

Topical Review

Corneal Emergencies

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Corneal emergencies can be due to a number of different causes and may be vision threatening if left untreated. In an attempt to stabilize the cornea, it is of benefit to place an Elizabethan collar on the patient to prevent further corneal damage. This article discusses the diagnosis, prognosis, and management of corneal emergencies in dogs and cats.

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Introduction

Corneal damage is a fairly common and potentially vision-threatening condition, which can present as an emergency to the small animal practitioner. Many conditions threaten the transparency of the cornea, whereas others have the potential to result in loss of the eye. The goal of this article is to provide the reader with an overview of the most common corneal emergency conditions. Assessment of their severity, corneal stabilization, therapy, and prognosis for saving vision and the globe are discussed.

The Cornea

The anatomy of the cornea allows light to be refracted and allows enough light to enter the eye for an image to be perceived by the retina. The cornea comprises an outermost epithelial layer, the deeper stroma, Descemet's membrane, and the inner endothelial layer (Fig 1).¹ There is a continuous turnover of the corneal epithelial cells that, in conjunction with the overlying tear film, serve as a defense mechanism of the cornea. In an effort to promote rapid and proper healing, therapy should also be directed to minimize further trauma to the cornea to promote translucency and minimize scarring. Disruption of the corneal integrity may lead to vascularization and pigmentation of the cornea, with malalignment of the corneal collagen fibrils within the stroma, all impairing transparency.

Ulcer

A break in the epithelial layer of the cornea leading to exposure of the underlying corneal stroma results in a corneal ulcer. Superficial ulcers limited to loss of the corneal epithelium are

the most common form of ulceration. As the corneal nerves enter the middle stroma and radiate to the anterior stroma, there is significant pain associated with ulceration of the cornea, which manifests in clinical signs of blepharospasm, protrusion of the nictitans, lacrimation, and miosis. Additional clinical signs of corneal edema, conjunctival hyperemia, photophobia, and, sometimes, aqueous flare may also be observed. Definitive diagnosis of an ulcer is made by topical application of fluorescein dye and its retention by the exposed corneal stroma (Fig 2). Although a tentative diagnosis may be made by observance of a corneal defect, this may be misleading in epithelialization cases with a loss of stromal depth or when excessive vascularization is present, making it appear that an ulcer is still present. Ulcers are further classified according to their depth or their cause.

Superficial

Although these cases are extremely painful and often present as emergencies, they generally are not vision threatening at this point. However, a thorough history and ocular examination should be conducted to determine an underlying cause, if apparent, and the cause should be eliminated to allow for healing and prevent further damage. Keratoconjunctivitis sicca, eyelid deformities, ectopic cilia, distichiasis, foreign bodies (Fig 3), viral infection, repeated trauma (Fig 4), and chemical burns may all be identified as possible etiologies. Without a persistent underlying cause, a superficial ulcer should heal within 2–6 days.¹ Lack of healing within 7 days and the presence of loose epithelium in an old patient suggests a nonhealing ulcer or spontaneous chronic corneal epithelial defect, which requires specific treatment.

Treatment should be directed to alleviate any underlying cause, promote comfort and healing, and prevent a deeper bacterial infection. Topical antibiotics commonly used for superficial ulcerative keratitis include tetracycline or a combination of neomycin,

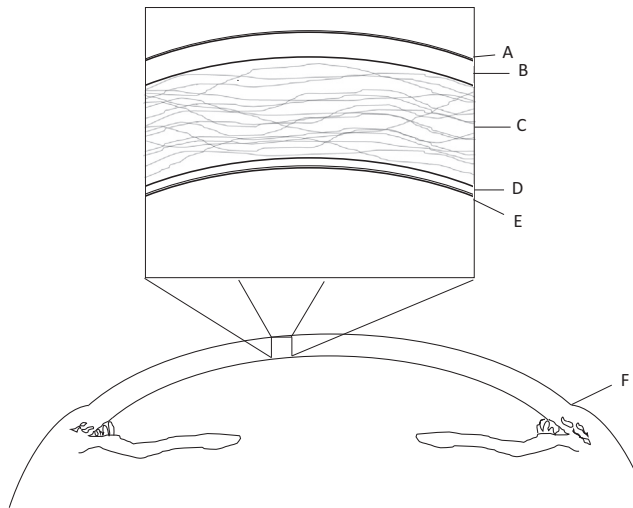


Fig. 1. Diagram of a canine cornea consisting of (A) tear film layer, (B) epithelium, (C) stroma, (D) Descemet's membrane, (E) endothelium, and (F) limbus.

polymixin B, and bacitracin. Superficial pain receptors in the cornea stimulate a neurogenic reflex, resulting in discomfort, miosis, and reflex uveitis. A mydriatic agent, such as 1% atropine sulfate, is applied every 12–24 hours to alleviate ciliary muscle spasm, minimize posterior synechiae development, and to stabilize the blood-aqueous barrier when secondary uveitis is present.² Nonsteroidal anti-inflammatory drugs (NSAIDs) may be used topically, with discretion as reports exist of associated corneal melting in humans,³ or systemically to treat concurrent ocular inflammation. Inflammation is present in the cornea due to the ulcerative keratitis and release of inflammatory mediators during the acute phase. Limiting inflammation is critical to minimizing vascularization, fibrosis, and pigmentation of the cornea as well as preventing synechiae and glaucoma. Although having greater anti-inflammatory properties, topical steroids, for their anti-inflammatory properties, are contraindicated in ulcerative keratitis due to inhibition of corneal healing and limiting defense mechanisms of the cornea. Commonly used topical NSAIDs for ophthalmology include diclofenac, flurbiprofen, and ketorolac, generally administered once to twice daily to treat ocular inflammation.

Chemical-induced ulcers are acute with severe blepharospasm, edema of the eyelids, conjunctival hyperemia and chemosis, and

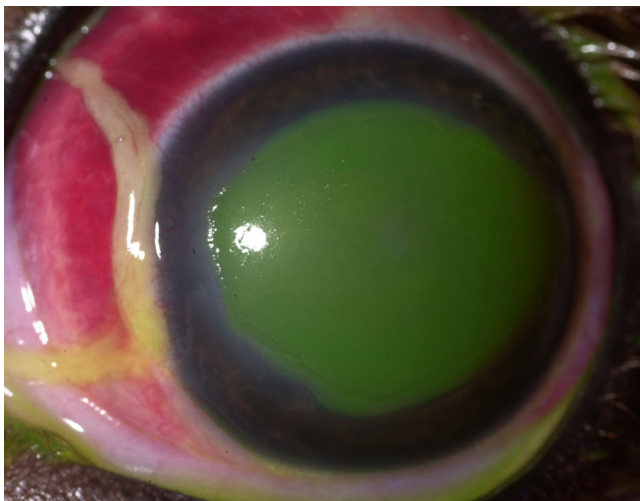


Fig. 2. Retention of topically applied fluorescein dye by the corneal stroma confirms diagnosis of superficial corneal ulcer.

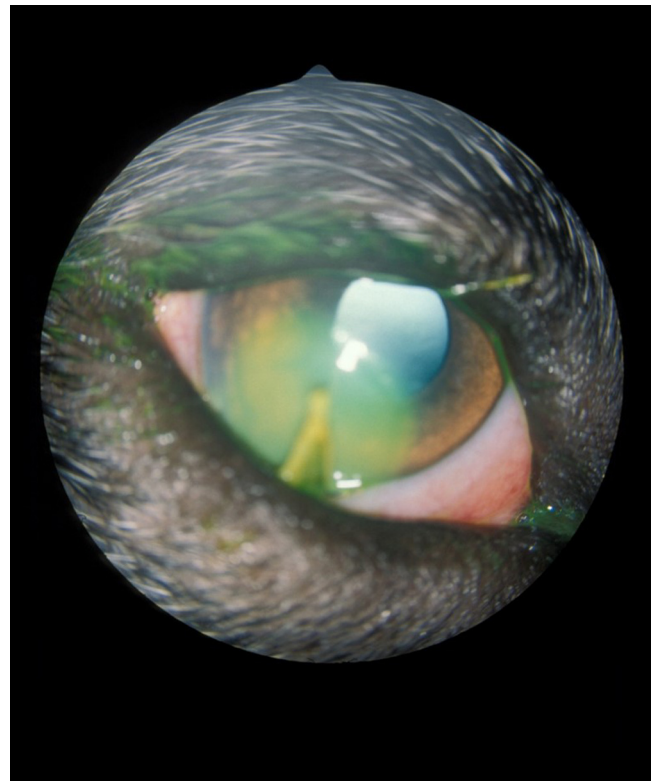


Fig. 3. A superficial ulcer with a foreign body identified. Removal of the foreign body resulted in healing of the ulcer within 36 hours.

corneal edema, and generally they rapidly progress to include the entire epithelial layer of the cornea (Fig 5). In most cases, there is a suggestive history of an encounter with a chemical—either alkaline or acidic. Initial treatment should be to rinse with tap water in cases of alkaline exposure, followed by serum and topical antibiotics every other hour as further loss of epithelium continues and corneal stromal destruction occurs.⁴ In contrast, acidic chemicals tend to cause superficial and nonprogressive ulcers due to coagulation of proteins in the epithelial layer. A broad-spectrum fluoroquinolone antibiotic, such as ofloxacin 0.3%, is suggested in these cases along with mydriatics, systemic anti-inflammatory drugs, and oral doxycycline. Due to the intense pain associated with this



Fig. 4. A superficial ulcer in a canine patient resulting from trauma due to suture material observed on the bulbar aspect of the nictitans from a previous surgery.

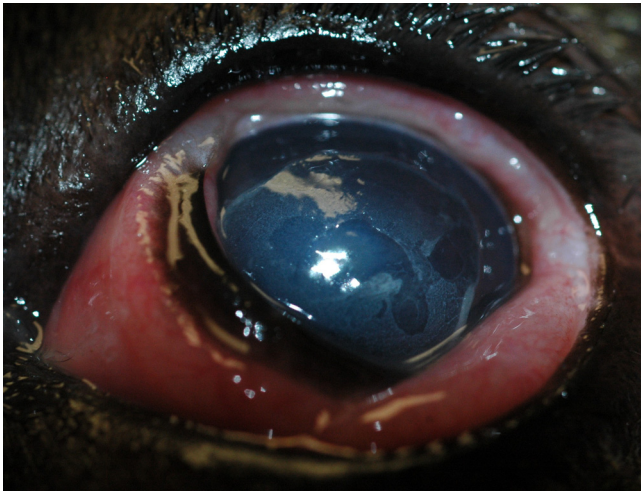


Fig. 5. A large superficial ulcer in a French Bulldog after eating a remote control and exposure to the battery. Notice the intense chemosis. The ulcer progressed and involved the entire cornea before healing without scarring.

corneal, and sometimes conjunctival, injury, administration of systemic pain medication is necessary for at least the first 24 hours.

In middle-aged to older canine patients with superficial ulcers and loose epithelium (Fig 6) or a ring of less intense fluorescein staining, one should consider spontaneous chronic corneal epithelial defects as the problem, once other causes for delayed corneal healing are ruled out. These specific nonhealing ulcers are characterized by epithelial dysmaturation and nonadherence with a hyalinized acellular zone of the anterior stroma preventing formation of normal adhesion complexes and basement membrane.⁵ Although these ulcers are generally chronic issues, they often present as an emergency case due to the waxing and waning of blepharospasm and the intense vascularization that the client may observe. Treatment specific to this type of ulcer commonly consists of epithelial debridement back to healthy adhered epithelium using a cotton-tipped applicator and a grid keratotomy using a 25 G needle; success rates typically are greater than 80%.⁶ The use of a diamond burr (Fig 7) for debridement and penetration into the stromal layer may also be used successfully to treat these ulcers.⁷ Healing of the ulcer takes 2–3 weeks, but normal adhesion complexes are not formed until at least a year after ulceration.⁶ Bandage contact lens use is advocated in many instances to

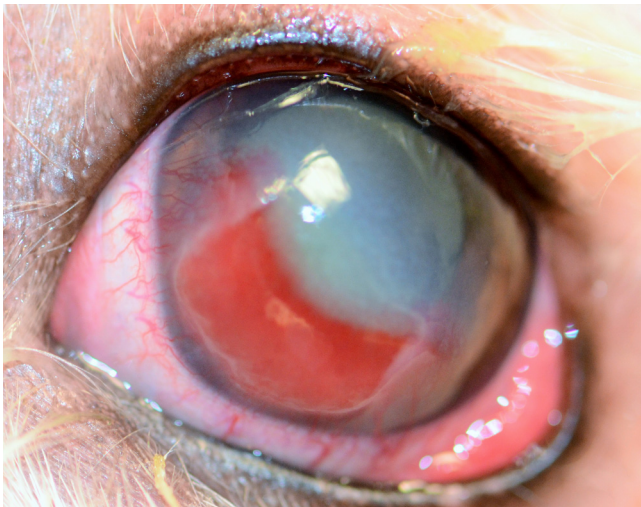


Fig. 6. Notice the loose corneal epithelium in this superficial ulcer. This is typical of spontaneous chronic corneal epithelial defects (SCCEDs).



Fig. 7. A diamond burr used to remove loose epithelium.

promote healing time and patient comfort. Education of the client to the likelihood of recurring problem is recommended. Although more common in the Boxer breed, this type of ulcerative keratitis should be considered in any old dog with evidence of chronic ulceration despite presentation as an acute emergency.

Although many feline patients may present with acute corneal injuries, some are more challenging to diagnose. In cases with concurrent conjunctivitis or upper respiratory tract symptoms, careful observation to detect feline herpesvirus-1 ulcerations should be performed. Some cats have larger geographic ulcers, whereas others have dendritic ulcerations (Fig 8), traveling along the nerve routes and more difficult to detect. In some instances, staining with Rose bengal may be necessary to detect minor epithelial defects. In suspected cases of feline herpesvirus-1 infection, treatment with topical oxytetracycline ointment, topical NSAIDs, and lysine (500 mg orally, every 12 hours) is thought to be appropriate. Through competitive inhibition with arginine, lysine inhibits viral replication, resulting in less outbreaks and minimizing severity of those which occur. In severe ulcerative cases, additional topical (cidofovir) or oral antiviral (famciclovir) medications may be used for treatment.⁸

Stromal Ulcer

A visible defect in the cornea generally suggests a stromal ulcer (Fig 9). Before topical fluorescein is applied, a sample for cytology

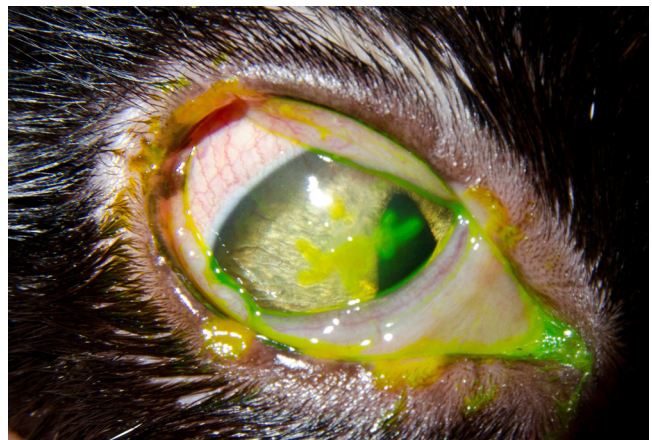


Fig. 8. A dendritic ulcer in an adult cat, FIV+ and treated with immunosuppressive corticosteroids for inflammatory bowel disease, stained with fluorescein. Notice the branching appearance of the ulcer, typical characteristic of FHV-1. Photograph courtesy of Dr. Caroline Betze. FHV-1, feline herpesvirus-1; FIV, feline immunodeficiency virus.

should be taken as well as one for aerobic culture and sensitivity as the depth of the ulcer is most likely due to progression of a bacterial infection in small animals. Occasionally, a stromal ulcer may be observed secondary to trauma and not be infected. Pain due to the ulcer and the accompanying uveitis may result in the clinical signs of blepharospasm, conjunctival hyperemia, miosis, and photophobia. Hypopyon and hyphema may also be observed. Some stromal ulcers may be classified as nonprogressive and treated similarly to superficial ulcerations. Others are observed to be progressive as indicated by increasing depth and width of the ulcer, a gelatinous appearance to the ulcer bed, or presence of cellular infiltrate. With these, treatment needs to be more aggressive to prevent loss of the corneal clarity and the globe itself with careful interpretation of initial cytology results.

Bacterial infection is diagnosed by either cytology or culture and sensitivity, but special care should be taken not to overlook fungal hyphae (Fig 10) in the sample. Mycotic ulcerations are rare, but not uncommon in those cases receiving chronic antibiotic or corticosteroid treatment or systemic immunosuppressive medications.^{9,10} Topical voriconazole with systemic fluconazole is used in these cases.

Concurrent reflex uveitis is observed in most corneal ulcers, as they progress from the epithelial layer to the deeper stromal layers of the cornea. Atropine is used to decrease ciliary spasm and minimize posterior synechiae formation, whereas NSAIDs, topically and systemically, are used to control the uveitis. Use of topical antimicrobials is important to sterilize the ulcer rapidly to prevent further destruction, while monitoring for signs of malacia. Adequate broad-spectrum topical antibiotics applied initially every 2–4 hours to attain therapeutic concentrations in the cornea are indicated in the first 48 hours. This can usually be followed by application every 6 hours. Aminoglycosides paired with beta-lactams or fluorinated quinolones are preferred in these cases.

Healing of stromal ulcers is dependent on epithelial coverage, collagen synthesis and cross-linking, proteoglycan synthesis, and eventual remodeling of the defect. Surgical intervention may be indicated if the ulcer is progressive and depth is greater than 50% of the stroma. Goals of surgery are corneal stabilization, nutritional support, and addition of fibrovascular tissue to fill the ulcerated area.¹¹ For deep stromal ulcers, a temporary tarsorrhaphy or a nictitans flap is not considered appropriate therapy because none of the goals are accomplished.

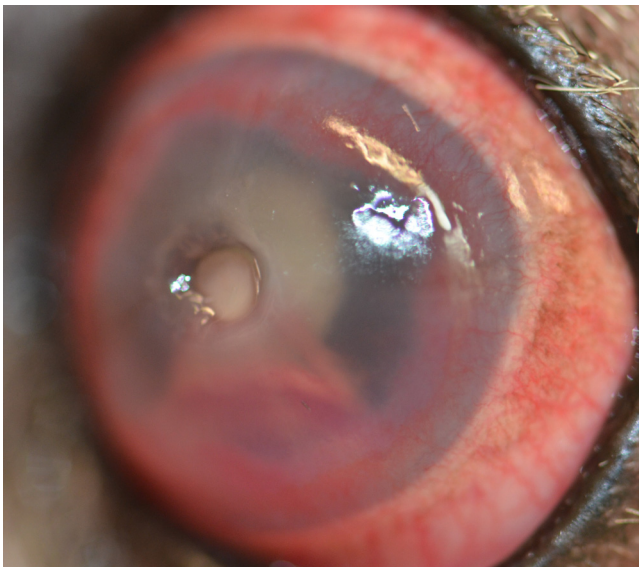


Fig 9. A deep stromal ulcer with the obvious defect observed with a transilluminator. Notice the significant inflammatory response in the anterior chamber along with 360° vascularization of the cornea.

Malacic Ulcer

When the balance of the corneal proteinases and proteinase inhibitors is disrupted, the character of the ulcer may become malacic and have a “melting” type appearance (Fig 11). This is due to the complicating pathologic degradation of stromal collagen and proteoglycans of the cornea by proteinases. Endogenous proteinases are secreted by corneal and inflammatory cells, whereas exogenous proteinases are produced by infectious organisms. Of these, serine proteinases and matrix metalloproteinases (MMPs) 2 and 9 are of the greatest importance.¹² MMP-2 is important in normal corneal collagen fiber turnover, whereas MMP-9 is increased after corneal injury. Neutrophil elastase is the most abundant serine protease and serves to degrade collagen, laminin, and fibronectin. Natural proteinase inhibitors of the precorneal tear film and cornea include α 1-antitrypsin, α 2-macroglobulin, and tissue inhibitors of MMPs.¹

Treatment of progressive keratomalacia in stromal ulcers is best accomplished with the use of appropriate broad-spectrum antibiotics, atropine with antiproteinases, and MMP inhibitors to minimize the progression of the ulceration and decrease the healing time. Of the antiproteinases available, the most efficacious are autogenous serum and tetracycline antibiotics, although *N*-acetylcysteine and disodium EDTA also have beneficial activity. Calcium and zinc, cofactors for MMPs, are chelated by tetracyclines, *N*-acetylcysteine, and EDTA.¹³ The serum contains α 1-antitrypsin and α 2-macroglobulin and inhibits serine proteinase activity by entrapment.¹³ Topical serum should be applied to the ulcer every other hour initially, and then its frequency should be gradually decreased to every 6 hours. The serum should be maintained in an aseptic manner, refrigerated, and discarded after 5–7 days of use. Systemic doxycycline (5mg/kg, orally, every 12 hours) may be administered in conjunction with topical serum for additive effects because of their different modes of action.

Descemetocoele

When the ulcer has reached the depth of Descemet's membrane, fluorescein retention is not observed as both the epithelial and stromal layers have been destroyed (Fig 12). The anterior chamber may be visible through the membrane, which is only 3–12 μ m thick and subjected to perforation. Due to this risk, descemetocoeles are considered surgical emergencies as a

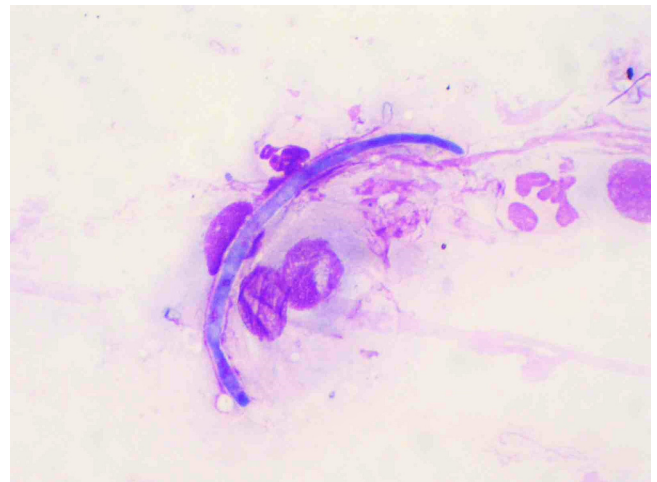


Fig 10. Photograph of corneal cytology taken with a cytobrush in a dog. Cells observed include squamous epithelial, neutrophils, and fungal hyphae. Diff-Quick staining— \times 100.

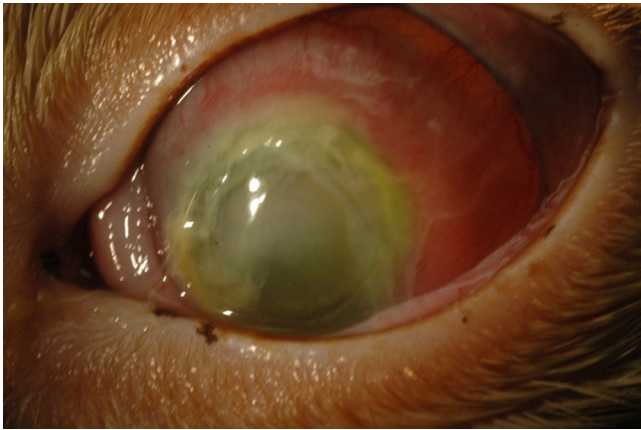


Fig 11. Keratomalacia in a feline patient. Notice the gelatinous appearance to the axial cornea.

perforation leads to a decreased prognosis for saving vision. Evaluation of the posterior segment is feasible in many of these cases, but if ocular ultrasonography is needed, it is best to perform in the sedated patient. If the patient does not have a menace response, a consensual pupillary light reflex, or dazzle reflex, the prognosis is poor for maintenance of vision or the globe following surgical correction. Otherwise, surgical correction of an uncomplicated descemetocele offers a good prognosis and may be accomplished by either a conjunctival pedicle graft, a synthetic graft, or a corneal transposition graft.^{14,15} If the surrounding cornea appears healthy, the author advocates the use of corneconjunctival transposition grafts as they result in less inflammation and greater clarity of the cornea postoperatively. Tissue adhesives are contraindicated in these cases as perforation may result due to heat production as the glue polymerizes. Referral to an ophthalmologist for surgical correction in these cases is considered to be an emergency to avoid perforation with contamination and greater inflammation of the anterior chamber with subsequent decreased prognosis due to possible endophthalmitis, retinal detachment, anterior synechiae, or increased corneal scarring.

Corneal Perforations

Corneal perforations may be due to continued progression of a corneal ulcer or descemetocele or trauma. In the acute phase, a fibrin plug may be present and impede further leakage of aqueous (Fig 13). When a perforation occurs, the aqueous humor leaks from the site and the iris may follow, resulting in iris prolapse. Identification of pigmented tissue on the injured cornea confirms a perforation and may indicate an iris prolapse (Fig 14). It is important not to mistake an iris prolapse for a corneal foreign body. To determine whether the defect is sealed, a Seidel test may be performed by applying a single drop of fluorescein directly on the site in question. Without irrigating the cornea, it should be observed whether the aqueous flows clearly through the fluorescein. The size of the fibrin plug is generally larger than the actual size of the perforation; the plug within the defect should be left alone until corneal surgery has commenced to preserve depth of the anterior chamber. Surgical therapy for corneal perforations is the most recommended therapy; however, if the defect is small (< 1-2 mm) with an intact anterior chamber and no iris prolapse, the case may be successfully managed medically with strict cage rest, although clinical results vary.¹¹

Ophthalmoscopy may not be possible and observance of a consensual pupillary light and dazzle reflex is a positive sign, although retinal detachments could still exist. A poor prognosis is

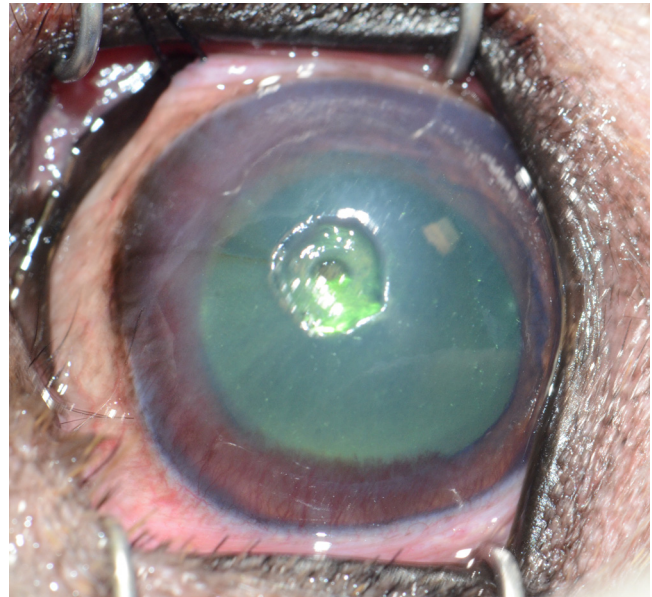


Fig 12. Notice the clear defect, a descemetocele, at the center of the ulcerated area.

usually given with the absence of consensual pupillary light and dazzle reflexes in an affected eye. With a deflated anterior chamber, significant iris prolapse, or hyphema, assessment of the posterior segment and its integrity may be best accomplished in the sedated patient to determine if surgery is warranted. It is imperative if ultrasonography is performed that the examination is performed through the eyelids and that the coupling gel does not enter the anterior chamber and create more inflammation. Correction of the defect with an attempt to preserve vision is best accomplished by surgery, usually by an ophthalmologist. Direct suturing of a small descemetocele or perforated cornea (< 3 mm) is seldom warranted due to potential astigmatism and interference with vision. Best success is obtained with grafting procedures including synthetic, autogenous sliding, or homologous corneal grafts. The use of a conjunctival graft by itself may be insufficient for adequate structural support in perforations and can be used in conjunction with other grafts, especially synthetic grafts.¹⁵ Critical assessment of these cases and early referral to an ophthalmologist for surgery warrants the best prognosis. If iris is already prolapsed, administration of topical mydriatics should be avoided until evaluated by an ophthalmologist. Administration of topical antibiotics is suggested before referral.

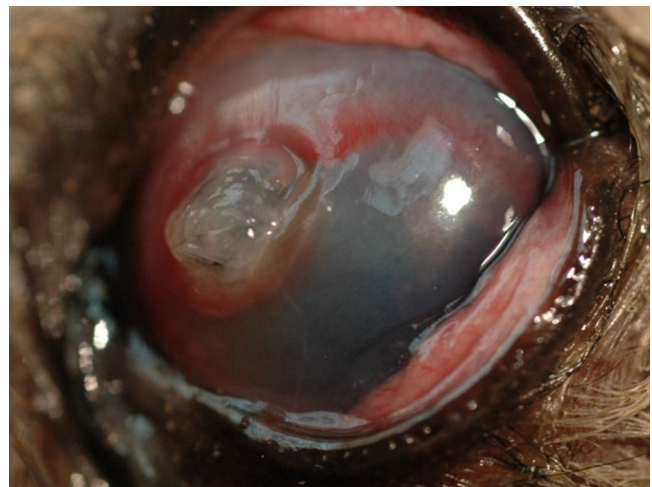


Fig 13. Corneal perforation with a fibrin plug sealing the cornea.

Corneal Lacerations

Lacerations to the cornea may be partial- or full-thickness lesions. Evaluation of the eye may be difficult. Corneal edema is apparent and progressive, the anterior chamber may be deflated, and hyphema with iris prolapse may be observed. Lacerations involving the limbus have a much poorer prognosis as do the cases without a consensual pupillary light or dazzle reflex.¹⁶ If the iris has been exposed for more than 8 hours, it may not be repositioned again in the anterior chamber. Obvious signs of trauma to the anterior lens capsule also have a poor prognosis due to lens-induced uveitis and cataractogenesis.

Corneal lacerations are seen most frequently in dogs and infrequently in cats. Bites, self-inflicted trauma, and other accidents can partially or totally penetrate the cornea. Partial-thickness corneal lacerations are usually highly painful and may require apposition with simple interrupted absorbable sutures to the healthy cornea. Excision of the lacerated section is not recommended. For full-thickness corneal lacerations, clinical signs usually include pain, blepharospasm, tearing, a corneal defect, and variable degrees of iris prolapse (Fig 15). Marked aqueous flare, hyphema, miosis, and distortion of the pupil are common. Initially, a fibrin plug forms and serves as a scaffold for fibroblastic repair of the defect; if left undisturbed, healing may occur without surgery. Often, the size of the fibrin plug or iris prolapse is much larger than that of the underlying corneal laceration, but cannot be assessed until surgery. Neutrophils migrate to the site early, followed by epithelial cell migration to cover the defect, and then fibroblasts proliferate and produce collagen and extracellular matrix to restore the stromal component. Endothelium is restored by sliding and mitosis and eventually produces a new Descemet's membrane, with better healing results in younger patients. Realignment of the collagen fibrils and minimizing of the fibroblasts are the final phase of healing to regain corneal strength and restore corneal clarity. The prognosis of a corneal laceration depends on its size and position, other ocular tissue involvement,

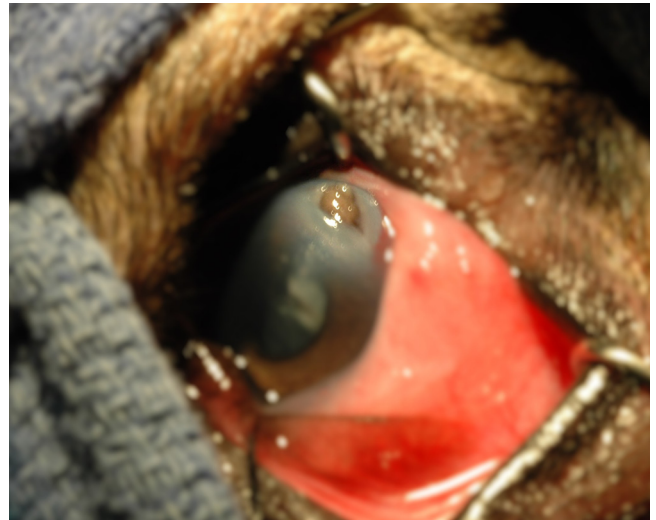


Fig 15. A corneal laceration in a Great Dane resulting from a cat claw injury. Notice the iris prolapse.

age of the animal, duration of the injury, and other systemic injuries. If the entire eye cannot be examined directly, B-scan ultrasonography is used, generally in the sedated or anesthetized patient, to evaluate the posterior segment for retinal detachment or vitreal hemorrhage.

The corneal laceration is apposed with simple interrupted 8-0 to 9-0 absorbable sutures, or nonabsorbable nylon to be removed 6 weeks after surgery. To provide additional protection and support, the sutured laceration may be covered with a bulbar conjunctival graft, or partial temporary tarsorrhaphy. Postoperative therapy to control the secondary iridocyclitis consists of topical and systemic antibiotics, systemic and topical NSAIDs, and mydriatics. Postoperative complications include variable and often dense corneal scarring sometimes with pigmentation, cataract formation with posterior synechiae, secondary glaucoma, phthisis bulbus, and bacterial endophthalmitis.

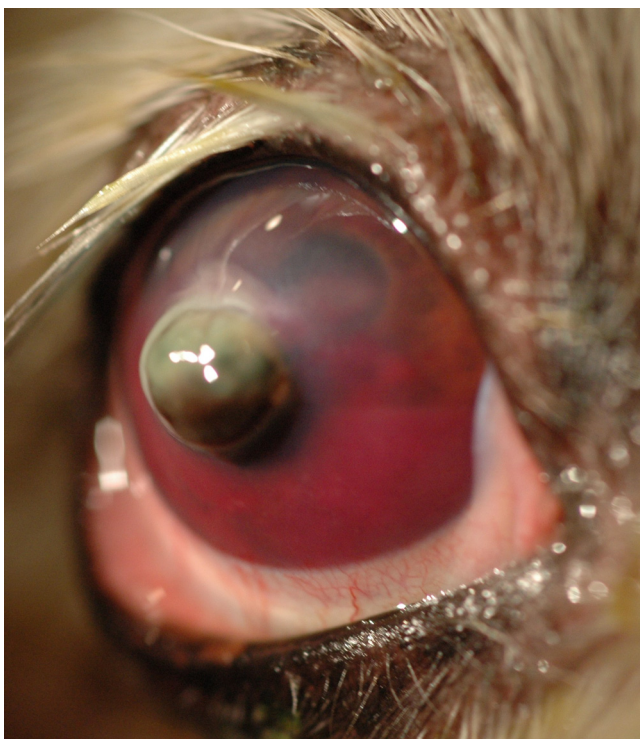


Fig 14. Pigmented tissue at the corneal perforation site, indicative of iris prolapse.

Corneal Foreign Body

Corneal foreign bodies are usually organic material, but sand, metal, and glass as foreign bodies are also seen. Presenting signs include blepharospasm, epiphora, and variable secondary iridocyclitis (aqueous flare, miosis, iridal swelling, ocular hypotony, and possible hypopyon). Ophthalmic examination reveals a foreign body (Fig 16) in the cornea. Foreign

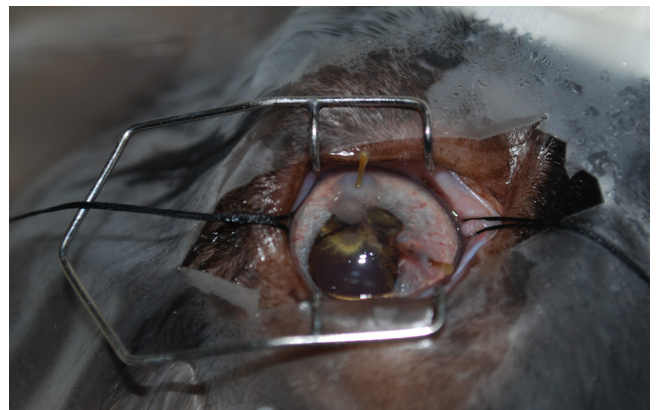


Fig 16. A plant material (cactus thorn) foreign body in the cornea of a cat. Photograph courtesy of Dr. Caroline Betze.

bodies that adhere to the ocular surfaces are usually removed under topical anesthesia with either vigorous irrigation or small serrated ophthalmic forceps, or by carefully using a 27 or 30 G needle to “flick” the foreign body out. If the foreign body has embedded within the deeper corneal layers or has penetrated into the anterior chamber, general anesthesia is required for careful removal from either the anterior corneal surface or the anterior chamber. Removal of foreign bodies with penetration into the anterior chamber and visible clot formation are likely to result in leakage of aqueous and are best removed using a surgical microscope. The corneal wound is apposed with simple interrupted 8-0 to 9-0 absorbable sutures if possible, whereas others may require a small corneal or conjunctival graft. Postoperative therapy includes topical and systemic broad-spectrum antibiotics, mydriatics, systemic NSAIDs, and if necessary, medications to reduce intraocular pressure. Prognosis for vision is usually good. Infrequent complications include variable corneal scar formation, septic endophthalmitis, cataract formation, and secondary glaucoma.

Conclusion

Thorough assessment of an emergency case with corneal damage is critical to determine whether referral to an ophthalmologist is warranted to save vision or irreparable damage necessitates salvage type procedures. Other cases are best managed by the emergency clinician with a predictable outcome for vision and saving the globe.

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