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Diagnostic approaches in veterinary ophthalmology: A brief review

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Abstract
Eye is a unique and highly complex organ in terms of structure and function. It is a very sensitive organ, the function of which may be affected even with mild insult to its homeostasis (Andrade *et al*., 2005). Occular affections are increasing day by day and are found maximum in Spitz (65%) and least in Dalmatian and Beagle (0.12%). Male animals are found mostly affected (60%).
Therefore early and correct diagnosis of ocular disorders is essential to a successful clinical result and a satisfied client. Investigation of a patient with ocular disease includes taking a thorough and directed history and performing a complete examination of the ocular and periocular structures, in some cases augmented by specialized diagnostic testing as directed by the history and examination findings (Maggs *et al*., 2018).
Nowadays, many of the specialized and advanced tests and instruments are being used in veterinary ophthalmology. Some of the example of tests performed are Neuro-ophthalmic examinations, Schirmer tear test, Fluorescein test etc. The equipments which are being used for diagnostic purpose, few of them are Ophthalmoscope, Tonometer, Pachymeter, Retinoscope and Gonioscope etc.
Some specialty is required for the handling of these equipments, therefore need to develop some skills. The recordings which we'll get, will serve to expand our knowledge and understanding of the anatomy and physiology of the visual system, to study pathological and disease processes in the eye and to improve the diagnostic and therapeutic capabilities of ophthalmologists.

Keywords: Veterinary ophthalmology, Occular affections, Diagnostic approaches, Retinoscope

Introduction
Eye is a unique and highly complex organ in terms of structure and function. It is a very sensitive organ, the function of which may be affected even with mild insult to its homeostasis, due to direct injury or due to other local or systemic diseases and hence studies on ocular affections may provide information on prevalence of ocular diseases and also help to limit diagnostic possibilities and treatment options (Andrade *et al*., 2005 and Balagopalan *et al*., 2016) [1-2].
As the incidence of ocular affection are increasing, therefore early and correct diagnosis of ocular disorders is essential to a successful clinical result and a satisfied client. Investigation of a patient with ocular disease includes taking a thorough and directed history and performing a complete examination of the ocular and periocular structures, in some cases augmented by specialized diagnostic testing as directed by the history and examination findings (Maggs, 2018) [3].

Ophthalmic Examination Procedure
An ophthalmic examination calls for the bare minimum of tools. The inspection must be carried out in low ambient light, preferably in a room or stall that has been completely darkened to reduce distracting reflections, for optimal yield.
In small animals, every attempt should be made to avoid sedation or anesthesia before or during the ophthalmic examination because it interferes with:
- Reflexes and responses
- Globe movement and position
- Vision, pupil size
- Palpebral fissure size
- Moistness of and reflections from the ocular surface

Basic Equipment for Ophthalmic Examination and Testing

Basic tests	Equipments
Neuro-ophthalmic examinations Schirmer tear test Fluorescein test	Focal light source (e.g. Finnoff transilluminator) Magnifying loupes Direct ophthalmoscope Indirect funduscopic lens Tonometer Gonioscope OCT (Optical Coherence Tomography) ERG (Electroretinography) Retinoscope USG (Ultrasonography) CT (Computed Tomography) and MRI (Magnetic Resonance Imaging)

Examination of the anterior segment

Examination of the anterior segment (i.e. third eyelid, nasolacrimal puncta, conjunctiva, sclera, corneoscleral limbus, tear film, cornea, anterior chamber, iris, pupil and lens) should be performed using three complementary techniques

- Diffuse illumination
- Retroillumination
- Transillumination with a slit beam.
- For diffuse illumination, a Finnoff transilluminator is preferred. It is crucial that the physician checks the eye from a variety of angles while the light is directed from a variety of contrasting angles in order to enhance the technique's usefulness.
- Retroillumination is a crucial technique for inspecting the anterior segment, particularly the transparent ocular structures and media that are otherwise challenging to examine (i.e., the tear film, cornea, anterior chamber, lens and vitreous).
- Transillumination is done using magnification and a slit beam (Maggs, 2018) [3]

Tonometry

Indirect (noninvasive) measured estimation of IOP (Intraoccular pressure) is called tonometry. The normal canine and feline IOP is 8 to 25 mm Hg in dogs and 9 to 31 mm Hg in cats. Presently, three functional principles of tonometry are used by veterinary ophthalmologists: indentation, applanation and rebound tonometry. A good rule of thumb is that IOP should not vary between right and left eyes of the same patient by more than 20% (Miller and Bentley, 2015).

Principle of various Tonometer

Each technique measures bulbar tonus, which is used to calculate the force the intraocular fluid exerts on the relatively rigid walls of the globe (IOP). Rebound tonometry is able to estimate IOP using the rebound kinematics of a light metallic probe being propelled electromagnetically against the corneal surface. While the functional principles of both indentation (Schiotz type) and applanation (Mackay-Marg type) tonometers are based on the Imbert-Fick law (stating that the external force (W) against a sphere equals the pressure within the sphere (Pt) times the area (A) (Von Spiessen *et al.*, 2015) [5].

The deviation from the normal values of IOP in different species suggests:

- **IOP raised:** Glucoma, orbital space occupying disease (neoplasia, cellulitis, etc.)
- **IOP unaffected:** Reddened eye, such as keratitis, conjunctivitis and scleritis
- **IOP decreased:** Anterior uveitis

Gonioscopy

Gonioscopy describes examination of the iridocorneal or "drainage" angle (the junction between the iris and cornea/sclera). In the normal eye of most species, visualization of the angle is not possible because of the scleral shelf. Therefore a goniolens is required to refract the light and magnify the image. Gonioscopy is used primarily to determine whether the angle is open, narrow, closed, or obstructed by mesodermal remnants and to check for the presence of foreign bodies, tumors, and inflammatory exudates. The technique is applicable to all domestic species but is most commonly used in dogs (Sanders *et al.*, 2021) [6].

The anterior chamber is deeper in cats, raptors, and horses than in dogs, and the cornea is larger in horses along the horizontal meridian. In these species, it is therefore possible to observe some of the drainage angle without using a goniolens.

Clinical application

Primary angle closure/ closed angle glaucoma is the condition in which angle between the iris and the cornea. This issue with the angle is termed pectinate ligament abnormality (PLA), but is also known as goniodysgenesis (gonio = angle, dysgenesis = defective development). Gonioscopy allows the clinician to differentiate between open-angle and closed-angle glaucoma, to estimate the severity of the obstruction of the iridocorneal angle, to select antiglaucoma drugs and to evaluate the response to therapy (Grundon *et al.*, 2018) [7].

The animals in which the iridocorneal angle closure i.e. ICA is more than 75 percent should not be used for the breeding purpose.

Fig 1: Goniolens

Pachymetry

The ability to accurately measure corneal thickness is essential in ophthalmology and vision science. Clinically, the information may be utilized to assist in surgical planning, monitor disease progression, and assess response to treatment. Furthermore, in the research setting, it may allow for detection of early corneal changes associated with endothelial toxicity. Pachymetry is a simple, quick and painless test for glaucoma, as glucoma is more likely to develop in animals with a thin cornea (Alario and Pirie, 2014) [8].

The corneal thickness varies among species and across regions of the cornea but in domestic species is usually between 0.5 and 0.8 mm. It tends to be thinner in birds, reptiles, and small (exotic) mammals.

Indications

- Helps to asses the function of the corneal endothelium
- Corneal refractive surgery or corneal transplantous
- Keratoconus screening
- Glaucoma suspects
- Bullous keratopathy
- Corneal edema

Ophthalmoscopy

A thorough ophthalmic checkup must include ophthalmoscopy. It can be challenging for a beginner to learn and develop expertise in this ability because of its intricate technical features and patients' propensity for becoming uncooperative if the operation is protracted. The vitreous and the components that make up the visible portions of the ocular fundus must be examined as part of a thorough examination of the posterior segment. One of the most challenging aspects of the eye examination is likely the interpretation of fundic lesions, which is a frequent and acceptable justification for consulting a veterinary ophthalmologist (McMillian *et al.*, 2021) [9].

Accurate assessment requires examination using one or more of three complementary methods of ophthalmoscopy:

- The direct ophthalmoscope
- The indirect lens
- The monocular indirect ophthalmoscope

Regardless of the ophthalmoscope being used, complete pupil dilatation is necessary for a comprehensive inspection of the fundus. This can be accomplished around 15 minutes after applying one drop of 1% tropicamide. Applying a second drop about 5 minutes following the first can occasionally increase the degree and speed of dilatation.

1. Indirect Ophthalmoscopy

With indirect ophthalmoscopy, a handheld lens is held at arm's length from the observer's eye and put next to the patient's eye (usually 20 to 30 D for domestic species, but higher dioptric strengths for foreign species with smaller eyes).

Salient features

- An inverted and reversed image is obtained.
- A large field of view is obtained, which permits examination of the majority of the fundus with just two or three fields of view.
- Facilitates comparison of various regions of the fundus within a field.
- Preferred as initial scanning technique for veterinary patients.
- It provides a better view of the fundus in patients with lens opacities than is allowed by direct ophthalmoscopy (Lewallen, 2006) [10].

2. Direct Ophthalmoscopy

The direct ophthalmoscope has a rheostat to adjust the brightness, colored filters, a slit beam for viewing elevations and depressions within the fundus, an illuminated grid that can be projected onto the fundus to measure lesions, and a set of lenses on a rotating wheel to change the depth of focus inside the eye.

Salient features

- It provides an upright and magnified (15 to 17 times) image.
- It is time consuming and often difficult because the field examined is so small and veterinary patient's eyes are constantly moving.
- Comparison of different sections of the fundus is difficult.

1. Monocular Indirect Ophthalmoscopy

Monocular indirect ophthalmoscopes can be used with the same battery-powered handset as direct ophthalmoscopes. These ophthalmoscopes provide an image that is erect and have a moderate field of vision and magnification. They are comfortable with one hand and simple to learn for new and infrequent users. However, there is reduced depth awareness because the observer only utilizes one eye.

OCT (Optical coherence tomography)

Optical coherence tomography (OCT) is one such powerful technology that has had significant clinical impact, particularly in the context of ophthalmic imaging. It is a noncontact, noninvasive imaging technique that produces high-resolution images of various ocular structures. OCT is often compared to B-scan ultrasonography. It relies, however, upon reflections of light instead of dynamic echoes of ultrasound to yield a two-dimensional image of the retina. Utilization of light provides OCT with very high spatial resolution (in the region of 10 µm) compared to conventional posterior-segment ultrasonography (approximately 150 µm) (Gekeler *et al*., 2007) [11].

OCT system consists of

- Fundus viewing unit
- Interferometer unit
- Computer display
- Control panel
- Color inkjet printer

OCT does not require direct contact with the tissue that is being investigated and this non-contact applicability has obvious advantages for maximizing patient comfort and minimizing risks of infection. OCT is non-invasive and has a greater patient safety profile than fundus fluorescein angiography, which is invasive and has serious, although rare, side-effects of allergy, anaphylaxis, mortality and cardiac complications (Chen and Lee, 2007) [12].

A very high correlation between OCT findings and histologic examinations and OCT in clinical practice helps to identify structures such as:

- Epiretinal membranes
- Vitreoretinal tractions
- Accumulation of fluid in the subretinal space or neurosensory detachments
- Retinal detachments
- Retinoschisis and retinal edema.

Retinoscopy

Retinoscopy is performed to evaluate the animal's refractive status, i.e. if the animal is near-sighted or far-sighted. Familiar myopia has been described in some dog breeds, and retinoscopy may be indicated in some behavioural problems. Among wild mammals the most common refractive state is a low degree of hyperopia. The retinoscope is held with one hand at a fixed distance from the animal's eye and the practitioner shines the light of a retinoscope into an eye, they see the light reflected from the retina. This reflected light is called the retinoscopic reflex. Depending on the animal's refractive error, when the practitioner moves the retinoscope, the retinal reflex will move in a certain way inside the pupil. Trial lenses can be used to measure the amount of movement that a retinal reflex has, so that the refractive error can be estimated accurately (Bracun *et al*., 2014) [13].

Nowadays they are slowly being replaced by automated refractors. These wavefront autorefractor models offer several practical advantages compared to retinoscopy such as:

- They provide rapid results.
- Have a relatively long working distance (0.35 m) that makes them especially useful for use in children and theoretically better suited for use in animals.
- Require little training to learn to accurately operate.

The device works by calculating the path of reflected light emerging from the eye, projected via a beam splitter to a Hartmann–Shack sensor. The sensor evaluates whether the light is converging or diverging as it exits the eye based on the distribution of light spots on the matrix camera (Groth *et al*., 2013) [14].

Fig 2: Automated refractor

Electroretinography (ERG)

The study of electrical potentials generated by the retina when light strikes it is known as electroretinography (ERG). The optic nerve and higher (intracranial) visual circuits do not provide any signal. In order to distinguish between retinal, optic nerve, and central neurologic causes of visual impairment, the ERG is very helpful. It is also possible to quantify the degree of retinal dysfunction using more selective ERG techniques, which can also be used to more precisely identify which retinal cells are dysfunctional. This is helpful for identifying the different types of progressive retinal atrophy (PRA).

Electrodes positioned around the eye detect potential variations on the retina as a result of light being directed onto the retina with variable intensity, wavelength, and flash frequency. Once these have been amplified, they take on a characteristic shape and can be recorded on paper or kept electronically, where they can be evaluated for amplitudes and implicit timings. The animal must be sedated deeply or under general anaesthesia for the ERG to be performed with correct results. The ERG is typically used to distinguish between blindness that originates in the retina (in which case the ERG will be abnormal) and blindness that originates in the optic nerve or the central nervous system (in which case the ERG will be normal), or to ensure that the retina is functioning adequately before cataract surgery (Maggs *et al.* 2018) [3]

The ERG may be used for these purposes

- Preoperative evaluation of retinal function before cataract extraction when fundic examination is not possible.
- Diagnosis and differentiation of inherited retinal disorders (e.g., rod–cone dysplasias, progressive retinal degeneration, hemeralopia).
- Investigation of unexplained visual loss (amaurosis) in which retinal lesions are not visible ophthalmoscopically (e.g., sudden acquired retinal degeneration syndrome (SARDS), optic neuritis without papillitis, CNS disease.

Ultrasonography

Ocular ultrasound is an effective and non- invasive technique for imaging the eye and is especially valuable for “seeing” retrobulbar and intraocular lesions, when severe swelling of the eyelids prevents examination of the globe. Because of the presence of the fluid-filled anterior, posterior and vitreous chambers, ultrasonography is a very useful technique in eyes in which opacities prevent direct clinical evaluation of all structures caudal to them (Fielding, 2001) [15].

Ocular biometry is a useful tool for the assessment of abnormalities such as phthisis bulbi, microphthalmia, pseudo-exophthalmia, scleral ectasia and congenital glaucoma (Potter *et al*., 2008) [16]. The patient is best examined without general anesthesia or sedation, both of which cause enophthalmos and reduce the clarity of the image obtained. A drop of topical anesthetic is applied to the ocular surface, and the ultrasound probe with sterile, water-soluble coupling gel is applied directly to the cornea or eyelids as the patient permits.

Doppler ultrasonography is shown to be an important tool in assessing the hemodynamic components of the eyeball and the retro-bulbar structures. Duplex ultrasonography is a new method in small animal diagnostic procedures. Real time B-mode ultrasonography supplemented by Doppler ultrasonic imaging not only allows the evaluation of the vessels, but also permits the assessment of blood flow (Sindak *et al*., 2003) [17].

Application of ultrasonography

- Detection of retinal separation
- Detection of lens dislocation or rupture
- Detection of vitreous degeneration or hemorrhage, asteroid hyalosis and synchysis scintillans
- Detection of intraocular tumors or foreign bodies
- Guidance of fine-needle aspirates of orbital and ocular lesions

Computed tomography and magnetic resonance imaging

Cross-sectional imaging techniques are particularly valuable for assessing aspects of the globe, orbit and surrounding structures that cannot be visualized clinically. CT and MRI provides superb detail for localization and characterization of orbital and intracranial lesions and have largely replaced skull radiography. Magnetic resonance imaging is less sensitive than computed tomography for the evaluation of the orbital bone and mineralized tissue, but is superior in the assessment of the globe, optic nerve, and/or optic chiasm (Boroffka and Saunders, 2018) [18].

Case reports and case studies are advancing our understanding of the CT and MRI appearances of diverse pathologic diseases. The normal CT and MRI appearances of canine, feline, and equine orbital, ocular, and periocular structures have been thoroughly documented. Tru-Cut biopsies or aspirates can be guided via ultrasound or CT, which has significantly decreased the requirement for "open" surgical biopsies.

The cross-sectional imaging techniques offer more information than radiography, and many contrast techniques are equally or even more suited to CT or MRI than to radiography. The following contrast techniques are employed to assist with diagnosis of ocular and periocular conditions:

- Dacryocystorhinograph
- **Contrast zygomatic sialogram:** Injection of contrast medium into the zygomatic salivary gland duct within the mouth outlines the gland in the ventral orbit for investigation of sialoceles, salivary gland neoplasia and sialadenitis.

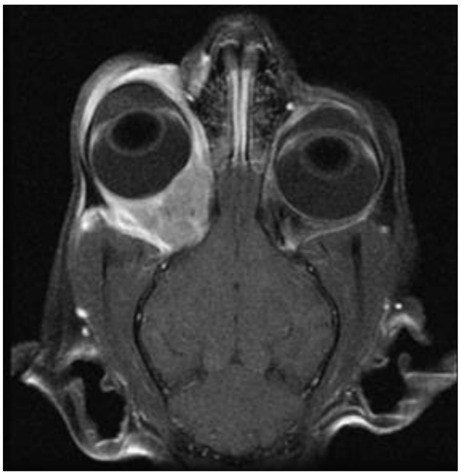

Fig 3: Post-contrast injection, frontal magnetic resonance image (MRI) of a cat

Conclusion

With the increase in incidence of ocular affections and awareness among owners, it is really important to have specialize equipments for the confirmatory and diagnostic purpose of ophthalmological conditions. These will not only help in early confirmatory diagnose of ocular affection but also save vision of animal and maintain the productivity of animal. Although specialty is required for the handling of these equipments, therefore need to develop some skills. The investment to buy some of the equipments is really high but their ability to provide exact diagnose of disease surpass the cost. Furthermore, the recordings which we'll get, will serve to expand our knowledge and understanding of the anatomy and physiology of the visual system, to study pathological and disease processes in the eye, and to improve the diagnostic and therapeutic capabilities of ophthalmologists.

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