LESSONS TO BE LEARNED FROM THE BEAUTIFUL STRUCTURE OF PET EYES

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Claudia Hartley encourages practitioners to become more familiar with their patients' eyes so they can spot the abnormal when it appears

GRANTED, I am coming from a biased place, but our pets' eyes are incredible. Not only are they capable of receiving and transmitting the world to their brains, they are one of the most beautiful structures to look at. Who doesn't find friendship and security when they look into their pet's eyes?

And your clients often feel this way about their pet's eyes too. Even if ophthalmology doesn't float your boat, it's clinically important to understand the structure and function of both the normal and diseased eye. I hope to encourage you to look into your patients' eyes more often. Most of them will be normal, but that will help you spot the abnormal. Think of it as building a reference atlas you can draw on for the rest of your career.

Much as ophthalmology can be shrouded in mystery for many vets (largely because many vet schools lack full-time ophthalmology services, so exposure as an undergraduate was limited), it is more accessible than many people would imagine. A lot of it is pattern recognition. While the diagnosis may require further investigation, you can usually focus the direction of your investigations and narrow down your preliminary list of differential diagnoses.

This article aims to highlight the normal ocular appearance in cats and dogs. Believe it or not, there are a few normal variations that can catch you out. Most of these are linked to coat colour or breed.

Hopefully, it will go some way to help build your reference atlas.

Orbit

The dog orbit is not a complete bony orbit. Dorsolaterally, the orbit is completed by a ligament (the lateral orbital ligament). The floor of the orbit is soft tissue (medial and lateral pterygoid muscles).

Other than the globe, the orbit also contains the extraocular muscles (in a cone with the base at the level of the back of the eye to the orbital apex), zygomatic salivary gland, lacrimal gland, fat pads and neurovascular structures.

In cats, the orbit is also incomplete; however, there is less retrobulbar fat, and the zygomatic salivary gland is vestigial. The feline optic nerve lacks the degree of sigmoid flexure present in dogs, and therefore is more prone to tractional injury when the globe is rostrally displaced. This has consequences for enucleation in cats in which it's important not to put too much tension on the optic nerve, as the contralateral optic nerve can be damaged via tension through the optic chiasm.

Orbital inflammation and swelling, or neoplastic processes, of any of these orbital structures may cause exophthalmos (anterior protrusion of the globe). Conversely, loss of any of these structures may cause sinking of the globe (enophthalmos).

Eyelids

The eyelids are important for protecting the globe, so they should be able to blink in response to anything potentially injurious. That means tapping the eyelid should illicit a brisk and complete blink. This is the palpebral reflex and tests both eyelid sensation (by the ophthalmic [medial canthus] and maxillary [ateral canthus] branches of the trigeminal nerve) as well as eyelid motor function (facial nerve and orbicularis oculi).

Similarly, a menacing gesture towards the eye (but be careful not to create an air current) should stimulate a blink (testing the retina, optic nerve, optic tracts, lateral geniculate nucleus and optic radiations, visual cortex – as it is a conscious response rather than a reflex – and the facial nerve to orbicularis oculi).

Unfortunately, many breeds are bred for larger eyelids (macropalpebral fissures) to create a more "droopy" look, or even "diamond eye". Some breeds will suffer with conformational entropion, some may have ectropion, and others may have a combination of both ectropion and entropion (diamond eye).

Some breeds will have heavy facial folds, and these may push eyelids into the eye or contact the globe directly. Sometimes they weigh the eyelids down (brow droop) and this can adversely affect vision, as well as push eyelid hair into the eye (trichiasis).

Eyelid agenesis can be seen in young kittens as a congenital defect. The lateral upper eyelid fails to form properly and results in trichiasis. This has not been reported in dogs. This defect may be seen in conjunction with other defects such as persistent pupillary membranes (PPM) or cataract.

The upper eyelids have cilia (eyelashes) in dogs, usually starting about a quarter of the way along the lid from the medial canthus until almost at the lateral canthus. Cats, however, have no true cilia on the upper eyelid, though the leading edge of eyelid hair can be distinct enough to be considered cilia.

The eyelid margins of both species have a line of meibomian gland openings (often referred to as the “grey line”). These openings allow meibum (the oily portion of the tear film) to be secreted on to the ocular surface. Blocked or inflamed ducts can result in pouting openings, inspissated secretions within the glands, and later chalazion if the glands rupture and release their lipid secretion into the eyelid tissue (inciting a granulomatous response). Cats may develop multiple chalazion in chains and this is often referred to as lipogranulomatous conjunctivitis.

The meibomian glands may also be the conduit for abnormally directed hairs (distichiasis), which is more common in dogs, and certain breeds appear to inherit this disease. Depending on the coarseness of the hairs, and the direction (corneal contact or not), these may or may not cause clinical signs (increased blink rate and lacrimation).

Conjunctiva and third eyelid

Normal conjunctiva is a pale pink and usually the palpebral conjunctiva is pinker than the bulbar conjunctiva, which should appear almost transparent over the white sclera unless it is inflamed. The conjunctiva should also be smooth and shiny in appearance – dry, red or thickened conjunctiva is not normal.

Abnormally directed hairs may exit through the palpebral conjunctiva and impinge on the cornea. These are almost always associated with corneal ulceration and intense discomfort. Generally, they can be found approximately 3mm to 5mm from the eyelid margin on the palpebral conjunctiva, usually (but not exclusively) on the upper eyelid conjunctiva. In dogs with pale coat colours, these are not always straightforward to find. Excision is curative.

The third eyelid is a fold of conjunctiva containing a flat T-shaped cartilaginous plate. In dogs, the leading edge of the third eyelid may be either pigmented or non-pigmented. In cats, however, the leading edge is rarely pigmented. The third eyelid should be smooth and follow the contour of the cornea, acting to sweep the tear film evenly over the ocular surface.

The third eyelid in dogs moves passively, as the globe retracts into the orbit it displaces the third eyelid over the cornea. This means that if a globe is smaller than normal (microphthalmos) the third eyelid may appear more protruded. Also, if the globe is retracted into the orbit (most commonly due

to pain) the third eyelid will be more prominent.

In contrast, movement of the third eyelid in cats can also be under autonomic control due to the presence of bands of smooth muscle attaching to the third eyelid. Protrusion of the third eyelid can be witnessed in cats infected with torovirus (often in conjunction with chronic or intermittent diarrhoea).

Nasolacrimal system

The nasolacrimal punctae are located medial to the most medial meibomian gland, and 1.0mm to 2mm inside the eyelid margin. The punctae open into lower and upper lacrimal canaliculae, which combine to form a lacrimal sac.

This is a common location for foreign bodies to lodge, causing dacryocystitis, and any resultant mucopurulent discharge can be milked from the sac to emanate from the lower punctum. Foreign bodies are more common in dogs than cats.

Apart from being a shorter system in cats and brachycephalic dogs, the nasolacrimal system is similar in cats and dogs. The nasolacrimal duct passes through a short bony channel (another site of potential foreign body retention) before continuing to the nasal cavity. The system terminates in a nasal punctum on the distal medioventral nasal mucosa.

Sclera and episclera

Normally, the cat has little sclera “show”, whereas in dogs this can be quite extensive, especially in the brachycephalic breeds. In some breeds, such as the pug or Chihuahua, the gaze can be divergent, leading to more medial scleral exposure than in other breeds (which tend to have only lateral sclera visible at rest).

Cornea

The cornea should be a transparent window, and the presence of any opacity is abnormal. It is composed of regularly arranged collagen fibrils and this allows for minimal scattering of light and, therefore, transparency.

Cellular deposition in or on the cornea may give a cream to yellow appearance (for exam ple, stromal abscess or eosinophilic keratitis).

Vascularisation may enter the cornea as a response to inflammation or injury. Blood vessels may be limited to the superficial layers of the cornea, or reach deep into the stroma. Often the depth of the blood vessels is dictated by the depth of the inciting inflammation, so this can help point to the

underlying cause.

Superficial corneal vessels will be seen to cross the limbus from the conjunctival vessels. Deeper vessels appear to start from limbus itself (in fact they arise from deeper episcleral and scleral vessels that may not be visible through the sclera).

Pigmentation in the cornea can occur with chronic inflammatory conditions of the cornea, but also in corneal necrosis (sequestrum).

Generally, pigmentation is more common in the canine cornea than the feline cornea. Sequestrum formation is the exception, however, and although there have been rare reports of corneal sequestration in dogs, it is almost exclusively a feline condition.

Lipid deposition in the cornea has a scintillating, sparkly white appearance. This can be seen with corneal degeneration (usually associated with vascularisation) or as part of an inherited and (always) bilateral canine corneal dystrophy. Lipid within the cornea is rare in cats.

Mineral deposition in the cornea can be encountered with corneal degeneration. Spicules of white mineral (calcium) may be seen and is frequently associated with ulceration.

Again, this is rarely encountered in the feline cornea.

Iris

The dog iris is most commonly brown, although that may vary from a pale, almost amber, colour, to a dark chocolate. A number of dog breeds may have blue irides, particularly associated with the merle coat colour gene, but also in husky and malamute breeds. It is also possible to see both brown and blue colour within the same iris, as well as in different eyes of the same dog (*heterochromia iridis*).

Cats most commonly have yellow-green irides, but again there is some variation including green, amber and bluecoloured irides.

The canine pupil is round unlike the vertical slit pupil of the cat. Interestingly, the two halves of the pupil in the cat are also independently innervated (by nasal and malar branches of the parasympathetic component of the oculomotor nerve CN III). This means that inflammation of one of these nerve branches in isolation can result in a D-shaped pupil (paralysis of the iris on the “wide side” of the D) or a reverse D-shaped pupil.

The iris can be divided into two zones – the pupillary zone (closest to pupil) and the ciliary zone (closest to sclera) divided at the iris collarette. This collarette is the source of blood vessels within the embryonic pupillary membrane. Therefore, PPMs are seen arising from the collarette. In

contrast, inflammation may cause the iris (pupil) margin to adhere to other intraocular structures (most commonly the anterior lens capsule), and these attachments are called synechiae.

When they attach to the lens capsule they are called posterior synechiae; when they attach to the inside of the cornea, they are called anterior synechiae. Thus, distinguishing the cause of iris attachments to intraocular structures is based on the source of the attachment.

Senile iris atrophy appears as thinning of the pupillary border of the iris. Initially, this may mean this region can be transilluminated, but later atrophy may cause the edge of the iris to have a lacy appearance. This is more common in some breeds of dogs (poodles, cocker spaniels) than others, and is rarely observed in cats.

Inflammation may cause the iris to be hyperaemic or develop new blood vessels to give the surface a reddened appearance (rubeosis iridis). This is not easily identifiable in a brown canine iris, but more visible in a feline yellow or blue iris, and a canine blue iris. Chronic inflammation can cause hyperpigmentation of the iris causing a darker brown appearance, or causing a blue iris to appear yellow to brown.

Pigmentation of the iris may also occur in iris “freckles” (or naevi). However, more ominously, this can occur with iris melanoma in both cats and dogs.

In dogs, most of these melanomas will be confined to the eye, but in cats uveal melanoma can readily metastasise and threaten the life of the cat.

Identifying benign from malignant pigment changes in cat irides is not always straightforward. A velvety appearance to any pigmented region in the iris, abnormal pupil movement or shape, extension into the iridocorneal angle, or pigment dispersion into the anterior chamber are all potential causes for concern. Better, more objective means of diagnosis of these life-threatening cases is the subject of research at the Animal Health Trust.

Uveal or iris cysts are structures that arise from the posterior pigmented epithelium of the iris. As fluid-filled cysts of epithelium, which may pinch off from the iris surface to become free floating, they can often be transilluminated. This helps to differentiate them from more sinister pigmented masses. Ocular ultrasound can also confirm the structures as fluid filled. Where they are numerous and interrupting vision they can be deflated by diode laser or evacuated surgically from the eye. In cases with less bothersome cysts benign neglect is often the recommended treatment.

The pupillary light reflex (PLR) is a test of the retina, optic nerve, chiasm, optic tracts, pretectal nucleus in the mesencephalon, the Edinger-Westphal nucleus (oculomotor parasympathetic [PSM] nucleus), the PSM portion of oculomotor nerve, ciliary ganglion and the short ciliary nerves to the iris sphincter muscle. It does not test vision, and sensitivity-wise not many retinal photoreceptors are required to provoke a positive PLR.

It is a good idea to test both the direct and consensual (indirect) PLRs to help neurolocalise if there is an abnormality present. Anisocoria is the term used to describe pupils of unequal size.

The sympathetic nervous supply to the iris arises in the hypothalamus and travels caudally to leave the spinal cord at T1-T3. The preganglionic fibres travel via the thoracic sympa thetic trunk, then the cervical sympathetic trunk, to synapse in the cranial cervical ganglion ventromedial to the tympanic bullae. From here the postganglionic sympathetic fibres run via the middle ear and along the ventral surface of the petrosal bone to enter the orbit via the orbital fissure. Interruption to this supply results in Horner's syndrome (ptosis, enophthalmos, third eyelid protrusion and miosis).

Lens

The lens is partly responsible for focusing sharp images on to the retina (the cornea and tear film also has a role). Naturally it should be transparent, and is suspended by zonular ligaments from the ciliary body to the anterior and posterior borders of the lens equator.

Occasionally, small flecks or spots of pigment may be seen on the anterior lens capsule as a legacy of the embryonic pupillary membrane. More extensive strands of persistent pupillary membranes (PPMs) may course from the iris collarette to the lens capsule and cause a focal cataract. PPMs can also run from iris to iris or iris to cornea (causing a corneal opacity).

Any opacity of the lens is termed a cataract. The location of this opacity can sometimes point to the original cause of the cataract (for example, anterior capsule cataract may be due to a PPM, other congenital defect, or trauma; posterior polar subcapsular cataracts are inherited in some breeds, such as the Labrador retriever).

Cataracts can also be categorised according to their stage of maturity – how dense they are. Incipient cataracts are where the opacity occupies less than 15 per cent of the lens volume.

In immature cataracts, the tapetal reflex can still be seen through the opacity, whereas in a mature cataract this is obliterated and the whole lens appears opaque.

In hypermature cataracts, the lens proteins start to liquefy and escape through the capsule, often inciting uveitis (lens-induced uveitis, and more specifically phacolytic uveitis), as well as causing the lens to shrink and the capsule to wrinkle.

Rupture of the lens capsule may release lens protein that is antigenic to the eye, and incites an aggressive phacoclastic uveitis. Hence, it is important to dilate the pupil in a traumatised eye (such as in an altercation with a cat's claw) as intraocular damage will require specialist assistance to save the eye.

Vitreous

The vitreous is largely water, collagen and hyalocytes, with a mix of glycosaminoglycans and other proteins. The full function of the vitreous is poorly understood, but it supports the retina against the choroid (the vast majority of the retina's vascular supply), and acts as a "sink" for metabolic waste products from the retina, lens and ciliary body.

Over time, the vitreous gel tends to liquefy (vitreal degeneration) and to a certain extent this is a normal ageing change. It may occur early or to a greater extent than normal, particularly in the face of inflammation, when white blood cells and pigment may be dispersed into the vitreous (seen as "floaters").

Another form of vitreal degeneration seen almost exclusively in dogs is asteroid hyalosis, where calcium phospholipid particles (white) can be seen suspended in the vitreous gel. Although there may be some mobility of these particles they tend to stay suspended so they are readily identifiable on retinal examination. In people, these may often be associated with resolving vitreal haemorrhage (for example, following head trauma or systemic hypertension), diabetic retinopathy or posterior segment neoplasia. However, this doesn't appear to always be the case in dogs.

Synchysis scintillans is similar in appearance to asteroid hyalosis but the vitreous gel has liquefied so the particles are no longer suspended, but swirl about the posterior segment with eye movements, rather like in a snow globe. The particles in synchysis scintillans are cholesterol crystals, and are not always white, or spherical (can be discoid in shape).

During embryonic development a vascular supply to the lens runs from the optic nerve across the vitreous. This should start to recede at day 42 of gestation and be complete by two weeks postnatally in cats and dogs. Persistence of part or the entire hyaloid artery is seen as a strand or stalk of tissue running from the optic nerve head (or, more unusually, the retina) to the posterior lens capsule. If the system remains patent, red blood cells may be seen within the strand and haemorrhages may even occur into the vitreous or lens.

Retina

The retina is beautiful in cats and dogs (also in horses, cattle, sheep and goats). Ours (like pigs) is rather dull.

The main aesthetic improvement is the addition of a tapetum. This is part of the choroid, but contains light-reflecting structures that enhance light reflection back to the overlying retina. The theory is this allows the retina a second chance at light that was transmitted through the retina on first passage rather than absorbed.

There are many tapetal variations, firstly in colour (such as miniature schnauzers and Staffordshire bull terriers having a fabulous violet border to theirs, or red cocker spaniel dogs often having an ambercoloured tapetum) but also in size with the miniature breeds tending to have smaller

tapetums. The tapetum can be absent altogether in some dogs, most notably the blueeyed patients.

The non-tapetal fundus is usually pigmented (pigment both within the choroid and retinal pigment epithelial layers), but where a patient is “subalbinotic” the pigmentation may be reduced to absent in these layers leading to choroidal vessel visibility through the overlying retina. Where just the RPE pigment is missing, the fundus is often described as “tigroid” at the choroidal vessels and intervening choroidal pigment give a tiger-striped appearance to the non-tapetal fundus. If pigment is absent in both layers the choroidal vessels will be seen as red stripes against a white background of sclera.

Optic nerve

The optic nerve in dogs is myelinated, so tends to have a whiter-pinker and fluffier appearance than ours or cats.

The shape of the optic nerve head is round and often darker in appearance in cats due to the lack of myelination. Dogs, in contrast, can have a variable shape to their optic nerve head dictated by how much myelination is present. Interestingly, often the longer-coated breeds have a fluffier appearing optic disc (for example, golden retriever) although the boxer appears to be an exception to this with often extensive myelination. Dogs also have a circle or partial circle of retinal vessels on the optic nerve head, whereas in cats the vessels curve over the disc rim and seem to disappear.

If you have time in your practice to examine your patient’s eyes, even if the animal came for a routine vaccination, you won’t be disappointed.

Not only will you become familiar with the normal appearance and all its variations, you may also pick up subclinical disease before it becomes clinical. The eyes can be a window on the nervous system, the vascular system and the immune system, as well as having diseases exclusive to the eye.

• All photos are used courtesy of the Animal Health Trust.