderm surface, while the iris and ciliary body retina and epithelial layers are derived from the anterior neural plate. The timely action of transcription factors and inductive signals ensure proper development of the various components of the eyes. Establishing the genetic basis of eye defects in zebrafish, mouse, and humans has been an important tool for analyzing this complex process in detail. During gastrulation, a single eye field arises centrally inside the anterior neural plate; at the molecular level, it is characterized by the term "eye-field transcription factors". The single eye field is divided into two, thereby creating the optic vesicle and the optic cup (influence of the lens placode). Under influence of the underlying optic vesicle the lens emerges from the lens placode (surface ectoderm). Pax6 acts as the master control gene in this process and genes are activated which encode cytoskeletal proteins, structural proteins or membrane proteins. The cornea is formed from the surface ectoderm, and cells from the periocular mesenchyma that migrate into the cornea giving rise for the future cornea stroma. The cornea is formed from the surface ectoderm and cells from the periocular mesenchyme migrate into the cornea giving rise to future cornea stroma. Similarly, the iris and the ciliary body are shaped from the optic cup. The outer layer of the optic cup becomes retina's pigmented epithelium, and the main part of the optic cup's inner layer later forms a neural retina of six distinct cell types including under the photoreceptors. The cells of the retinal ganglion develop towards the optic stalk which forms the optic nerve.

Bibliography

1. Biology Dictionary, Animal eye structure.
2. Land M. "The Evolution of Eyes". *Annual Review of Neuroscience* 15.1 (1992): 1-29.
3. Montag E D. "Parts of the Eye" (2017).
4. Liz Segre; eye illustration by Stephen Bagi. Human Eye Anatomy - Parts of the Eye Explained. Retrieved (2017).
5. The New Encyclopedia Britannica. Chicago: Encyclopedia Britannica (1987).
6. University of Tennessee.
7. Modified from Evans HE [1993]: Miller's Anatomy of the Dog, 3rd ed. Saunders, Philadelphia.
8. Remington LA. Clinical Anatomy of the Visual System, 2nd ed. Butterworth-Heinemann, St. Louis (2005).
9. The fourth edition of this bestselling book continues to provide a comprehensive description of the anatomy and physiology of dogs and cats. The Authors is Victoria Aspinall, Melanie Cappello. CABI, (2019).
10. Scott E. Brodie, in Brocklehurst's Textbook of Geriatric Medicine and Gerontology (Seventh Edition) (2010).
11. John V Forrester., *et al*. The Eye (Fourth Edition) (2016).
12. Kirk N Gelatt. Department of Small Animal Clinical Sciences, College of Veterinary Medicine, University of Florida.
13. "Fibrous Tunic - Veterinary Histology". updated: 23-07-2019. 10:50 (2019).
14. Atlas of Plant and Animal Histology, Dep. of Functional Biology and Health Sciences Faculty of Biology, University of Vigo, Spain.
15. Eye development, Current Topics in Developmental Biology, Jochen Graw (2010).