The cornea is a smooth, clear, physically tough “window” into the eye. A healthy cornea is imperative to normal vision. To maintain corneal health external protection is required (orbit, eyelids, third eyelid) as is a constant source of lubrication (precorneal tear film). Pathologic responses are limited in this highly organized, avascular structure with many changes potentially leading to vision loss.

**Corneal Ulceration**

A corneal ulcer results from a loss of epithelial cells and allows exposure of the underlying corneal stroma which stains positive with sodium fluorescein (highlighted by cobalt blue light). Ulcers can occur due to trauma, foreign bodies, chemical or thermal insult, conformational issues (entropion, macropalpebral fissure, lagophthalmos), hair/eyelash disorders (distichiasis, ectopic cilia, nasal fold trichiasis), or acquired conditions (KCS, facial nerve paralysis, eyelid masses, indolent ulcers). Infectious organisms are typically secondary invaders which complicate compromised corneas. The appearance and location of an ulcer may suggest the underlying etiology and help direct therapy so always look for and address all underlying causes! Simple, uncomplicated ulcers should be managed in a way that prevents infection/complication, reduces pain and aids healing (which should occur in a matter of days) while not impeding it (e.g. with topical steroids/nonsteroidals/anesthetics). Therapy includes an E-collar, a topical ophthalmic antibiotic TID-QID, +/- ophthalmic atropine SID-BID, +/- systemic nonsteroidal anti-inflammatory drug or tramadol PO for a few days. A recheck is warranted in 3-5 days to ensure ulcer healing without complication. Complicated, melting and/or infected ulcers require more aggressive management with culture and cytology helpful to guide therapy. Treatment may include topical ophthalmic antibiotics (e.g. ofloxacin 0.3%, tobramycin 0.3%, and/or compounded cefazolin 5%) every 1-4 hours, plasma/serum every 1-4 hours, atropine BID, a systemic NSAID +/- tramadol, and a systemic antibiotic (e.g. doxycycline or Clavamox®) with an E-collar still imperative to prevent injury of a fragile eye. Eyes should be rechecked in 36-48 hours to assess patient comfort and ensure the eye is not worse. Ulcers 50% deep or greater are candidates for surgery as well as those that worsen or fail to improve with appropriate medical therapy. Ruptured corneal ulcers may be able to seal and heal on their own with aggressive medical therapy but surgery is usually recommended. Surgical options for
complicated ulcers include a conjunctival graft, corneo-conjunctival transposition, corneal transplant, collagen or amnion graft.

**Indolent Corneal Ulcer**

Indolent ulcers are also known as refractory ulcers, Boxer ulcers (given the breed predilection) or superficial chronic corneal epithelial defects (SCCEDs). These ulcers occur in middle aged to older dogs and are superficial epithelial defects only with **no corneal stromal loss**. Epithelium fails to adhere to underlying stroma so a loose epithelial margin is commonly noted on examination. Sometimes fluorescein staining will appear negative at recheck visits due to loose epithelium completely covering a defect but signs of patient discomfort and ocular redness remain to indicate the persistent ulcerative disease. A cotton-tipped applicator may be used to gently “test” the lesion and see if epithelium is able to be easily removed. Other causes of non-healing ulcers MUST be ruled out (KCS, foreign body behind third eyelid, conformation issues, eyelash disorders, etc.) for an ulcer that fails to heal with appropriate management before specific indolent ulcer treatment should be attempted. Therapy for indolent ulcers is the same basic management for a simple ulcer (noted above) as well as sterile cotton tip applicator debridement under topical anesthesia to remove loose epithelium. Debridement alone results in a healing rate of 30-40% so grid, punctate, or diamond burr keratotomy may be needed to improve the odds of healing (to 80-90%). Surgical superficial keratectomy is nearly 100% successful and may be needed in select cases. Tetracycline antibiotics (oxytetracycline topically or doxycycline systemically) may aid healing as well as other topical therapies (serum, ophthalmic sodium chloride, PSGAGs) or a soft contact lens.

**Corneal Foreign Bodies**

Plant material is the most common type of foreign body that may become stuck on the corneal surface or even get embedded. Superficial foreign bodies can commonly be removed following topical anesthesia with irrigation (hydropulsion) or a sterile cotton-tipped applicator. Deep and penetrating foreign body patients should be referred to an ophthalmologist for management as linear corneal foreign bodies may require a needle to be carefully inserted adjacent to the foreign body to enable removal and penetrating cases need surgical removal and corneal suturing. Following removal most corneas heal very rapidly if not infected but patients should still be managed with topical antibiotics, atropine, pain control and an e-collar.
Chronic Superficial Keratitis (Pannus)

Chronic superficial keratitis is a progressive, bilateral immune-mediated condition that affects the cornea of dogs. Corneal disease typically starts temporally or nasally with vascularization, cellular infiltration and superficial pigmentation, but without treatment can progress to involve the entire cornea and even cause blindness. The third eyelid can be affected with or without corneal changes as a lymphocytic-plasmacytic conjunctivitis resulting in margin depigmentation and an irregular surface. Greyhounds, German Shepherds and associated breeds are more commonly affected and ultraviolet light exposure exasperates the disease. Young animals tend to have more severe disease that may be more challenging to control; while middle-aged to older dogs have a better prognosis. Diagnosis is typically based on clinical signs and signalment though cytology showing lymphocytes and plasma cells is supportive. Topical ophthalmic corticosteroids (prednisolone acetate or dexamethasone TID-QID) and immunomodulators (cyclosporine or tacrolimus BID) along with UV light reduction (provide shade, tinted Doggles®, etc) are the basis for therapy, with gradual tapering of topical steroids (dose reduction every 2-3 weeks) and only immunomodulator use SID long term if possible.

Keratoconjunctivitis Sicca

Keratoconjunctivitis sicca (KCS) or dry eye disease is due to decreased aqueous tear production and is easily diagnosed by use of a Schirmer tear test strip (normal 15-25 mm/min in dogs). Values of 10-15 mm/min may indicate KCS if consistent historic client observations and/or clinical signs are also present (conjunctivitis, intermittent mucoid or mucopurulent discharge, corneal changes), while values less than 10 mm/min are diagnostic for KCS. Causes of KCS are numerous including infectious/inflammatory disease processes, trauma, iatrogenic damage, systemic metabolic diseases, congenital acinar hypoplasia, lacrimal gland neoplasia, neurologic dysfunction, and drug toxicity; however, immune-mediated lacrimal gland adenitis is the most common cause. Tear production can be transiently lowered by debilitation, dehydration, anesthetic drugs (topical or systemic) and parasympatholytic drugs (e.g. atropine) but will not permanently result in KCS. Treatment of KCS involves tear stimulant therapy lifelong, tear replacement therapy until tear values improve, and supplemental treatments on an individual case basis. Client education is the most important tool in managing KCS as diligent treatment is required, results may not be immediate (can take 1-3 months), and lifelong treatment is necessary.
Lacrimostimulant drugs used for treatment of KCS include cyclosporine and tacrolimus. Cyclosporine is available as Optimmune® 0.2% ophthalmic ointment or can be compounded (1% or 2%) as drops or ointment. Tacrolimus must be compounded with 0.03% most common; however, stronger concentrations have been attempted for refractory cases. For compounded formulations a reputable pharmacy is recommended. Cyclosporine or tacrolimus is used every 12 hours for most cases of KCS; however, severe, refractory patients may need more frequent treatment (every 8 hours) or use of both medications in combination. If a positive response is seen maintain on that frequency of medication and do not decrease or discontinue use as tear values can quickly drop and may not respond when treatment is resumed. Quality tear substitutes, such as I-Drop Vet, Optixcare, GenTeal Severe gel, etc., are recommended until the STT improves and should be used as frequently as needed for the individual patient (range 2-3 times to 8-10 times daily). An ointment formulation can be used before bedtime/naptime. Additional therapies may include eye wash to remove excessive ocular discharge, n-acetylcysteine 5% BID-QID short term to help remove severe mucoid secretions, topical ophthalmic antibiotics (TID-QID) short term if bacterial conjunctivitis is present or if there is a corneal ulcer, systemic doxycycline and/or omega-3 fatty acid supplementation to help reduce inflammation and improve tear film quality/stability. Topical corticosteroids are NOT recommended for patients with KCS due to the high risk for corneal ulceration. Lacrimostimulants have anti-inflammatory properties that will reduce keratitis and conjunctivitis, but it is the improved tear production and supplemental lubrication that will be most important in improving the clinical signs of KCS. Patients nonresponsive to aggressive medical therapy for KCS may benefit from parotid duct transposition surgery. Though this surgery does provide saliva as an ocular lubricant, it rarely obviates the need for topical medications and may result in postop complications. Other surgeries under investigation include episcleral cyclosporine implant placement and buccal mucosal graft transplantation surgery. Preliminary results are encouraging but long-term follow-up is still needed.

Qualitative Tear Deficiency

Qualitative tear deficiency is due to an abnormality in the mucin or lipid layer of the tear film. Clinical signs may appear similar to KCS but are typically more subtle. The key difference is a normal STT (>15 mm/min) with a qualitative tear deficiency since aqueous tear production is unaffected. Rose Bengal staining may be of value to highlight corneas with poor mucin coverage and/or dead epithelial cells. To document a deficiency in the lipid component of the tear film meibomian gland secretion (mebum) analysis is performed, while a mucin deficiency is evident by reduced goblet cell numbers in a conjunctival biopsy. More commonly a tear film break-up time (TBUT) is performed to highlight general tear instability. A TBUT involves
application of concentrated fluorescein to an eye (without rinsing). The lids are blinked to spread tears and then held open while a cobalt blue light illuminates the corneal surface and allows for timed evaluation of dark “windows” or “fissures” developing within the tear film. Normal tear film should remain homogenous and stable for 20 seconds or longer. Break-up noted in 10 seconds or less is diagnostic, with values of less than 5 seconds suggestive of a mucin deficiency.

If impacted or infected meibomian glands are evident to suggest a lipid deficiency treatment of the specific issue (e.g. manual gland expression and warm compresses for impacted glands, medications for meibomianitis, surgical curettage of chalazia) and application of lipid substitutes is necessary. If a mucin deficiency is suspected topical cyclosporine is used twice daily long-term for its mucinogenic properties and viscous artificial tears are used until the tear film improves. Topical antibiotics may also be needed if a corneal ulcer is present or a secondary bacterial conjunctivitis exists. Topical steroids should NOT be used to reduce inflammation (status will improve with lubrication) given the risk for ulceration. Many patients with poor tear quality have confounding ophthalmic or conformational issues that may also need addressed (e.g. medial lower lid entropion, trichiasis, macropalpebral fissure, lagophthalmos, etc.).

**Exposure Keratitis**

Exposure keratitis is due to a disorder of corneal coverage or tear distribution and may manifest with a roughened corneal surface, ingrowth of blood vessels, resultant corneal edema and/or pigmentation, corneal scarring, corneal ulceration and even globe perforation. Though the cornea can only respond in a limited number of ways, the causes of this corneal pathology can be numerous (exposure during anesthesia, eyelid agenesis, acquired eyelid margin defects, facial nerve paralysis, lagophthalmos, macropalpebral fissure, exophthalmos, buphthalmos). In order to determine the definitive cause a complete ophthalmic exam must be performed (including cranial nerve testing and globe retropulsion) along with baseline diagnostic tests (STT, fluorescein stain for ulcers +/- TBUT, and tonometry). Patients with any form of exposure keratitis require ocular lubrication using a viscous product (e.g. Optixcare or GenTeal severe gel) to improve corneal health; however, diagnosis and treatment of the underlying problem is necessary to permanently resolve the situation. Eyelid defects can be surgically corrected with eyelid margin apposition most important to ensure proper function. Facial nerve paralysis results in an inability to blink the eyelids and therefore cover the cornea. Patients with concurrent neurogenic KCS have the worst prognosis; however, if parasympathetic stimulation to the lacrimal gland remains, globe retraction and third eyelid elevation may allow adequate tear spread and globe protection. A temporary tarsorrhaphy may be performed for select
patients to help retain moisture and protect the cornea while awaiting the return of nerve function. If the facial nerve remains paralyzed long-term and the eye is very painful with recurrent problems (e.g. ulceration/perforation) enucleation may be considered. Macropalpebral fissure and lagophthalmos can be corrected with medial canthoplasty surgery as previously discussed. Exophthalmic eyes need the underlying condition addressed (e.g. orbital cellulitis, abscess, neoplasia, cystic disease, etc.); however, a temporary tarsorrhaphy may be used to partially close the eyelids and protect the globe in the short term. Buphthalmic globes typically have chronic glaucoma and are irreversibly blind so end-stage treatment should be considered (e.g. enucleation, evisceration, or chemical ablation).

**Pigmentary Keratitis**

Pigmentary keratitis develops secondary to chronic corneal irritation and is more prevalent in certain breeds of dogs (e.g. Pugs). Treatment is directed at halting the progression of pigmentation and correcting the inciting cause such as surgery to address trichiasis, entropion, lagophthalmos, etc. Topical tacrolimus 0.03% or cyclosporine 0.2-2% BID may be helpful to reduce corneal pigment or prevent further pigment extension. Ophthalmic lubrication (e.g. Optixcare or GenTeal severe gel) is imperative to reduce irritation and can be used as prevention in patients at risk. Topical steroids are generally not recommended given the risk of corneal ulcers in brachycephalic breeds or other dogs with chronic ocular irritation.

**Corneal Dystrophy and Degeneration**

Superficial white corneal infiltrates may be seen in puppies (juvenile or puppy corneal dystrophy), adult purebred dogs (inherited corneal dystrophy) or in eyes following some type of ocular pathology (corneal degeneration). The infiltrates may be mineral (calcium) or lipid (cholesterol, triglycerides) but are typically nonpainful. Exceptions to this are older dogs with dense mineral plaques that may slough to result in corneal ulceration or patients with superficial punctate keratitis lesions (more common in Shelties and Dachshunds). Corneal dystrophy is commonly bilateral but not always symmetric and does not impact vision so does not require topical therapy. The condition in puppies may manifest as only faint opacities that resolve on their own. Adult animals can be tested for systemic diseases that may result in elevated blood calcium or lipid values (e.g. hypothyroidism, hypercholesterolemia, hypertriglyceridemia, etc.) and be put on a low-fat diet if indicated. Patients with corneal degeneration should have the underlying ocular condition addressed and have possible corticosteroid use discontinued as corticosteroids exacerbate deposits. Topical EDTA 1-2% BID-
QID can be attempted in patients with presumed mineral deposits to potentially decrease calcium. Topical cyclosporine BID may be of benefit long term in some cases.

**Endothelial Dystrophy and Degeneration**

Endothelial cells that do not function normally due to an inherited defect (dystrophy – more common in Boston Terriers and Dachshunds) or acquired degeneration (age-related or following intraocular disease processes) result in corneal edema that becomes progressive as more and more endothelial cells are exhausted. The condition commonly starts laterally then extends to involve the entire cornea and can cause blindness. Topical sodium chloride ointment (Muro128® or generic) can be used TID in an attempt to minimize edema and prevent further endothelial cell exhaustion but may not be effective in improving corneal clarity or vision in severely affected dogs. Surgical treatment considerations for patients with these conditions include thermokeratoplasty if painful recurrent corneal erosions occur, a very thin conjunctival graft (Gunderson flap), or even corneal transplantation.

**Other Corneal Pathologies**

Uncommon corneal congenital lesions like dermoids (congenital plaque of abnormally placed skin tissue) or leukomas from iris to cornea persistent pupillary membranes (must distinguish PPMs from anterior synechia) may be noted on initial puppy or kitten examinations. Less common acquired corneal conditions include Florida spots (multifocal variable white circular lesions), inclusion cysts (may occur after trauma), corneal squamous cell carcinoma (more common in large animals), and nodular granulomatous episclerokeratitis (immune-mediated disease affecting the sclera and possibly extending to involve the cornea) among other possibilities. Appropriate treatment varies with each condition (see an ophthalmology textbook for details).

**General Eye Medication Tips**

Teach clients how to administer eye medications before they leave the clinic in order to reduce frustration and improve compliance. When giving small animal patients eye medications it is easiest to support the chin with one hand and direct the nose upward, then hold the medication bottle/tube in the opposite hand and elevate the eyelid to apply to the ocular
surface. Once medication is on the cornea or conjunctiva the eyelids are blinked to distribute
the drug. When solutions or suspensions are used only 1 drop is needed and with ointments
1/8” is sufficient (grain of rice). Liquid medications should be given at least 5 minutes apart to
allow time for absorption. Aqueous drops should be given before oil based drops which should
be given before gels or ointments if all are being used in sequence. Multiple ointments should
be spaced 30 minutes if possible.