Ocular Trauma

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KEY WORDS

- ocular trauma
- blunt trauma
- chemical injury
- penetrating injury
- foreign body
- sharp trauma
- perforating injury
- hyphema

The eye is often subject to traumatic injury. Such injuries are classified according to the tissues involved and the severity of the injury:

- Contusions—overlying tissue is intact
- Penetrating injuries—tissue is abraded or partially cut
- Perforating injuries—tissue is completely cut

In addition, the etiology of the trauma should be categorized as sharp or blunt in nature because the resulting damage and prognosis vary according to the etiology. Regardless of the nature of the injury, there are a few basic rules that must be applied to all animals suffering from ocular trauma (see boxes on p. 85).

ORBIT

The dog and cat have an incomplete bony orbital rim comprised of the frontal, lacrimal, maxillary, and zygomatic bones and the lateral orbital ligament. The frontal sinus is located dorsomedial to the orbit, and the maxillary sinus is ventromedial to the orbit. The nasal cavity lies between the medial walls of the bony orbits. Orbital trauma can result in proptosis of the globe, orbital fractures, and damage to the associated soft tissue structures of the globe, adnexa, and nasolacrimal system. It is important to remember that in addition to the globe the orbit contains the extraocular muscles, zygomatic salivary gland, lacrimal gland, cranial nerves II, III, IV, V (ophthalmic branch), and VI, orbital fat, and arteries and veins of the globe and maxillary region. The muscles of mastication also border the orbit and serve as the ventral, caudomedial, and caudolateral orbital boundaries.[1] The oral cavity and the roots of the caudal maxillary teeth lie ventral to the orbit. Iatrogenic trauma during dentistry has been reported as a source of ocular and orbital trauma.[1]

The diagnosis of an orbital fracture is based on history, clinical signs, and radiographs. Oblique radiographic views, highlighting the area of greatest concern, are usually required. Care must be taken to evaluate the nasal and sinus anatomy, especially when subcutaneous emphysema is present. In addition, orbital ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) are also useful in evaluating the orbit and associated soft tissue structures.[1]

Traumatic fractures of the orbit are often associated with concomitant injury of the globe and adnexa. Complete ophthalmic examination is essential. This must include assessment of vision (menace response, maze testing), pupillary light reflex, fluorescein staining to detect the presence of a corneal ulcer, examination of the anterior chamber for hyphema and/or anterior uveitis, fundic examination evaluating the retina and optic nerve, assessment of globe and eyelid mobility, and nasolacrimal irrigation. For those eyes in which ocular damage precludes examination of the posterior segment, ocular ultrasound is advised.

Blunt trauma to the orbit can result in a breakdown of the fibrous orbital septum and subsequent herniation of orbital fat. Clinically, this is a nonpainful swelling that appears at the time of or following orbital trauma. It is best treated surgically by removing or replacing the herniated portion of the orbital fat pad and attempting to repair the rent in the septum.

Treatment of orbital trauma in the acute phase may include systemic antiinflammatory therapy, systemic antibiotic (especially if there is nasal or sinus involvement), and cold compresses. Local therapy is required for the management of corneal exposure, ulceration, and anterior uveitis. If eyelid movement is impaired, as the result of either neurologic dysfunction or swelling of the eyelids, the cornea must be protected from exposure and desiccation by applying a topical, sterile ophthalmic lubricant as frequently as possible or, in the more severe cases, through the use of a temporary tarsorrhaphy. Topical broad-spectrum antibiotics are indicated for eyes with corneal ulceration, and atropine is used as needed to relieve the discomfort associated with secondary anterior uveitis.

Although facial and orbital fractures will often heal without surgery, they may do so in a manner that results in deformity and interferes with the normal function of the eye and adnexa. Therefore surgical correction may be indicated, especially for displaced fractures. Fractures that extend into the nasal or sinus cavities must be considered to be open fractures as

INITIAL EXAMINATION PROCEDURES FOR A TRAUMATIC OCULAR EMERGENCY

- Obtain history with regard to duration, etiology, and medication administered.
- Perform a complete physical examination to assess associated injuries.
- Assess vision using the menace response, dazzle response, and maze testing.
- Palpate the orbital rim for crepitus, fractures, and emphysema.
- Examine eyelids for contusions and lacerations. Evert the eyelids and the nictitans and examine for foreign bodies.
- Gently retract the eyelids and examine the cornea and globe. Fluorescein stain all corneas suspected of sustaining trauma. If lacerations are present, note their depth and extent.
- Note the pupil size and compare it with the opposite pupil. Assess the pupillary light reflex.
- Inspect for hyphema.
- Evaluate for the presence of lens luxation.
- Perform a fundic examination. Examine the optic disc for size, color, and shape. Look for retinal hemorrhage or detachment.
- Consider ocular ultrasonography to assess intraocular damage if clarity of the ocular media prevents a complete examination.
- Irrigate the nasolacrimal system if there is soft tissue or bony involvement of the medial canthus.
- Avoid doing harm. Refer what you do not feel comfortable repairing.

these cavities contain resident bacterial and fungal flora. Early repair is associated with a more favorable cosmetic result as skull fractures consolidate rapidly and the resulting fibrous callus may interfere with surgical reduction. Generous skin flaps in the surgical approach are advised because fractures are often more extensive than initially thought. Excessive periosteal dissection should be avoided as the periosteum provides both stability and blood supply to the damaged area.

Traumatic proptosis is more common in dogs and cats because of the incomplete bony orbital rim. In addition, the globes of brachycephalic dogs are proptosed more readily and with less trauma than those of dolichocephalic dogs and cats. If the globe of a dolichocephalic dog or cat is proptosed, it indicates severe head trauma and thorough physical and neurologic examinations are required. Provided the optic nerve and extraocular muscles are intact, a proptosed globe should be replaced. Globes with avulsion of multiple extraocular muscles or the optic nerve, severe hyphema, or rupture of the fibrous tunic are best enucleated. The pupil size and pupillary light response do not correlate with vision prognosis.[2] Replacement of a proptosed globe requires general anesthesia except in the occasional brachycephalic dog with proptosis associated with excessive tension on the cervical skin during restraint. A lateral canthotomy may be required to facilitate replacement. Intravenous methylprednisolone sodium succinate (15–30 mg/kg) is indicated to decrease swelling of the optic nerve and orbital tissues.[2] Once the globe is replaced, a partial thickness temporary tarsorrhaphy is performed to protect the eye until the swelling subsides. Three to four sutures are placed in an interrupted or a mattress pattern 4 to 5 mm from the eyelid margin and emerge at the Meibomian gland opening. Stents may be used to prevent pressure necrosis; I prefer 4-0 to 5-0 monofilament, nonabsorbable suture. Systemic antibiotics and antiinflammatory drugs are indicated to control postoperative complications, and topical antibiotics and atropine may also be used if needed.

MEASURES TO AVOID WHEN TREATING OCULAR INJURIES

- Avoid the chronic use of topical anesthetics for superficial pain.
  - — These will delay healing, and their effect decreases with each administration.
  - — Their use is appropriate to aid in the examination of a painful eye.
- Avoid topical corticosteroids:
  - — If the diagnosis is uncertain.
  - — If the corneal epithelium is damaged.
  - — If corneal infection is present.
- Avoid topical ointments:
  - — If penetrating trauma is present. The ointment may enter the anterior chamber where it will incite inflammation.

Sequelae of proptosis include blindness (64% of dogs, 100% of cats),[2] strabismus, keratoconjunctivitis sicca, corneal ulceration, neuroparalytic keratitis, lagophthalmos, retinal and optic nerve degeneration, cataract, and phthisis bulbi.[1]

EYELIDS

Eyelid trauma includes both contusions and lacerations. Corneal abrasions or lacerations and anterior

TENETS OF EYELID REPAIR

- Treat promptly.
- Irrigate copiously to remove debris.
- Use minimal debridement.
- Never amputate a pedicle of eyelid.
- Use two layer closure, beginning with the deeper layer.
- Use smallest suture possible.
- Perform anatomic restoration of the eyelid margin.
- Prevent self-trauma following surgery.
- Control swelling with compresses and antiinflammatory drugs.
- Administer systemic antibiotics to prevent infection.

uveitis are commonly associated with eyelid trauma. Eyelid contusions often result in blepharedema and hemorrhage. Although this does not require therapy, recovery can be hastened by using systemic antiinflammatory agents, cold compresses in the acute phase, and warm compresses beginning the day following the injury.

Eyelid lacerations are more serious and usually require immediate therapy. The vascular supply to the eyelid is extensive, and many apparent avascular segments of eyelid will recover following repair. If possible, primary wound closure is preferred (see box above). All debris must be removed from the wound prior to closure. The eyelid surface and adjacent tissues are disinfected with a 1:50 dilution of povidone-iodine solution. Avoid excessive tissue debridement, and under no circumstances should a pedicle of eyelid be amputated. If the laceration is near the medial canthus, the nasolacrimal system must be evaluated and repaired if damaged.

Lacerated eyelids are sutured (the animal should be under general anesthesia) with a two-layer closure, ensuring accurate anatomic apposition of the wound edges and eyelid margin. The deeper conjunctival layer is sutured first using 6-0 to 7-0 absorbable polyglactin 910 suture in a horizontal mattress pattern beginning away from and working toward the eyelid margin. Care is taken to avoid penetrating the conjunctiva so that the suture does not contact the cornea. The skin is closed with 4-0 to 6-0 nonabsorbable suture. The eyelid margin is the most important portion of skin wound closure and is closed first. I prefer to use a cruciate suture pattern at the eyelid margin and a simple interrupted pattern for the remainder of the skin closure. Medical therapy includes systemic antibiotics for 5 to 7 days, warm compresses, and antiinflammatory agents if inflammation and swelling are a problem. Topical medication is not required for eyelid injuries unless there is associated corneal or anterior segment damage. Eyelid function must be evaluated, and the eyelid must provide adequate protection to the cornea. If the blink response is impaired, the cornea should be protected with topical lubricants as often as possible.

CORNEA

Corneal injury is categorized based on the size and depth of the injury and whether the trauma was blunt or sharp in nature or caused by chemical injury. The most severe form of trauma is the blunt, perforating or explosive injury. Penetrating injuries of the cornea are categorized as superficial, mid-stromal, or deep stromal. Treatment of a traumatic corneal ulcer is not different than that of other forms of corneal ulceration.

If not associated with a corneal ulcer, corneal edema is the result of corneal endothelial damage. Blunt injuries can lead to the displacement of the corneal endothelium from the posterior surface of the cornea. This causes full-thickness, diffuse corneal edema, which may gravitate to the ventral cornea with time. Although there is no specific treatment, topical hyperosmotic agents such as 5% NaCl applied every 4 to 6 hours may decrease the severity of the edema. In my opinion, this has only minimal efficacy. With time, the corneal endothelium may reattach or adjacent endothelial cells may hypertrophy, resulting in a decrease in the corneal edema. During the period that the edema is present, the cornea is compromised and at risk of ulceration. Topical corticosteroids are therefore to be avoided.

Corneal perforation may occur as the result of a complicated corneal ulcer that progresses to a descemetocele and subsequently ruptures or may occur acutely as the result of trauma. Culture, antibiotic sensitivity, and cytology should be considered for all corneal ulcers and perforations.

Ulcers that progress usually do so as a result of enzymatic degradation with or without microbial involvement. The perforation is most often round with edematous and necrotic edges that require some debridement. Deep corneal vascularization may be present depending on the duration of the ulcer; vessels require 3 to 5 days to begin infiltrating the corneal stroma and progress less than 1 mm per day. The intraocular structures are usually intact, but anterior uveitis is always present and iris prolapse and intraocular infection are possible. Repair of this type of corneal defect requires replacement of the missing tissue and is best performed as a corneal transplant rather than a conjunctival graft.

Chemical burns may be caused by mild irritants such as soaps; more severe injuries are due to acids, and the worst chemical injuries are alkali burns. Chemical burns may be due to accidental spillage or malicious attack. In addition, smoke from house fires contains noxious chemicals; when exposed to the moisture of the tears and airway secretions, the smoke causes acidic change to these fluids and secondary chemical injury. All chemical injuries should be copiously irrigated with an artificial tear solution or lactated Ringer's solution. The volume of solution and duration of irrigation should increase in conjunction with the degree of irritation the chemical causes. With alkali damage, continuous irrigation for 30 minutes is advised regardless of how quickly the animal is presented. Soap injury results in superficial corneal ulceration, acid injury causes ulceration and coagulation of the anterior stroma, and alkali injury induces progressive, melting corneal ulceration and/or perforation. In addition, chemosis, hyperemia, hemorrhage, blepharoedema, and necrosis of the conjunctiva, nictitans, and epidermis may be present. Reflex miosis and anterior uveitis are also common and result in significant discomfort. Atropine (1%) should be used to dilate the pupil, and topical antibiotics, neomycin-bacitracin-polymyxin B, or ciprofloxacin is indicated to prevent secondary infection. Anticollagenase therapy may be used as required for acid and alkali damage. Corneal scar, perforation, and loss of an eye are all potential sequelae of severe chemical injury. Surgical repair of damaged corneas using conjunctival or corneal grafting procedures may be required.

Traumatic corneal perforation/laceration is an acute injury and should be categorized as the result of sharp or blunt injury. In addition, a complete ophthalmic and physical examination should be performed to evaluate for possible trauma to other structures.

Sharp Trauma

Sharp injury, such as that caused by a cat claw, plant thorn, or other like material, results in laceration of the cornea from the epithelial side and may be partial or full-thickness.

If small, partial-thickness lacerations may require only medical management. Larger partial-thickness lacerations can be apposed with 7-0 to 9-0 suture, and postoperative treatment of the eye is the same as for a corneal ulceration. Healing is often rapid, and suture removal should be planned after 21 days, regardless of whether the suture material was absorbable, to minimize corneal vascularization and associated scar formation.

Full-thickness lacerations penetrate the chamber rapidly and may or may not traumatize the intraocular structures or leave foreign material in the cornea or the globe. Damage to the cornea is repairable; provided the intraocular structures are not severely damaged by the penetrating object, the prognosis for vision and cosmetic appearance is fair to good. In addition, the prognosis is more favorable in cats than in dogs, in younger than in older animals, and for damage to the peripheral cornea than to the axial cornea.[3] Care must be taken during examination, anesthesia, and surgery to avoid inadvertent pressure on the globe with consequent opening of the wound and expulsion of intraocular contents. Occasionally, small lacerations may self-seal and thus may not require surgical intervention. To test whether a small laceration has sealed, a Seidel test is performed: Sodium fluorescein is placed on the cornea (do not irrigate), and the area of the laceration is examined for the presence of a clear river of aqueous running through the fluorescein film, indicating that the anterior chamber is not sealed. Small wounds that are not sealed should be repaired surgically by direct suturing or, in some instances, by using cyanoacrylate tissue adhesive.[3] Medical management (i.e., cage rest, an Elizabethan collar, and topical therapy as for a corneal ulcer) can be attempted in cases in which the anterior chamber is formed, the laceration is small (<1–2 mm), no iris prolapse is present, and the eye is comfortable.

Foreign bodies may remain imbedded in the cornea and/or anterior chamber following trauma. While removal of superficial foreign bodies can be performed in the examination room using topical anesthesia, removal of deep or penetrating foreign bodies may be difficult and is best performed under general anesthesia using magnification. Prior to removal, slit lamp examination and a Seidel test are used to assess depth of penetration. The clinician must be prepared for the possibility of a leaking wound following removal and the potential for entry into the anterior chamber to facilitate recovery from the endothelial side of the cornea. Intraocular foreign bodies should be categorized with respect to the degree of irritation they will produce. In general, iron, copper, steel, and plant material are considered very irritating, lead, zinc and nickel as mildly irritating, and glass, stone, rubber, silver, and lead as inert.[4] Slit lamp examination, gonioscopy, and ultrasound are all used to examine for and localize intraocular foreign bodies. Removal of magnetic intraocular foreign bodies may be facilitated with the use of a magnet.

If the penetrating object traumatizes the iris, hyphema and iris laceration may occur immediately, followed by possible iris prolapse and anterior or poste-

rior synechia. If the hyphema is complete, assessment is made of the intraocular structures and the prognosis based on the presence or absence of a consensual pupillary light response; in addition, an ocular ultrasound performed through the eyelid using a 7.5 or 10.0 MHz probe will allow examination of the intraocular anatomy.[3]

Iris prolapse is common and, when combined with an aqueous clot, often results in a temporary seal and the reformation of the anterior chamber. This seal should not be disturbed until the animal is anesthetized and the cornea is about to be repaired. The surgeon must decide whether to replace a prolapsed iris or excise the prolapsed portion. Replacement is always preferable, but an iris that has been prolapsed for several days or that is heavily contaminated or necrotic is best excised. Topical 1:10,000 epinephrine will decrease iris hemorrhage associated with replacement or excision.[3] Gentle irrigation with a balanced salt solution is used to remove debris prior to repositioning. The iris will be adherent to the edges of the corneal laceration and is freed using a iridodialysis spatula or dissection with viscoelastic material. If amputation is required, sharp Westcott or Vannas scissors with or without wet-field electrocautery are used to amputate the iris flush with the corneal surface. If hemorrhage occurs, 1:10,000 epinephrine is placed in the anterior chamber and the surgeon should wait several minutes for the vessels to seal and a clot to form. The anterior chamber is then gently irrigated with balanced salt solution or, if that is unavailable, lactated Ringer's solution, and the clot is removed. A viscoelastic material is placed in the anterior chamber to reform the anterior chamber, separate tissues, minimize synechia, and tamponade vessels. The viscoelastic agent should be placed between the cornea and iris and between the iris and anterior lens capsule. Care is taken at all stages of surgery to avoid trauma to the corneal endothelium, iris, or lens.

Rupture of the anterior lens capsule may also occur as a result of sharp trauma and is an indication for lens extraction with or without replacement with an intraocular lens implant.[3] Lens extraction is best performed at the time of primary corneal repair but is often performed through a second limbal incision made following repair of the initial laceration. Failure to remove a lens with a ruptured capsule is associated with cataract formation and often with chronic severe lens-induced uveitis due to cortical material that leaks into the anterior chamber. Lens subluxation/luxation may also occur as a result of trauma but is more common in cases of blunt trauma than sharp trauma. If there is vision in the eye, removal of a luxated lens is the treatment of choice and may be combined with corneal repair and possibly a lens replacement.

In instances of sharp trauma, the corneal defect has edematous margins that usually align well; thus primary closure with 7-0 to 9-0 suture in a simple interrupted, simple continuous, or double-sawtooth continuous pattern is possible.[3] I prefer 8-0 or 9-0 polyglactin 910 or 9-0 nylon in a double-sawtooth pattern. If the laceration is not linear, simple interrupted sutures should be placed to subdivide the wound, thereby facilitating closure of each portion as linear wound. The aim of repair is to restore normal corneal integrity and achieve a watertight seal while minimizing astigmatism and scar formation. Suture tension should be appositional, not compressive. Sutures should be placed to a depth of 75% to 90% of the corneal stroma and should enter and emerge a short distance from the wound edge to avoid placement in edematous cornea. A few well-placed sutures will result in a superior repair, whereas poor suture placement will result in the need for increased numbers of sutures and wound breakdown.

The full extent of the laceration must be visualized; if the laceration extends to the limbus, the limbal conjunctiva should be reflected to allow examination of the underlying sclera for involvement in the laceration. In addition, if wound integrity is questionable, a conjunctival pedicle graft can be placed over the primary closure to add strength and facilitate wound vascularization.[3] This should be performed over absorbable sutures only and will result in a more intense reaction and subsequent scar formation than primary closure alone. If there is loss of corneal tissue, a free or sliding autologous lamellar corneal graft may be performed to repair the defect.

Balanced salt solution or lactated Ringer's solution is used to reform the anterior chamber and is injected either through the laceration using a 27 or 30 gauge cannula or at the limbus using a 27 gauge needle. The chamber should be reformed, not overinflated. While reinflating the anterior chamber, observe the wound for leaks and place additional sutures as needed to achieve a watertight seal.

Postoperative therapy should include topical and systemic broad-spectrum antibiotics, topical mydriatics, an Elizabethan collar, and exercise restriction for 10 to 14 days. If the anterior uveitis is severe, topical nonsteroidal agents or systemic corticosteroids can be used with caution. If excessive fibrin or synechia is present at time of reevaluation, 25 to 50 µg of intracameral tissue plasminogen activator (tPA)[a] can be used to degrade fibrin and adhesions.[3]

[a]Genentech, San Francisco, CA.

The prognosis following a penetrating injury varies depending on the size of the wound, location, depth of penetration, intraocular damage, and the presence or absence of infection or retained foreign objects. Postoperative complications include wound dehiscence, cataract, synechia, bacterial endophthalmitis, glaucoma, chronic uveitis, blindness, and phthisis bulbi.

Blunt Trauma

Blunt ocular trauma, such as might be caused by a dog bite, kick, or other high velocity projectile, results in compression of the globe, rapid and severe elevation in intraocular pressure, and an explosive rupture that expels the intraocular contents,[3] which can include the lens, vitreous, and retina. Severe intraocular hemorrhage, choroidal and/or retinal detachment, lens luxation, and rupture of the posterior eyewall are all common with blunt injuries. In addition, the corneal defect is irregular, portions of the cornea may be absent, and the margins fail to align well. The prognosis for vision or cosmetic repair is guarded, and enucleation or intrascleral prosthesis may be indicated. In cases of blunt ocular trauma and associated hyphema, the intraocular structures are not visible and complete assessment of the damage is difficult. Despite the hyphema, a consensual pupillary light reflex should still be present; its absence is a negative prognostic sign. Determination of intraocular pressure is useful, and profound hypotony may indicate an occult rupture of the fibrous tunic. In addition, ocular ultrasonography, performed through the eyelid if the cornea is ruptured, often yields essential information to assess intraocular damage and predict future vision. A 7.5 or 10.0 MHz probe placed on the eyelid using sterile KY jelly as a contact will give excellent results. The ultrasound is evaluated for the presence of foreign bodies, lens position, intralenticular echo indicating cataract or lens fiber disruption, vitreous echo indicating hyphema, retinal or choroidal detachment, and the integrity of the posterior eyewall. Abnormalities of the lens or posterior segment are negative prognostic indicators for vision, and damage to the posterior segment often results in progression to phthisis bulbi. Radiographs may be indicated to examine for foreign bodies such as pellets and to evaluate the orbit and skull for possible fractures.

HYPHEMA

It is essential to remember that not all hyphema is the result of ocular trauma. Consideration must be given to systemic diseases that result in clotting disorders or intraocular inflammation.

If the hyphema is complete and precludes the evaluation of intraocular structures, ocular ultrasound is indicated to assess the lens position, retina, and posterior eyewall. The probe can be placed directly on the cornea, or imaging can be performed through the eyelid or an offset device. Provided no other intraocular damage is seen, hyphema will resolve, often without significant sequelae. If the inciting trauma was severe, potential sequelae include cataract, posterior synechia, glaucoma, and blindness.

When hyphema results from a traumatic event, concurrent anterior uveitis is usually present. Although hyphema does not typically require therapy, the associated anterior uveitis does. If there is no corneal ulcer associated with the hyphema, topical corticosteroids may also be administered. Resolution of hyphema may require 7 to 21 days, and the animal should be cage-rested or kept quiet during this time to decrease the incidence of rebleeding. Surgical intervention to remove the hyphema is rarely, if ever, indicated.

If excessive fibrin or synechia is present at reevaluation, 25 to 50 µg of intracameral tPA can be used to degrade fibrin and adhesions. This should not be administered in the first 7 to 10 days, however, as it may cause lysis of the clot within the vessel wall resulting in rebleeding.

CONCLUSION

When presented with a patient suffering from traumatic ocular injury, it is essential to examine the entire eye and its associated structures and to perform a complete physical examination. Adequate restraint and sedation must be used to avoid further trauma to the eye. Rapid assessment and repair of the damage will yield the best results for both a cosmetic appearance and vision. Use appropriate instrumentation and sutures for the eye. Select topical and systemic medications to treat inflammation and pain and prevent infection. Ensure that the owners are able to apply the topical medications as prescribed. Evaluate the eye frequently following repair. Treat only those problems that you are capable of repairing, and avoid damaging the eye further; refer those traumatic injuries of a more severe nature.

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