Examination of the feline eye and adnexa

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SUMMARY

The feline eye is large and easy to examine and ophthalmic assessment is a rewarding procedure, provided that the examiner is patient and the correct equipment is selected and properly used.

This paper was commissioned for publication in EJCAP.

Introduction

It is often possible to reach an accurate ophthalmic diagnosis on the basis of the history, observation and examination, provided that the examiner is familiar with the normal function and structure (Fig. 1) of the feline eye (globe) and adnexa (eyelids, lacrimal apparatus, orbit and para-orbital areas), as well as the selection and use of ophthalmic diagnostic equipment [5, 6, 18, 19, 20].

Equipment

The basic equipment required for examination consists of a focal light source, ideally a Finhoff transilluminator, some form of magnifying device, a condensing lens and a direct ophthalmoscope. For those who take a particular interest in the subject, additional equipment, notably a slit lamp biomicroscope, binocular indirect ophthalmoscope and a device for measuring intraocular pressure, will be required.

Various disposable items are also needed in order to perform a range of diagnostic tests; the essential ones are topical ophthalmic stains (e.g. fluorescein sodium), ocular irrigant (e.g. sterile saline), local anaesthetic (e.g. proxymetacaine hydrochloride), tropicamide 1%, Schirmer tear test papers, cotton wool, sterile culture swabs, surgical blades, forceps, glass slides, lacrimal cannulae, sterile syringes and needles.

Use of Instruments

Focal Illumination

A Finhoff transilluminator or pen light provides a useful light source for examination of the eye and adnexa (Fig. 2). In cats it is possible to examine the drainage angle directly, if somewhat incompletely, using focal illumination and this technique should be included at this stage of the examination. If there is any suggestion of abnormal intraocular pressure or abnormality of the drainage angle, the intraocular pressure should be measured as part of the assessment.

Magnification

Some form of magnification will be required as a diagnostic aid and this is most readily achieved with a magnifying loupe (ideally combined with a light source), an otoscope with

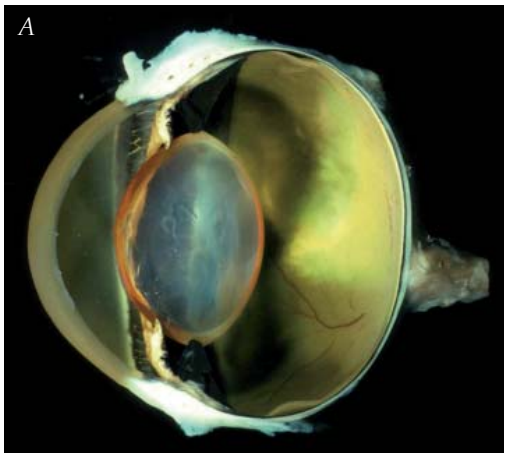

Fig. 1 Gross specimens of the adult feline globe (with acknowledgements to J. R. B. Mould). The feline eye is superbly adapted to vision under a range of lighting conditions, including dim light and near darkness. In (a) note the almost spherical globe and large cornea and lens, together with the wide drainage angle and clearly defined pectinate ligaments which span the cleft between the iris (right) and cornea (left). In (b) note the extent of the tapetal fundus and the location of the optic nerve head within the tapetal fundus.

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Fig. 2 A focal light source being used for examination of the eye and adnexa. This examination should be performed in the dark and the light shone from as many different angles as possible in order to build up a full picture.

Fig. 3 An otoscope with the speculum removed provides a simple means of combining magnification and illumination. This examination is best performed in the dark.

Fig. 4 The Kowa hand held models are excellent for use in cats and cordless models such as the SL 14 are available. The Kowa SL2 is illustrated here.

Fig. 5 A Nikon desk mounted slit lamp biomicroscope in use. Most cats can be examined with this type of slit lamp and photography is much easier than with hand held models.

speculum removed (Fig. 3), a direct ophthalmoscope, or a slit lamp biomicroscope.

Slit lamp biomicroscopy

The slit lamp biomicroscope consists of a light source (diffuse illumination or a slit beam) and a binocular microscope which can be moved in relation to the light source. Whilst primarily a

Fig. 6 A cat with lysosomal storage disease (mucopolysaccharidosis). In (a) subtle pancorneal clouding is apparent and details of the iris are indistinct (compare with the normal external eyes illustrated in Fig. 16, 21). Such changes are very obvious with slit lamp examination (b).

Fig. 7 Monocular indirect ophthalmoscopy being performed with a 28D condensing lens and penlight. Mydriasis is desirable, if not essential, for all types of indirect ophthalmoscopy and the technique must be performed in the dark. A virtual and inverted image should fill the whole of the lens if the technique is carried out correctly.

Fig. 9 Binocular indirect ophthalmoscopy using a spectacle indirect ophthalmoscope. Examination should be performed in the dark following mydriasis.

means of providing magnified detail of the adnexa and anterior segment, the posterior segment can also be evaluated if a high dioptre (for example +90D) condensing lens is interposed. In cats it is possible to use either a hand held model that needs a mains electricity supply (Fig. 4), or a hand held cordless model, or a table mounted slit lamp (Fig 5).

Focal examination

Gross lesions involving, for example, the eyelids, cornea, anterior chamber, iris, lens or anterior vitreous can be examined with a diffuse beam of light (Fig. 6a). When the diffuse beam is narrowed to a slit (Fig. 6b) an optical section of, for example, the cornea or lens may be visualised when the beam is directed obliquely (up to an angle of 45 degrees).

Retro-illumination

Retro-illumination uses the reflection from the iris, lens or ocular fundus to illuminate the cornea from behind. Minute corneal changes can be detected with this method. The technique is impressive when the fundus reflex is used as the reflecting medium following dilation of the pupil (mydriasis).

Fig. 8 Monocular indirect ophthalmoscopy using a commercially manufactured instrument. Examination should be performed in the dark, ideally, following mydriasis.

Fig. 10 A direct ophthalmoscope (Keeler).

Indirect Ophthalmoscopy

This technique can be performed most simply following pupil dilation with one drop of tropicamide 1%. Monocular indirect ophthalmoscopy can be performed with a condensing lens (for example, 20D or PanRetinal 2.2) and a focal light source (Fig. 7). The lens is held some 2-8 cm from the cat's eye and the fingers of the hand holding the lens should rest lightly on the animal's head. The focal light source is shone through the lens from a distance of some 50-80 cm (the distance between the cat's eye and the observer's eye).

Monocular indirect ophthalmoscopy produces an image which is virtual (that is, viewed indirectly), inverted and magnified, with the magnification depending on the strength of the lens. More refined and expensive monocular ophthalmoscopes (Fig. 8) which produce an erect image are also available.

The advantages of indirect ophthalmoscopy include a wide field of view and a reasonable image, even when the ocular media are cloudy. Binocular instruments (Fig. 9) are also available, although they are expensive; they provide the additional advantage of depth perception (stereopsis).

Direct Ophthalmoscopy

The direct ophthalmoscope (Fig. 10) consists of an on/off switch with incorporated rheostat, a light source, a beam selector (for example, large diameter beam, small diameter beam, slit beam and red-free light as an alternative to the normal white light source) and a selection of magnifying (black = +) and reducing (red = -) lenses housed in a lens magazine. The observer looks directly along the beam of light to view the object of interest.

Fig. 11 Distant direct ophthalmoscopy. This technique should be performed in the dark and a mydriatic should not be used until the size and shape of the pupils have been compared.

Fig. 12 Lens opacities appearing as dark silhouettes when viewed using distant direct ophthalmoscopy.

Distant direct ophthalmoscopy

Distant direct ophthalmoscopy can be used as a quick screening method prior to more detailed examination (Fig. 11); it is an essential aspect of ophthalmic examination and can provide information about the direction of gaze, pupil size and shape, as well as the presence of any opacities between the observer and the ocular fundus. Any opacities in the path of the fundus reflex appear as silhouettes (Fig. 12). The ophthalmoscope is usually set at 0 and the tapetal or fundus reflex is viewed through the pupil, with the observer at about arm's length from the patient. Distant direct ophthalmoscopy is the easiest way of comparing both eyes simultaneously.

Close Direct Ophthalmoscopy

Close direct ophthalmoscopy provides an image which is real (that is, viewed directly), erect and magnified. Fundus magnification is greatest with direct ophthalmoscopy, followed by panoptic ophthalmoscopy and then indirect ophthalmoscopy.

Close direct ophthalmoscopy is used for examination of the ocular fundus following indirect ophthalmoscopy and distant direct ophthalmoscopy. Close direct ophthalmoscopy should be performed with the ophthalmoscope placed as close as possible to the observer's eye and some 2 cm from the patient's eye, usually with a setting of 0. Modern halogen bulbs provide very bright illumination, so the examiner should employ the rheostat which is incorporated in the on/off switch, both to ensure that the light intensity is kept at comfortable levels for the patient and to make sure that subtle lesions are not missed because the light is too bright. The instrument should be lined up in the correct position, with the light shining through the pupil, before the examiner looks through the viewing aperture (Fig. 13a). Fingers of the hand holding the ophthalmoscope can be rested lightly against the animal, so that any head movements can be accommodated and the position of the cat in relation to the ophthalmoscope is more readily appreciated (Fig. 13b). The use of over bright light is probably the commonest reason for failure to examine the fundus adequately. Cats generally resent close bright light and, because there is voluntary control over third eyelid movement, the field of view can be limited. In addition, the pupil constricts rapidly to a vertical slit when a bright light is shone in a normal eye when a mydriatic has not been used.

It is easiest for spectacle wearers to remove their spectacles and set the ophthalmoscope according to the prescription issued for the eye they will use for examination. This allows the instrument to be placed much closer to the observer's eye.

Fig. 13 Close direct ophthalmoscopy. This technique should be performed in the dark and mydriasis is essential for comprehensive examination. The ophthalmoscope is placed in the correct position with the light shining through the pupil before the examiner looks through the viewing aperture (a). The examiner is now viewing the fundus and the ophthalmoscope is manipulated to ensure that logical examination of each quadrant is performed. Note how the instrument is steadied against the cat's head and the lack of any restraint (b).

Fig. 14 Normal adult cat. Note the symmetry of the face, eyes and pupillary aperture.

Fig. 15 Horner's Syndrome. In this cat the asymmetry is obvious as the palpebral aperture is smaller on the right and there is also some prominence of the third eyelid and constriction of the right pupil relative to the normal pupil of the left eye.

Protocol for Examination of the Eye and Adnexa

History

Once the age, breed, sex and vaccination status of the cat has been recorded, information about the present problem and any previous health problems should be obtained, as well as details of any current or past treatment. Other relevant enquiries include the management and lifestyle of this cat and any others with which it may come into contact.

Examination

Examination is usually best undertaken in a quiet room which can be darkened completely and ophthalmic examination follows general and neurological examination. Aspects of neurological examination that relate specifically to ocular disease include visual placing reactions, relevant cranial nerve examination and autonomic nervous system assessment and these are included in the protocol that follows. Ophthalmic examination is performed in two parts; the first part in daylight or artificial light and the second part in the dark.

Initially the cat is observed from a distance in order to assess the nature and severity of the ocular problem. If appropriate, the cat should be allowed to move freely about the consulting room, under different lighting intensities, as a very crude way of assessing vision (see below), as well as mental status, posture and gait. Normal cats are often reluctant to move around in strange surroundings, so ***obstacle tests*** are of limited value. Likewise, there may be difficulties in interpreting the ***following response,*** which is the ability to follow a cotton wool ball usually when dropped from a height under conditions of normal lighting. In a compliant patient both central and peripheral vision can be tested in this way, but unfortunately, many normal cats are indifferent to the test. In darkness the following response can be tested by playing a bright light on the surface of the examination table and this is often more likely to elicit the interest of a normal cat and can be used as a rudimentary test of vision.

Under conditions of **daylight or artificial light** the general appearance of the eyes and adnexa is observed and each side compared to ensure that they are symmetrical (Fig. 14, 15). The position of the globe in relation to the orbit should be assessed from in front of the patient and from above. The incomplete bony orbital rim should also be inspected both visually and manually.

Fig. 16 External eye of a normal adult cat. The eyelid margins (upper and lower eyelid) are clearly defined and heavily pigmented; the leading edge of the third eyelid is also pigmented There is an undisrupted corneal reflex (the camera flash) and the cornea fills almost the whole of the palpebral aperture in this animal with only a small area of bulbar conjunctiva visible laterally (temporally). Note that there is no clear distinction of the pupillary and ciliary zones of the iris and that relative lack of surface iris pigment allows portions of the major arterial circle to be viewed at the iris periphery.

The lacrimal apparatus is not evaluated in any detail at this stage, although the presence and position of the upper and lower lacrimal puncta should be confirmed and the possibility of abnormalities of production, distribution and drainage may be suspected according to the clinical presentation. The frequency and adequacy of blinking should be noted as an empirical means of assessing distribution of the tear film.

The external eye should be assessed (Fig. 16), starting with the margins, outer and inner surfaces of the upper and lower

Fig. 17 A cat with extensive symblepharon as complication of neonatal feline herpes virus (FHV-1) infection. There is occlusion of the upper and lower lacrimal puncta, the third eyelid is adherent to the palpebral conjunctiva and the ventral conjunctival fornix has effectively been obliterated.

Fig. 18 The corneal reflex is disrupted in this cat. The pathognomonic superficial dendritic ulcers associated with herpetic keratitis have been stained with fluorescein.

eyelids. There is close apposition of the upper and lower eyelids to the globe, so examination of their inner surface is not always easy. Nonetheless this is an important aspect of examination in a species in which developmental defects of the eyelids and symblepharon are not uncommon (Fig. 17). The presence and position of the third eyelid should be observed and its outer surface inspected once the eyelid has been protruded by pressure on the globe through the upper eyelid. The inner surface of the third eyelid is not examined routinely.

The ocular surface, defined as the continuous epithelium which begins at the lid margin, extends onto the back of the upper and lower eyelids, and both surfaces of the third eyelid, into the fornices and onto the globe, is examined next. Naked eye examination should indicate whether the appearance of the ocular surface is normal. A light source can be used to ensure that the ***corneal reflex*** is normal (in this situation the corneal 'reflex' is the light from the light source reflected in miniature on the corneal surface without disruption). Any disruption of the corneal reflex indicates a tear film deficit, a superficial corneal abnormality (Fig. 18), or both. It may also be appropriate to check corneal sensitivity at this stage, particularly in those situations in which corneal anaesthesia may be part of the clinical presentation (for example, herpetic keratitis). This can be done in an empirical fashion by touching the cornea lightly with a fine wisp of cotton wool (afferent arm – cranial nerve V), which should elicit a brisk blink (efferent arm facial nerve – cranial nerve VII) and retraction of the globe (efferent arm abducens – cranial nerve VI) in the normal cat.

A quick assessment of the remainder of the eye is made at this point, to check the pupil size and shape and any gross deviation from normality requiring more accurate assessment in the dark. It is also appropriate to assess the relevant cranial nerves (CNs) and autonomic nervous system in more detail at this juncture [4, 21].

Cranial nerve II (Optic)

Vision is tested by means of an obstacle test, the following response, menace response, dazzle reflex and visual placing response, The limitations of an **obstacle test** and interpretation of the **following response** have been outlined above.

The **menace response** evokes a blink in reaction to a hand or object moved slowly and steadily towards the eye. As well as the afferent sensory pathway (CN II), a motor pathway via the facial nerve (CN VII) is involved. It is important not to generate air movement as this can stimulate the cornea (CN V).

The **dazzle reflex** (retinal light reflex) is a subcortical reflex which initiates a bilateral partial eyelid closure (CN VII) when a bright light is shone into the eye.

The **visual placing response** involves moving the cat towards the edge of a table and checking for appropriate extension and placing of the thoracic limbs on the table.

Cranial nerve III (Oculomotor)

The oculomotor nerve (CN III) nerve is responsible for pupillary constriction (via parasympathetic innervation), innervation of extra-ocular muscles (dorsal, medial and ventral rectus, and the ventral oblique) and partial innervation of the upper eyelid (levator palpebrae superioris). CN III is assessed by observation of pupil size (symmetry, direct and indirect pupillary light response, eye position and eye movements).

Deficits of CN III produce mydriasis, inability to constrict the pupil in response to light, ventrolateral strabismus with no movement of the globe except laterally, and ptosis.

Cranial nerves IV (Trochlear) and VI (Abducens)

These nerves supply motor function to extra-ocular muscles. The trochlear (CN IV) innervates the dorsal oblique, and the abducens (CN VI) innervates the lateral rectus and retractor oculi muscles.

A deficit of the trochlear (CN IV) causes mild rotation of the globe with the dorsal aspect turned laterally (dorso-lateral rotation),

the abnormal direction is easiest to discern by examination of the accompanying pupil rotation.

A deficit of the abducens (CN VI) causes medial strabismus and a lack of globe retraction in response to touching the cornea as described earlier.

Cranial nerve V (Trigeminal)

The trigeminal nerve (CN V) is responsible for sensory input from the entire face, and also provides motor function to the muscles of mastication.

A deficit of motor function results in an inability to close the mouth and reduced tone, with or without atrophy, of the masticatory muscles.

Sensory function can be assessed in the three main branches of the nerve (ophthalmic, maxillary and mandibular), but only the ophthalmic branch is discussed as it is the branch which conveys afferent sensory stimulation from the eye. The **ophthalmic branch** is tested by the palpebral (blink) reflex (elicited by touching the medial canthus, tested in conjunction with CN VII which provides the motor input for the blink) and the corneal (blink) reflex (see above). Stimulation of afferent fibres of the ophthalmic branch will also stimulate tear secretion. Sensory deficits of the cornea result in an exposure keratopathy which particularly affects the exposed area of cornea in the palpebral aperture.

Cranial nerve VII (Facial)

The facial nerve (CN VII) provides motor innervation to the muscles of facial expression and parasympathetic fibres supply the lacrimal glands (see below). The facial nerve becomes closely associated with the vestibulocochlear nerve once it has left the brain stem and they enter the internal auditory meatus together; a single lesion may involve both nerves.

Abnormality of CN VII causes facial paralysis. Unilateral deficits may be observed as asymmetry of the ears, eyelids, lips and nose. Specific tests include the palpebral blink reflex (see CN V) and corneal blink reflex (see CN V), the menace response (see CN II), and observation of normal ear and facial movements. When the cat attempts to blink, the globe is retracted and the third eyelid sweeps across the cornea, but there is no movement of the upper and lower eyelids.

Cranial nerve VIII (Vestibulocochlear)

The cochlear portion of the eighth cranial nerve (CN VIII) is responsible for hearing, and the vestibular portion is responsible for equilibrium of posture and gait and co-ordination of eye movements

Cochlear deficits result in deafness, while vestibular deficits may manifest as nystagmus. If spontaneous horizontal nystagmus is present, the fast phase moves away from the side of the lesion. Nystagmus can be horizontal, vertical or rotatory; if it is vertical, it indicates that the disease is of central origin (i.e. a disease affecting the vestibular nucleus). The other two forms of nystagmus can occur with either central or peripheral (vestibular nerve or vestibular apparatus) disease. Positional nystagmus may also be detectable, with nystagmus occurring or changing as the position of the head is altered. Unilateral vestibular disease will also result in a head tilt and circling to the side of the lesion, with ataxia, whereas in bilateral disease the head becomes hyperflexed with the chin tucked onto the sternum.

It is worth noting that nystagmus and convergent strabismus are common abnormalities in imperfect albinos such as Siamese and Himalayan cats in which pigment production is deficient. Melanin, an essential regulator of axonal growth, is deficient in the retinal pigment epithelium of these breeds and this leads to misdirected axonal projections from the eye to the brain, so that central visual pathways do not develop properly. The misrouting of the central visual fibres results in reduced visual acuity and absence of binocular vision. The convergent strabismus (esotropia) which develops at about three months of age in some cats is probably a consequence of abnormal visual perception and attempts by the brain to create a complete visual field. The mechanism underlying the nystagmus, which is present in most cats, is less well understood, but may be due to contradictory information perceived at the level of the mesencephalon.

Light Reflex Pathway (Pupillary Light Response)

Pupil size is controlled by the iris sphincter muscle (under cholinergic parasympathetic control) and the iris dilator muscle (under adrenergic sympathetic control) and the balance between the two systems is in a constant state of flux. The pathway for the light reflex originates in the retina following stimulation of receptors by bright light and the afferent pathway begins in the ganglion cell layer. A proportion of the second order neurones in the optic nerve that carry impulses derived from stimulation of receptor cells are pupillomotor fibres, which leave the optic tract to enter the midbrain where they synapse with third order neurones in the pretectal nucleus, which in turn synapse within the parasympathetic component of the oculomotor nucleus. There is extensive cross-over of both second order neurones at the optic chiasm, and third order neurones at the caudal commissure (between the pretectal and oculomotor nuclei) allowing a bilateral pupillary light response (PLR) to stimulation with light. Efferent parasympathetic fibres from the oculomotor nucleus are contained in the oculomotor nerve (CN III), they enter through the orbital fissure to synapse at the ciliary ganglion lateral to the optic nerve, with post-ganglionic fibres passing in two short ciliary nerves (medial and lateral) to innervate the iris musculature. Partial internal ophthalmoplegia with a hemidilated pupil occurs if only one of the two ciliary nerves supplying the iris constrictor muscle is paralysed; a 'D-shaped' or 'reverse D-shaped' pupil is the consequence, depending on which of the two nerves is affected

Oculosympathetic Pathway

Sympathetic innervation to the iris originates in the hypothalamus. Upper motor neurones synapse with lower motor neurones at the T1-T3 level of the spinal cord, and their axons exit and travel in the thoracic and vago-sympathetic trunk to synapse in the cranial cervical ganglion close to the tympanic bulla. Postganglionic fibres pass through the middle ear and join the ophthalmic branch of the trigeminal (CN V) nerve to innervate

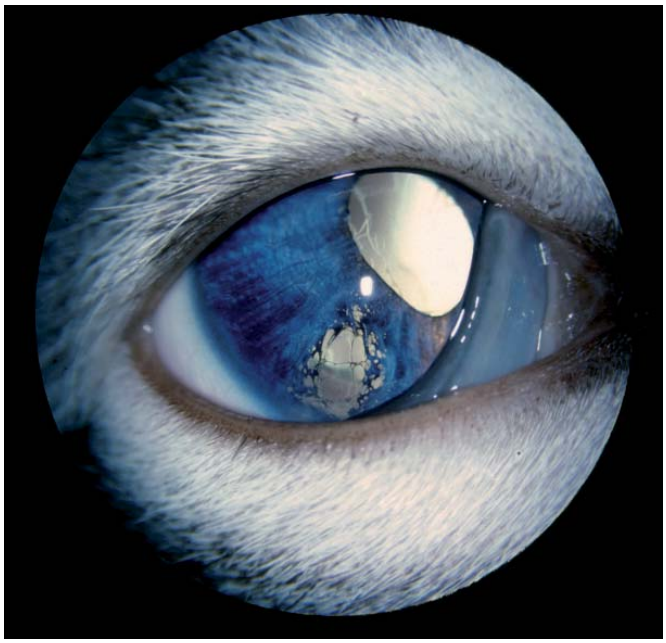


Fig. 19 In this cat with multiple ocular defects there is some reduction in the size of the eye (microphthalmos) note the exposed bulbar conjunctiva laterally and third eyelid prominence. The iris is markedly hypoplastic with obvious full thickness defects ventro-laterally. The lens equator is visible in the gap as are a few poorly developed ciliary processes. Persistence of the tunica vasculosa lentis, mainly as pupillary membrane remnants, is visible as faint opacties in the pupillary aperture

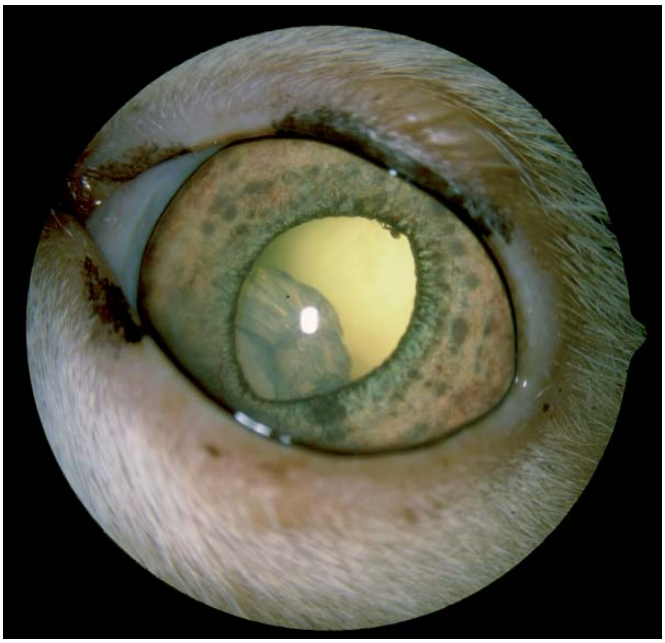


Fig. 20 This cat was scratched by another cat some years earlier and at the time it was assumed that only the upper eyelid was damaged (note that the eyelid remains swollen). In fact the globe had also been penetrated and the lens directly damaged by the claw. In this photograph a posteriorly luxated lens, with a hypermature cataract, is apparent, together with focal changes of iris colour (greyish) and iris neovascularisation. Pigmented strands, marking the site of previous posterior synechiae, are apparent in the dorsal aspect of the pupillary aperture.

the iris dilator muscle and the smooth muscle of the periorbital muscles and eyelid. Damage to the sympathetic supply to the eye results in Horner's syndrome, of which the obvious ocular features are third eyelid prominence, a reduced palpebral aperture and a miotic pupil (Fig. 15).

Assessment of pupillary response

Pupillary assessment under a range of lighting conditions is a standard feature of neuro-ophthalmological examination. The shape, size and position of the pupils under normal conditions of illumination are examined first, then the examination is repeated with the lights dimmed; a technique which helps in the differentiation of sympathetic and parasympathetic defects. In bright light miosis due to sympathetic dysfunction may be difficult to detect, because of the dominance of the parasympathetic system. In dim light, however, such a defect is obvious as the anisocoria (inequality of pupil size) becomes more marked with the smaller pupil being on the affected side. Conversely, the mydriasis found in parasympathetic paralysis (for example, traumatic damage to the ciliary ganglion), may be obvious in bright light, but difficult to detect in dim light.

The direct (ipselateral) and consensual (indirect and contralateral) response to **bright** light is assessed next and this test is best performed in conditions of near darkness. Partial decussation of the optic nerve fibres at the optic chiasm and caudal commissure of the midbrain ensures that the normal pupil response to a bright light directed into one eye will be more intense miosis in the stimulated eye (dynamic contraction anisocoria). If the light is swung to stimulate the fellow eye then the pupil of this eye will, in turn, become more miotic and if the light is swung from one eye to the other, the miosis will alternate (alternating contraction anisocoria). This is the basis of the swinging flashlight test which can be used to detect the presence of a relative afferent pupillary defect (Marcus Gunn phenomenon). With a prechiasmal lesion, for example, when the light is swung to stimulate the fellow eye, the miotic pupil of this eye suddenly dilates whilst receiving direct illumination - a positive swinging flashlight test.

Anisocoria (inequality of pupil size) may be a consequence of topically or systemically administered drugs (e.g. mydriatics, miotics, ketamine), congenital or acquired abnormalities of the eye, the light reflex pathway, oculosympathetic system (e.g. Horner's syndrome), midbrain or cerebellum. The underlying cause is not always obvious, particularly in relation to inflammatory disorders and detailed investigations may be required [2, 4, 21]. It is important to detect which eye is abnormal and this may require careful observation of direct and consensual pupillary light reflexes and pupillary dilation in response to low lighting conditions. It is also important to realise that mild inequality of pupil size is quite common in cats and is assumed to be due to differences in basal sympathetic or parasympathetic tone to the two eyes. The origin of this type of anisocoria may be 'central' in so far as it relates to asymmetries of supranuclear inhibitory control of the parasympathetic nuclei of the oculomotor nerves.

Fig. 21 Normal iris (a) and ocular fundus (b) in a black cat (normal pigmentation). Note that the optic nerve head is round and slightly sunken. The three pairs of primary retinal vessels curve over the rim and the venules (wider and darker) can be readily distinguished from the arterioles (slightly more tortuous). The optic nerve head is located within the tapetal fundus which is reflective and slightly granular, part of the non tapetal fundus is visible ventral to the optic nerve head..

It may be sensible to instil a mydriatic once neuro-ophthalmological examination is complete, as mydriasis is needed for comprehensive examination of the lens, vitreous and fundus. This is because, in comparison with the dog, the pupil of normal cats responds briskly and more completely to bright light and the pupil shape changes from round to a narrow vertical slit, resulting in a very limited field of view. Tropicamide 1% is the drug of choice and one drop should be applied to each eye at the end of the neuro-ophthalmological examination; it takes some 15 minutes to achieve sufficient mydriasis for examination, although maximal dilation takes about two hours [22].

In the dark

Darkness minimises distracting reflections and is an essential part of ophthalmic examination. A light source and magnification, or a slit lamp biomicroscope, is required for the first phase of this examination. Both direct and indirect ophthalmoscopy are required for examination of the ocular fundus in the second phase and the techniques are complimentary rather than exclusive.

The anterior segment (the internal structures of the globe up to and including the lens) is examined with a light source and magnification, or a slit lamp biomicroscope.

The limbus and cornea are examined first. Most of the limbus is invisible in the normal cat except, sometimes, laterally. The limbal zone is usually clearly defined because of a rim of pigment on the corneal side.

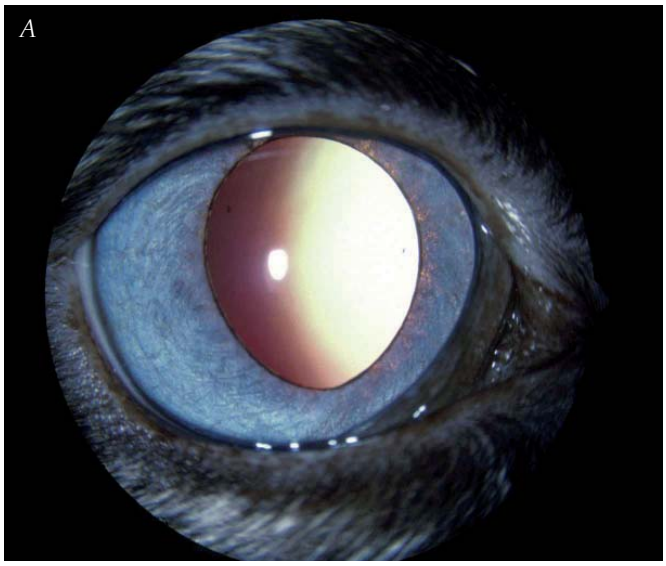
The cornea should be of the right shape, size and profile, of lustrous appearance and optically clear. Any opacities, whether focal or diffuse, are abnormal, as is any vascularisation or other infiltration. The extent and position of any corneal abnormality is usually readily determined, whereas the depth is not always easy to assess unless a slit lamp biomicroscope is used.

The anterior chamber should also be optically clear. A slit beam, rather than a diffuse beam, is used to detect subtle opacities within the aqueous, be they focal or diffuse in nature. The depth of the anterior chamber is also most easily assessed by use of a slit beam, or by shining a beam of light across the eye from lateral to medial. The anterior chamber is deep and the pectinate ligament of the iridocorneal angle can be observed directly.

The iris of most cats is lightly pigmented and the distinction between the pupillary zone (usually darker) and ciliary zone (usually lighter) at the collarette is not always present, so that the iris is of uniform colour. Colour variations may be present between irides and within different sectors of the same iris. Variations of pigmentation produce a range of colours. In the least pigmented, genuinely subalbinotic iris, which is almost pink in colour, the iris is often so thin that it can be transilluminated. Full thickness iris defects are indicative of congenital (Fig. 19) or acquired abnormality. Similarly, any acquired loss of iris detail or change of iris colour is indicative of abnormality (Fig. 20).

The adult pupil is round when dilated and narrows to a vertical slit on constriction. It is important to observe the size and shape of the pupil, both constricted and dilated, paying particular attention to the pupillary margin, as deviations from normal may indicate posterior synechiae or neurological abnormalities. It is also important to ascertain that no opacities can be detected in the pupillary aperture or beyond.

The whole lens can only be examined in detail when a mydriatic has been used, paying particular attention to its shape, position and clarity. The light source is used to demonstrate the anterior and posterior lens surfaces by observing the catoptric images



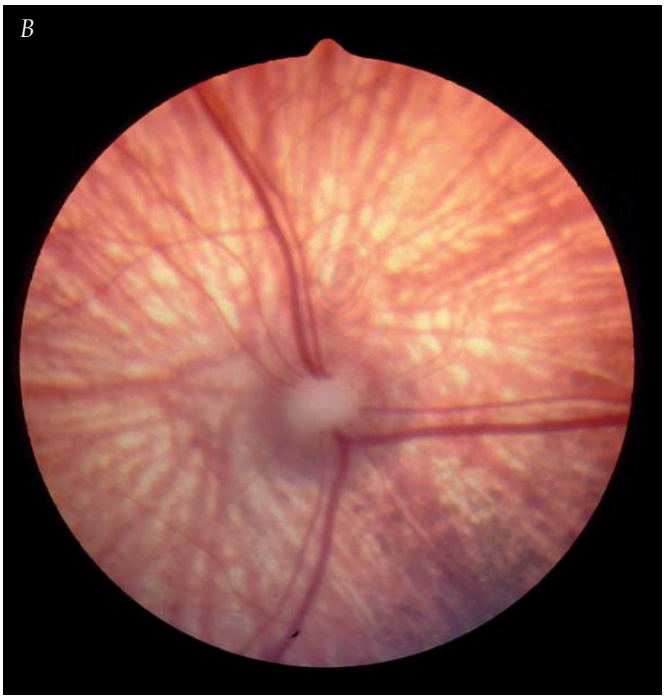


Fig. 22 Normal iris (a) and ocular fundus (b) in a subalbinotic cat. In this animal there is no tapetum and both retinal and choroidal vessels are obvious against the creamy white scleral background. There is sparse pigmentation ventral to the optic nerve head.

which are visualised on the anterior lens capsule (erect) and the posterior lens capsule (inverted). It is easier to establish these boundaries by noting the relative movement of the images in relation to the light source (parallax).

The posterior segment (the internal structures of the globe beyond the lens) is examined next using some or all of a light source, slit lamp biomicroscope, indirect ophthalmoscope and direct ophthalmoscope.

The anterior vitreous is most easily examined with a pen light or slit lamp and should be free of obvious opacities.

Indirect ophthalmoscopy and direct ophthalmoscopy are used to examine the ocular fundus and, to some extent, the posterior vitreous. Indirect ophthalmoscopy provides low power examination of a wide area and is particularly useful when the ocular media lack optical clarity. Direct ophthalmoscopy provides a magnified view of a relatively small area. Both distant direct ophthalmoscopy (see above) and close direct ophthalmoscopy should be used as part of routine examination.

With either type of ophthalmoscopy the optic nerve head (optic disc or papilla), which is situated within the tapetal fundus, is located first and its size, shape and colour should be noted (Fig. 21). In cats the optic nerve head (ONH) is usually unmyelinated so that the ONH is round in shape and slightly recessed, the optic nerve becoming myelinated posterior to the ***lamina cribrosa***. The retinal vasculature is next examined, paying particular attention to the number and distribution of the retinal vessels as they hook over the rim; the venules are generally wider and darker than the arterioles. The terminal choroidal vessels appear as dark dots because they are viewed end on. In poorly pigmented, subalbinotic, eyes the tapetum may be absent and larger choroidal vessels will be visible (Fig. 22). Finally, all four quadrants of the ocular fundus are checked in whichever order the examiner finds most convenient; for example, dorso-lateral, dorso-medial, ventro-medial and ventro-lateral. The tapetal fundus is extensive and reflective, finer details will not be appreciated and subtle abnormalities will be missed if the intensity of illumination is too high. It is easiest to record any abnormalities using a simple diagram comprising a circle divided into quadrants. Variations, which may or may not be of clinical significance, can only be appreciated if there is an understanding of the normal range of appearances. Fortunately there are fewer normal variations in cats than dogs.

Recording

The findings of ophthalmic examination should be recorded by means of annotated diagrams which take only seconds to produce. Photography, of course, is also helpful, particularly as a means of charting changes of appearance. Accurate recording should be continued if the cat is examined on more than one occasion and the importance of repeat examinations as a means of monitoring progress and separating true abnormalities from artefacts, cannot be overemphasised (Fig. 23).

Diagnostic Texhniques [10, 14, 20]

Sampling techniques

Swabs and scrapes may be helpful in establishing aetiology and should be taken from the affected area. Topical local anaesthesia is not necessary when sampling the conjunctiva and eyelid margins, but is essential for corneal samples.

It is important to select the correct culture medium; for example, viral and chlamydial transport medium (VCTM) is needed for the isolation of ***Chlamydophila*** and viruses, standard bacteriology culture media are inappropriate. If there is any uncertainty as to the normal microbiology of the conjunctival sac [11, 12, 25],

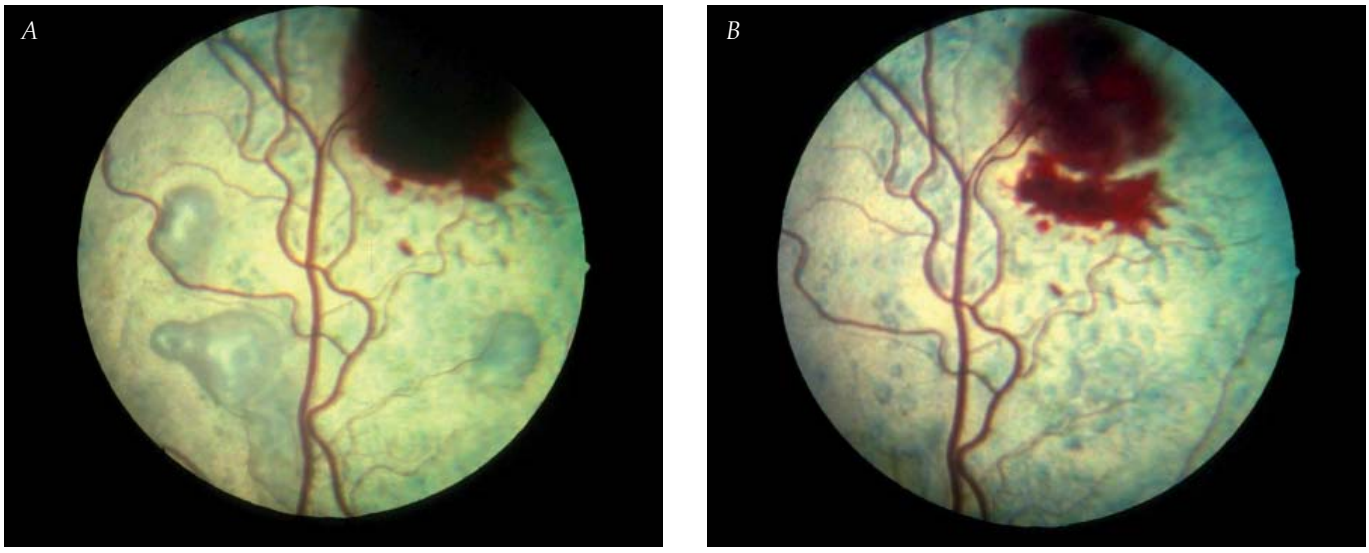


Fig. 23 Feline systemic hypertensive disease. The most obvious feature in this cat are variations of retinal vessel calibre, retinal oedema, focal bullous retinal detachments (largely as a consequence of subretinal effusion). An extensive area of pre-retinal haemorrhage is apparent dorsally, Mean systolic blood pressure was 280mmHg at the time of the photograph (a). Within a week of treatment, mean systolic blood pressure has fallen to 210mmHg, the retina has re-attached and the haemorrhage is resorbing (b), Systemic hypertensive disease is a common condition in the cat and the eye is a most sensitive target organ. The two photographs illustrate the importance of sequential examination and accurate recording.

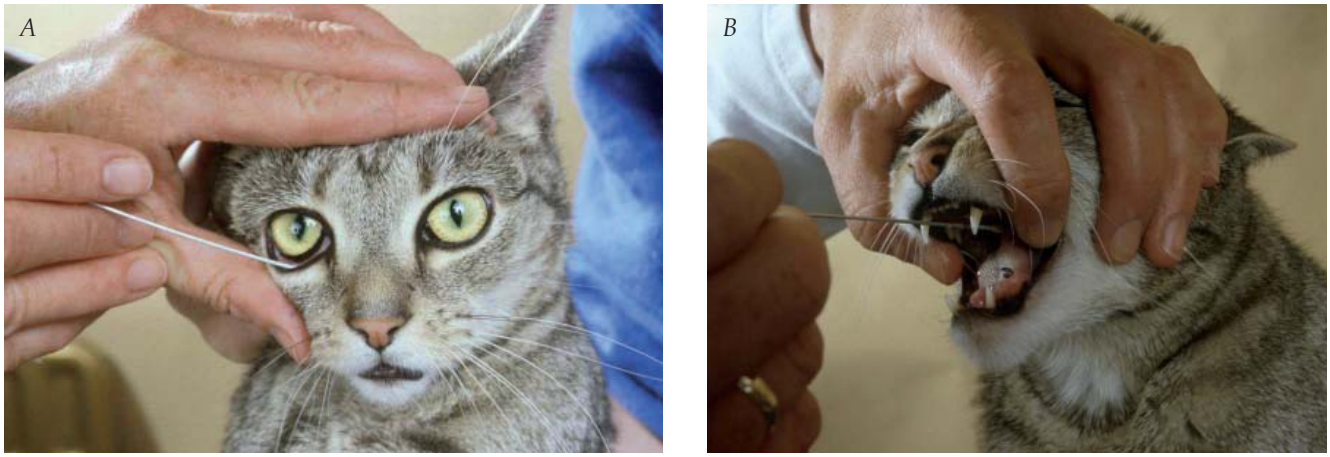
or which diagnostic test to perform, it is prudent to contact a diagnostic laboratory before taking the samples. Ocular (conjunctival or corneal) and oropharyngeal swabs will be required as part of the diagnostic work up in most cats which present with ocular surface disease (Fig. 24a, 24b). Dacron or cotton wool swabs have been used traditionally for obtaining superficial cells from sites such as the conjunctiva and cornea, but other instruments such as the cytobrush may be superior in terms of the yield, distribution and preservation of cells [1].

Scrapes are obtained with, for example, a sterile Kimura spatula or the blunt end of a sterile 15 gauge Bard Parker disposable scalpel blade. A smear is made directly onto a clean, dry, glass slide and the preparation is air-dried, fixed in methanol and Gram-stained, or it may be submitted to a pathologist for staining and interpretation.

Impression smears are useful as a means of sampling abnormalities of the eyelid margin or ocular surface. A clean dry glass slide is pressed gently, but firmly, against the abnormal area and the preparation is air-dried and fixed in methanol. As these smears can be difficult to interpret, they are best submitted to an experienced pathologist. A minimum of two slides should be sent.

Biopsies may be taken from the eyelids and conjunctiva following topical anaesthesia. One drop of local anaesthetic (e.g. proxymetacaine hydrochloride) is applied to the eye and shortly afterwards a cotton-wool tip soaked in local anaesthetic is held against the area which is to be sampled for approximately one minute. More extensive surgery is better performed under general anaesthesia, with topical anaesthesia as a useful adjunct. A biopsy needle (fine needle aspiration biopsy) or surgical excision is used to obtain the sample, which is transferred immediately into fixative. The amount of fixative should be at least ten times

Fig. 24 A conjunctival swab being taken from the lower conjunctival sac (a) and from the oropharynx. (b)



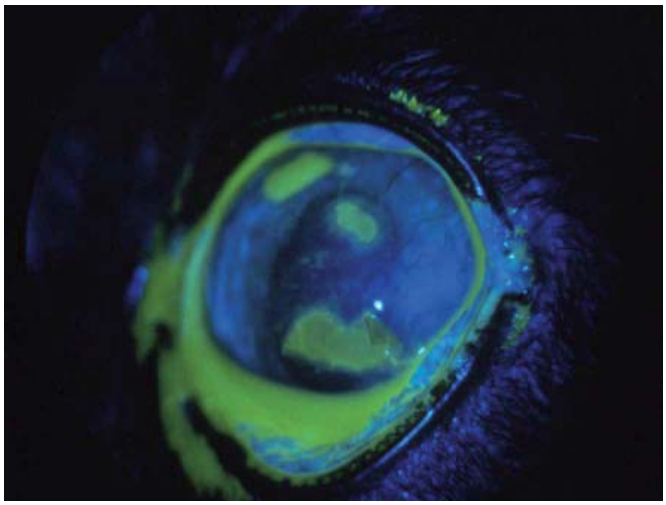


Fig. 25 Multiple superficial erosions stained with fluorescein and viewed in blue light. The cat had a nasal squamous cell carcinoma and the ulceration was thought to be a consequence of reactivation of latent FHV-1.

the volume of the specimen. Neutral buffered formaldehyde can be used for routine light microscopy and immunohistochemistry. Glutaraldehyde (2.5% in 0.1M cacodylate buffer) should be used for electron microscopy.

Corneal biopsy is useful on rare occasions. General anaesthesia is required and the biopsy must include the edge of the stromal infiltrate using a microsurgical scalpel blade. The biopsy can be pressed directly onto a microscope slide for impression cytology.

Aqueous and vitreous paracentesis are of occasional value. For example, neoplastic cells can be harvested from the iris and anterior chamber and the technique can aid identification of intraocular yeasts and fungi

Topical ophthalmic stains

Fluorescein sodium is an orange dye which changes to green in alkaline conditions (eg in contact with the normal preocular tear film). It is mainly used to detect corneal ulceration (Fig. 18, 25) and is rapidly absorbed by the exposed hydrophilic stroma; fluorescein does not stain the lipid-rich anterior epithelium or Descemet's membrane. Fluorescein should be applied after other tests (e.g. Schirmer tear test, scrapes and swabs for culture and sensitivity) have been performed, as the dye can interfere with certain diagnostic tests [7]. Impregnated strips or single dose vials may be used and it is usual to place the strip or solution in the lower conjunctival sac and allow the blink to distribute the fluorescein. A small quantity of sterile saline can be used as an ocular irrigant to provide sufficient moisture and to flush excess stain from the ocular surface. Subtle staining can be demonstrated with a blue light source.

Fluorescein can also be used as a means of identifying aqueous leakage (Seidel test) following corneal damage (Fig. 26) or after corneal repair and is sometimes helpful when checking the patency of the naso-lacrimal drainage apparatus (Fig. 27).

Rose bengal is a red dye used to demonstrate ocular surface and tear film abnormalities. It is not employed as a routine stain because it irritant to the eye and can interfere with the isolation of pathogens from corneal and conjunctival scrapes.

Schirmer Tear Test

The Schirmer I tear test is the method most commonly employed to test aqueous tear film production (Fig. 26). The test should be performed on the conscious, non-sedated cat so as to avoid falsely low readings; even so, the values are likely to be noticeably lower than those obtained in dogs. Topical local anaesthetic solution is not used for a Schirmer I tear test (STT I) so that it is stimulated (reflex) tear production which is being assessed. Mean values of **approximately** 12mm (+/- 5) per minute are obtained in normal cats. Schirmer II testing (STT II) checks basal

Fig. 26 Penetrating injury to the cornea before (a) and after (b) staining with fluorescein. Gentle pressure applied to the globe via the upper eyelid following application of fluorescein (forced Seidel test) indicated, on slit lamp examination, that subtle aqueous leakage was present. Note that the third eyelid has been damaged in a previous fight.

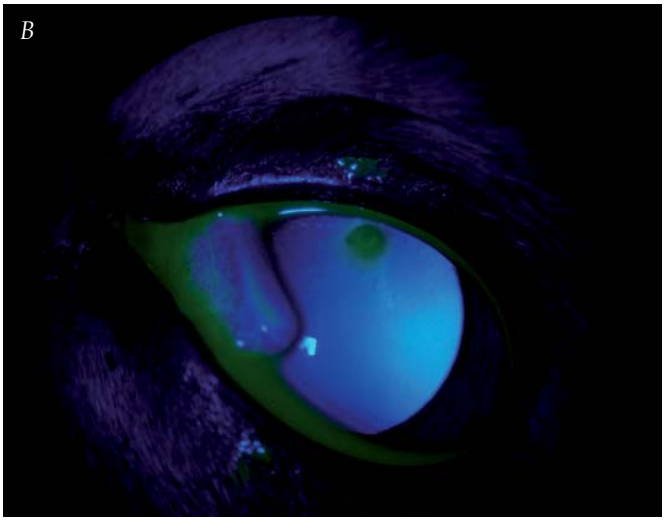


Fig. 27 In this Persian cat with chronic epiphora, fluorescein has been applied to both eyes, in sequence, and no fluorescein has emerged from the nostrils or been visualised in the oropharynx. Investigations of chronic epiphora can be difficult in this breed for a number of reasons, including the facial anatomy (flat face), overlong palpebral aperture, close apposition of the eyelids to the cornea, shallow lacrimal lake, a wick effect from hairs at the medial canthus and lower medial eyelid entropion. Poor distribution and drainage of the tear film resulting in epiphora are a common consequence.

Fig. 28 A Schirmer tear test strip being used to check tear production.

secretion and is performed after the application of topical local anaesthetic; mean values of **approximately** 10mm (+/- 5) per minute are obtained with this technique [6]. With both tests the range of values is wide; in one series of 76 cats the range for Schirmer II tear tests was 1mm to 33mm and the test results for cats of less than 12 months of age were significantly lower than those obtained for cats of more than 12 months [24]. In general, values of less than 8mm per minute should be regarded with suspicion, especially if there is an abnormal ocular appearance or disparity in the STT values between the two eyes. Repeated values of less than 5mm, **together** with other clinical signs, are indicative of a lack of aqueous component production, clinically manifest as keratoconjunctivitis sicca.

The test is performed using commercially available test strips which are up to 60mm in length, with a notch some 5mm from the tip. The strip is bent at the notched region whilst still within the packing so as to avoid contaminating the tip with grease from the fingers, the tip is placed just within the conjunctival sac (Fig. 28). The strip is removed after 1 minute and the value, in millimetres, is read immediately as measured from the notch.

Investigation of naso-lacrimal drainage

The upper and lower lacrimal puncta are small openings located near the eyelid margins approximately 2mm from the medial canthus. They can be examined directly if the medial margins of the eyelids are everted slightly. The excretory portion of the lacrimal system consists of the lacrimal puncta, canaliculi, a rudimentary lacrimal sac and the nasolacrimal duct. The duct passes through the lacrimal bone along the medial surface of the maxilla to the nasal cavity.

Initial examination consists of **visual inspection** of the lacrimal puncta. Their presence, size and position should be checked, low power magnification may be useful.

Patency of the lacrimal system can be tested using **fluorescein** drops instilled into the lower conjunctival sac, which may appear at the ipselateral nostril (or the back of the throat) within 1-10 minutes of application in approximately 50% of normal cats. In the other 50% of normal cats fluorescein fails to appear. A positive result is therefore significant, whereas a negative result does not necessarily mean that the duct is blocked. Both sides should be tested but with sufficient time between tests to avoid misinterpretation. If samples are required for culture and sensitivity as detailed below, checking patency with fluorescein is usually omitted.

When samples are required for culture and sensitivity they can be obtained by irrigation with sterile water following **cannulation or catheterisation** of the upper punctum and canaliculus; a range of nasolacrimal cannulae are available and 24-25 gauge disposable are ideal for cats.. It is best to perform all investigative and treatment techniques under general anaesthesia to reduce the risk of damage to the drainage apparatus. The pharynx should be packed with moist, soft, gauze bandage and the patient positioned with a head down tilt in order to prevent inadvertent inhalation of the irrigating fluids.

To confirm that drainage is normal, or to re-establish drainage in uncomplicated cases, a set protocol should be followed. Digital pressure is applied over the region of the lacrimal sac to occlude the entrance to the nasolacrimal duct and sterile water or saline is injected via a 25 gauge lacrimal cannula in the upper punctum and canaliculus. Silver lacrimal cannulae are the most satisfactory as they are less traumatic than plastic cannulae and can be re-used after sterilisation. The liquid is injected with only moderate force and should appear at the lower punctum almost immediately. Once liquid appears, the lower punctum and canaliculus is occluded by digital pressure and fluid should then pass along the nasolacrimal duct and appear at the ipselateral nares a short time after injection. Samples can be collected for

culture (aerobic and anaerobic) as fluid drips from the nares.
If it is impossible to establish patency using irrigation a fine catheter or monofilament nylon may be passed through the drainage system via one of the puncta. The end of the catheter or nylon must be smooth and rounded to avoid iatrogenic damage.

Dacryocystorhinography is a technique whereby an iodine-based contrast agent may be used to delineate the nasolacrimal drainage system. After plain radiographs (usually lateral and open mouth views) have been taken, the upper or lower punctum and canaliculus is cannulated and 2-3ml of contrast agent is injected as further radiographs are taken.

Tonometry
Tonometry is the measurement of intraocular pressure. The MacKay-Marg electronic applanation tonometer is the most accurate indirect device for use in cats; portable tonometers, such as the ProTon, Tono-Pen, Tono-Pen XL and Tonovet, are all reasonably accurate [15]. Results between the different tonometers are not directly comparable and repeat measurements should always be made with the same instrument. Furthermore, it is sensible to build up a library of values from normal cats, whatever instrument is selected for use. Schiøtz indentation tonometry can also be used, but repeatable accurate results are more difficult to achieve and electronic applanation tonometers are a better choice, despite their greater expense.

The mean normal intraocular pressure of conscious unsedated cats has been reported as 22.2mm Hg ±-5.2 when measured with the Mackay-Marg tonometer and this correlated with mean readings of 21.6mm Hg obtained with the Schiøtz tonometer and converted into millimetres of mercury using the human calibration table, the Tono-Pen gave statistically significant lower mean readings of 20.2mm Hg [16]. Another study, using the Tono-Pen XL, indicated an intraocular pressure of 18.1 ± 0.31 mmHg over a 24-hour period. [8].

Topical local anaesthetic (proxymetacaine hydrochloride) is applied prior to measuring the intraocular pressure in the conscious non-sedated cat. Sedation and general anaesthesia should be avoided prior to tonometry as they will affect intraocular pressure; furthermore, topical mydriatics produce a transient increase in intraocular pressure [22]. There is also a daily variation of intraocular pressure that appears to be independent of sex, age, or ocular disease [8].

Diagnostic Imaging [13, 17]
Radiography can be useful when there are bony changes or radio-opaque foreign bodies, but it is of limited value in aiding diagnosis of soft tissue problems of the eye and orbit.

Ocular ultrasonography (both A-scan and B-scan) is a valuable method for soft tissue imaging in most species [9, 17], including cats, and is best performed with a high frequency transducer of between 7.5 - 10 Mz. The technique can be used in conscious cats and general anaesthesia is not usually necessary. Ultrasonography is used in biometric studies, to help with the assessment of cloudy and opaque eyes and for identification of foreign bodies in the eye and orbit. It may also be used to locate intraocular and orbital space occupying lesions, but will not distinguish the tissue of origin and may not always allow differentiation of inflammation and neoplasia.

Computed tomography (CT) will locate and define abnormalities within the eye, orbit and cranium and has been used to evaluate orbital neoplasia in cats [3].

Magnetic resonance imaging (MRI) is the best method of imaging currently available and provides superb detail of the eye, orbit and intracranial structures [17]. The excellent spatial and soft tissue resolution allows space-occupying lesions to be delineated accurately; so necessary in surgical planning [23].

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