Complications of Ophthalmic Surgery in the Horse

Dennis E Brooks, DVM, PhD, Dip ACVO
Professor of Ophthalmology
Department of Large Animal Clinical Sciences
College of Veterinary Medicine
University of Florida
2015 SW 16 Ave
Gainesville, FL 32608
Office Phone: 352-392-2229 Fax: 352-294-9867
Email: brooksd@ufl.edu

COMPLICATIONS OF OPHTHALMIC SURGERY

Advances in the understanding of ophthalmic diseases of the horse and improved microsurgical technologies now allow for more complicated ophthalmic surgical procedures to be successfully performed on the horse eyelids, cornea, lens and vitreous, and for the successful treatment of equine glaucoma. A discussion of the common complications of selected ophthalmic surgical procedures in the horse can perhaps reduce their occurrence and minimize the degree of ocular dysfunction per occurrence.

EYELIDS

Traumatic Eyelid Lacerations

Indications

Lacerations of the eyelids should be repaired promptly to inhibit formation of cicatricial eyelid deformities, prevent a reduction in eyelid blinking function, and reduce the chance of infections and exposure-induced damage to the cornea (1). Corneal ulcerations, globe perforation, uveitis, periorbital fractures, and orbital cellulitis or abscessation can accompany eyelid lacerations.

Technique of Eyelid Laceration Repair

Surgery to repair a small eyelid laceration may be performed with sedation and local anesthesia alone, while severe lacerations that require sophisticated blepharoplastic repair require the animal to be under general anesthesia.(1,2) The eyelids have a rich vascular supply and generally do not require removal of tissue of questionable viability. Even desiccated, avulsed eyelids are capable of revascularization following a surgical repair (1,2). For this reason and because of the concern for exposure keratitis, it is

imperative that eyelid tissue tags and pedicles not be amputated, and instead replaced to as near normal an anatomical position as possible.

It is wise to consider culturing a traumatic eyelid wound of any long-standing duration prior to suturing the defect. Thorough flushing of the affected area with saline and a dilute povidine/iodine (2%) solution should be performed to clean the area. The first step taken in the surgical repair is to accurately appose the lid margin.(1,2) A figure-eight suture is placed on the eyelid margin that allows for knot placement away from the cornea. The remainder of the defect is closed in two layers – a deep layer in the palpebral conjunctiva with 4-0 to 6-0 absorbable suture material in a simple interrupted or simple continuous pattern starting at the eyelid margin, and a superficial layer through the skin with 4-0 to 5-0 non-absorbable suture in a simple interrupted pattern. Sutures are usually left in place for 7-10 days.

Administration of topical and systemic antibiotics, systemic antiinflammatory drugs, and tetanus toxoid are important for postoperative medical care. Protection of the cornea is absolutely imperative if the lids are swollen or compromised in such a way that the cornea is perpetually exposed. Some eyes may need a temporary tarsorrhaphy.

Complications

Some dehiscence of the eyelid margin nearly always occurs postoperatively. This margin breakdown can cause varying amounts of lid misalignment with resulting entropion or ectropion. Gaping of the conjunctival side of the incision due to poor suture placement can slow healing and allow a suture to rub on the cornea to cause painful corneal ulcers. Such sutures would need to be replaced or removed. Skin sutures can also become infected.

Intralesional injection of topical anesthetics would cause a performance animal to be positive during a postperformance drug test. Communication with trainers and owners is imperative, but lid pedicle amputation, especially of the upper eyelid, is never to be recommended.

Lacerations of the eyelids near the medial canthus may involve the nasolacrimal apparatus and affect tear drainage. The integrity of the duct should be tested by close examination and the passage of fluorescein sodium dye through the nasolacrimal duct. (1-4).

Entropion

Indications

Entropion is the inward rolling of the eyelid margin to allow contact of eyelid hairs with the cornea.(1,2) Clinical signs include excessive tearing and blepharospasm, and variable amounts of keratitis and conjunctivitis. Entropion is most often seen in young foals, and may be either anatomical from too much eyelid skin, secondary to enophthalmos from ocular pain, or be associated with dehydration, malnutrition, or the atrophy of orbital fat from the cachexia present in debilitating systemic diseases. Since the growing foal has a dynamic facial conformation, permanent surgical correction is not recommended until maturity is reached.

Entropion is rarely anatomic in adult horses, and is generally associated with spasms of the orbicularis oculi muscle due to chronic, irreversible ocular pain, or may be cicatricial due to previous eyelid trauma. Topical anesthetics and a local nerve block will facilitate differentiation between any existing primary anatomic component of the entropion and any secondary entropic contribution of spasm.

Temporary Entropion Surgery in Foals

Ocular lubricants and sometimes temporary eversion of the offending eyelid with vertical mattress sutures or staples is helpful for treating entropion in foals. In rare cases eyelid eversion can reduce the strength and ability of the tarsal plate to hold the lid margin in position if the sutures or staples are not removed in 10-14 days. Chronic lid margin flaccidity, entropion, and blepharospasm in the adult horse are the result if the sutures or staples are not removed in the foals.

Entropion Surgical Technique (Modified Hotz-Celsus Procedure)

The goal of surgical correction of entropion should be slight undercorrection. (1,2) The modified Hotz-Celsus procedure is particularly useful for dealing with most entropion conditions in the adult horse (2). The procedure is simple and involves removing a crescent-shaped piece of skin and orbicularis muscle. The initial incision is made with a No. 15 scalpel blade 2 mm from the eyelid margin, its length dependent on the amount of eyelid margin that is entropic. A second elliptical incision made parallel to the first joins the two ends of the first incision. The width of the piece of tissue to be excised should have been previously determined while examining the nonsedated horse. After the skin is incised to the depth of the orbicularis oculi muscle, the skin and a portion of this muscle are undermined and excised with scissors. The defect is then closed using 4-0 to 6-0 nonabsorbable suture material in a simple interrupted pattern. The suture ends adjacent to the cornea are trimmed short to avoid irritation of the cornea. The sutures are left in place for 10 to 14 days.

Complications

Eyelid swelling is common postoperatively. If the excised piece of tissue is too narrow undercorrection of the entropion will result, while removal of too wide a piece of skin will result in ectropion. Ectropion and exposure keratitis with ulcers can result from overcorrection of the entropion. Suture ends can rub on the cornea to cause ulcers and should be removed. Sutures can become infected to cause cutaneous abscesses. The operated lid may exhibit ptosis later in life for no apparent reason.

Laser as Alternative Surgical Technique for Eyelid Tumor Removal

Care must be used in removing superficial or deep eyelid margin or third eyelid tumors with CO_2 or other lasers as any excessive heat generated can adversely affect the cornea. Melting ulcers are a serious complication in such cases.

NICTITANS

Nictitans or Third Eyelid Flaps

Indications

The third eyelid (TE), nictitans, or nictitating membrane lies in the ventral-medial orbit of horses where it produces some of the tears and also acts like a windshield wiper to distribute the precorneal tear film. It consists of a "T"-shaped piece of hyaline cartilage and a large seromucoid gland surrounding the base of the cartilage. (1,2)

Third eyelid flaps provide physical support to a weakened cornea, reduce contamination of the surface of injured corneas, and minimize tear evaporation from the exposed corneas of exophthalmic globes. Nictitating membrane flaps do not provide plasma derived antiproteases to melting ulcers, and are not a source of collagen to replace missing corneal tissue. They are indicated in superficial nonhealing, noninfected corneal ulcers, ulcers caused by facial nerve paralysis, and also to reinforce a conjunctival

graft.(5) Third eyelid flaps are contraindicated for melting corneal ulcers in horses because they do not provide a blood supply or fibrovascular tissues to the ulcer. In addition, they may make it impossible to visually observe the progression of the disease, may impede the penetration of topical medications to the cornea, and cause the retention of inflammatory exudates adjacent to the corneal lesion.(5,6)

Technique for Third-Eyelid Flap

General anesthesia is recommended for performing a TE flap. Formation of a third-eyelid flap with attachment to the upper eyelid is performed by placing 2-4 horizontal mattress sutures through stents high in the upper eyelid and dorsal fornix of the desired location. Direct the needle (4-0 suture) through the anterior face of the TE approximately 3 mm from the leading edge, and then again through the fornix to the skin adjacent to the first bite. These sutures should pass through the cartilage but not be full-thickness in the TE. The flap can be released in 7-10 days.(5)

Complications

Cartilage of the TE can be deformed to cause corneal irritation, and necessitate TE removal. Sutures can rub on the cornea and cause an ulcer if placed too low in the fornix. The skin can be ulcerated from the sutures if stents are not used. The globe can rupture behind the flap if not carefully monitored.

Surgical Technique for Removal of the Third Eyelid

Indications

Surgical removal of the third eyelid is strictly reserved for malignant neoplasia of the third eyelid, or a nictitans that is so severely traumatized that it interferes with nictitans and globe function.

Technique

It is possible to remove the entire nictitans with heavy sedation and sensory nerve blocks in most standing horses. The dorsal margin of the third eyelid is gently grasped with small hemostats or toothed forceps, and the third eyelid pulled up and outward. A curved hemostat is positioned and clamped below the mass halfway across the base of the third eyelid at the most ventral region of the third eyelid. This minimizes postoperative hemorrhage. A second curved hemostat is positioned and clamped opposite the first hemostat such that the base of the third eyelid is completely clamped. A #15 blade is used to cut the third eyelid and neoplastic tissue along the hemostats. The hemostats are left clamped for 2 to 3 minutes after TE removal. The conjunctival area at the base of the third eyelid can be carefully sutured with 5-0 vicryl, but is generally not sutured and left to granulate. Hemorrhage postoperatively is slight in my experience but can be controlled with pressure and light cautery. Topical antibiotics are indicated for 5-7 days postoperatively.

Complications

Complications, although rare, include orbital fat prolapse, slight hemorrhage, keratoconjunctivitis sicca (KCS) or superficial keratitis. Third eyelid cartilage incompletely excised can irritate the cornea to cause entropion, conjunctivitis, and infection. The absence of a TE can alter nasal lid conformation such that environmental debris accumulates and causes persistent inflammation of the nasal conjunctiva and eyelids.

CORNEA

Corneal Lacerations

Indications

Full thickness corneal lacerations with or without iris prolapse require surgical correction. If the laceration involves the limbus, the adjacent sclera under the conjunctiva should be carefully examined.

Technique

The aim of the repair is to restore corneal integrity and achieve a watertight seal. Prolapsed iris should be amputated and any hemorrhage controlled with pressure or careful and gentle iris cautery. Simple interrupted sutures (7-0 to 8-0 suture) are placed to close the laceration and the anterior chamber reformed with lactated Ringer's solution (LRS). The sutures should be perpendicular to the laceration, enter and leave the cornea 1 mm from the wound margin, and be placed 2/3 of the thickness of the corneal stroma. Superficial sutures will result in incision gaping, and sutures that penetrate the cornea will result in microleaks of aqueous humor. Suture tension should be appositional, not compressive, as some corneal edema will be present. The lacerations may be covered with a conjunctival pedicle graft if corneal melting is present. A small syringe with a 25 or 27 gauge needle can be used to reform the anterior chamber with sterile LRS.

Complications

Dehiscence, aqueous humor microleaks, anterior and posterior synechia, corneal infection, infectious endophthalmitis, uveitis, cataract, blindness, and phthisis can occur following the surgical repair of a corneal laceration. Reforming the anterior chamber with sterile water can result in corneal edema.

Melting Ulcers and Keratectomy, Conjunctival Grafts, Amniotic Membrane Grafts

Indications

Melting ulcers in horses are sight threatening as they can rapidly lead to globe rupture. This aggressive form of ulcerative keratitis is associated with high levels of tear film proteolytic activity. Neutralizing and normalizing proteolytic activity in the tear film is an important objective of the medical and surgical treatment of melting corneal ulcers in horses.(2,7,8) Melting ulcers that are nonresponsive to medical therapy, ulcers deeper than one-half of the thickness of the cornea, and full thickness corneal perforations with iris prolapse will require surgical therapy.(2,5,7) In these cases, superficial keratectomy or direct surgical debridement in conjunction with conjunctival, corneal or amniotic membrane transplant grafts are required.

Keratectomy

Indications

A keratectomy involves removal of the corneal epithelium and a portion of the stroma. Keratectomy speeds healing of melting ulcers by removing necrotic and infected tissue, and encouraging vascularization, minimizing scarring, and decreasing the stimulus for anterior uveitis.(5,7) It may also be done to prepare the cornea for a conjunctival or amniotic graft.

Technique

Superficial layers of necrotic tissue in melting ulcers can be cut and removed with topical anesthesia, a cellulose sponge or cotton swab, and corneal or tenotomy scissors held parallel to the corneal surface.(5) A microsurgical blade can also be used to debride the epithelial layers prior to placement of a conjunctival or amniotic membrane transplant graft.

Keratectomy for removal of deeper layers of degenerate cornea requires general anesthesia. A corneal incision is made to outline the lesion to be removed with a corneal trephine, a diamond knife or a microsurgical blade. The depth of the incision in the stroma should be adequate to remove the lesion completely. The edge of the tissue to be removed is grasped by forceps, and a corneal dissector introduced and held parallel to the cornea. The dissector is tangentially used to separate the corneal lamella without penetrating deeper than the original cutting plane. The cornea is then separated until the opposite incision line is reached.(5-7) Depending on the amount of the stromal defect, a conjunctival or amnion graft may then be placed.

Complications

The complications of superficial and deep keratectomy include infection, stromal granulation tissue formation, and globe perforation.(2,5-7)

Conjunctival Transplant Grafts

Indications

The conjunctiva is a mucous membrane that begins at the eyelid margin, lines the insides of the eyelids, and then reflects at the fornix to extend over the sclera to end at the limbus. It is composed of a nonkeratinized, stratified, squamous epithelium with goblet cells and an underlying fibrous Tenon's capsule. The bulbar conjunctiva is freely movable except near the limbus, whereas the palpebral conjunctiva is not movable. (5)

Conjunctival transplant grafts or flaps are frequently used in equine ophthalmology for the clinical treatment of melting corneal ulcers, deep stromal ulcers and descemetoceles, and perforated corneal ulcers with iris prolapse. Melting ulcers should always be stabilized with medical therapy before the surgical placement of the

11

graft to provide a healthier cornea for suturing, and to prevent proteinase digestion of any absorbable sutures that will hold the conjunctival graft in place.(2,3,5,9)

Conjunctival transplant autografts consist of a highly viable epithelium, and a stroma with significant antibacterial, antifungal, antiproteinase and anticollagenase effects. Plasma derived antibodies and macrgloubulin are placed in direct contact with the corneal ulcer bed. The fibrovascular or deeper layer of the conjunctival transplant graft offers fibroblasts and collagen with which to begin rebuilding the corneal stroma.(2,5,7) Although not as strong as corneal tissue, conjunctival transplant grafts do provide some physical support to the weakened cornea.(5)

There are different types of conjunctival transplant grafts based on the source of the mucosa (bulbar or palpebral) and the type of graft (total or 360º, bridge or bipedicle, hood or 180º, and the pedicle conjunctival graft). A 360º conjunctival transplant graft is utilized for large corneal lesions, but it covers the entire cornea which makes vision impossible, prevents monitoring of lesion progression, and often leaves large, often blinding, corneal scars.(2,5,7) The 360º conjunctival transplant graft is thus no longer recommended. Hood transplant flaps cover half the cornea and are also associated with large scars. The bridge or bipedicle transplant flap is indicated for large melting ulcers in the central, dorsal paracentral and lateral paracentral corneal regions. The pedicle or rotational transplant grafts from the dorsal or temporal bulbar conjunctiva are the most useful and versatile conjunctival transplant grafts as they generally leave smaller scars to have minimal effects on postoperative vision, allow for postoperative intraocular examination, and do not inhibit drug penetration to the cornea and anterior chamber. (2,5,7)

Conjunctival transplant grafts are usually harvested from adjacent bulbar conjunctiva. (2,5,7) The disadvantage of the palpebral derived conjunctival graft is that the eyelids are mobile and some tension will be applied postoperatively during blinking to the sutures of the conjunctival graft, thereby leading to a higher rate of graft dehiscence. The bulbar conjunctival flap moves with the eye such that little or no eyelid tension is applied to the sutured graft itself. It is also not recommended to use the conjunctiva near the nictitating membrane because nictitans movement can put tension on the graft sutures to result in premature graft release. (2,5,7) Conjunctival transplant autografts should be thin, and not include Tenon's capsule or the bulbar fascia. The inclusion of the Tenon's capsule may contribute to surgical failure by increasing postoperative traction on the transplanted conjunctival tissue.(2,5,7) Conjunctival grafts should have tension relieving sutures placed at the limbus to prevent the graft prematurely pulling away from the ulcer bed. With all the conjunctival graft types, it is important that the corneal graft bed and ulcer site be properly and carefully prepared. The recipient bed for the conjunctival graft is prepared by debridement of the epithelium surrounding the ulcer and removal of any necrotic corneal tissues. Great care should be taken to prevent corneal perforation during this debridement. (2,5-7)

Conjunctival transplant autografts are more difficult to perform than nictitating membrane flaps but simpler than surgeries such as corneoconjunctival grafts, corneoscleral transpositions and penetrating keratoplasty (PK).(5) They are also easier to perform in the horse than in other species, because horses have a great deal of very mobile bulbar conjunctiva. Temporary tarsorrhaphy is often performed concurrently with

13

conjunctival grafts to minimize blinking movement, prevent excessive lid trauma to the graft and its sutures, and to encourage graft adherence to the stroma. (2,5,7)

Technique for Pedicle Conjunctival Transplant Graft

The pedicle conjunctival graft should be oriented such that the dissected conjunctival graft tissue is not rotated greater than 45º from its perilimbal conjunctival base of origin. Once the location for mobilizing the graft is determined, the conjunctiva is tented with the 0.12 mm Colibri forceps, and a small slit is made in the conjunctiva with Westcott scissors 1-2 mm from the limbus. This initial conjunctival incision is continued, parallel to the limbus. The entire conjunctival flap site is then undermined using blunt dissection with Steven's tenotomy scissors. The underlying fibrous tissue (i.e. Tenon's capsule) should be freed from the overlying conjunctiva so that the conjunctiva appears nearly transparent and permits the visualization of the scissors' tips underneath the conjunctiva. The second incision is then made perpendicular to the first incision (and to the limbus) at the tip of the graft. The width of the incision should be 1 to 2 mm wider than the size of the corneal lesion to cover. The third and final incision is made parallel to the first, extending to the bulbar attachment of the graft. (2,5,7) The strip of conjunctiva thus created is then rotated to the cornea such that graft covers and sits on the corneal defect with no tension or retraction. The angle of rotation should not exceed 45º. The flap is then sutured to the cornea with simple interrupted sutures 1.0 to 1.5 mm apart of 7-0 to 8-0 absorbable suture material. Two interrupted sutures may be placed at the limbus on either side of the graft to decrease the tension applied to the corneal recipient site. To prevent disruption of the blood supply, sutures are not placed within the pedicle portion of the graft, or at the proximal portion of the lesion. Conjunctival grafts will adhere to the

corneal stroma of the lesion but they will not usually adhere to the epithelium surrounding the flap.

Six to 8 weeks after the placement of the flap, the blood supply can be interrupted by cutting the base of the flap at the limbus. The graft transection procedure can usually be performed with the use of a topical anesthesia and Steven's tenotomy scissors. Eliminating the blood supply will allow the conjunctival graft to recede and lessen the resulting corneal scar. Trimming of the pedicle conjunctival graft should be done carefully in horses as exacerbation of the ulcer and accompanying episodes of severe uveitis can follow this apparently benign procedure a few days after transection. (2,5,7,10)

Complications

Proper suture placement in healthy cornea using a thin conjunctival graft concurrent with appropriate medical therapy will reduce postoperative complications of conjunctival transplant graft surgery. (2,5-7) The most common complication from any type of conjunctival grafting procedure is dehiscence and premature retraction of the graft from the corneal lesion. This may occur because the corneal lesion is progressing (worsening), there is excessive tension on the graft, or too much of the fibrous Tenon's capsule was left on the graft.

Graft necrosis from vascular infarction of the conjunctival graft vessels due to attempts to make the conjunctival graft too thin causes an initial purple color change followed by graft ischemia manifested by a white discoloration of the flap. Some graft ischemia at the periphery of the flap results from overly tight sutures. Ischemic necrosis or infarction of the graft vessels can result in premature graft retraction and graft failure.

Ischemic, infarcted conjunctival grafts can still in some cases successfully serve a tectonic function but must be observed closely for infection and dehiscence.

Microleaks from a corneal fistula, suture perforation of the cornea, or incisional breakdown can cause graft fibrosis from exposure of the subepithelial conjunctival graft tissue to aqueous humor. Something in aqueous humor is apparently toxic to conjunctival fibroblasts to result in graft thickening, nonadherence, and graft retraction. Fibrin and increased signs of uveitis may also be seen with microleaks.

Suture abscesses will incite a uveitic response. They are generally yellow exudates surrounding a suture and are treated by culture, suture removal and topical antibiotics. Beta hemolytic *Streptococcus* commonly causes this in the horse.

Conjunctival grafts result in various sizes and degrees of corneal scars. Scarring can be minimized, however, by removal of necrotic cornea with keratectomy before graft placement. Corticosteroids are not recommended but cyclosporine A can be used topically after surgery to reduce postoperative scar tissue formation. (2,5,7)

Transection of the pedicle graft causes acute ischemia to the ulcer site. The whole disease process can thus rapidly begin again as the acutely ischemic corneal scar can rapidly become infected if microbes are still present on the graft surface.

Amniotic Membrane Grafts

Indications

Amniotic membrane (AM) has replaced the use of 360º and 180º conjunctival transplant flaps for melting ulcers involving the entire cornea. Amniotic membrane consists of an epithelium, a thick basement membrane, and an avascular stroma. High concentrations of antiangiogenic, antiprotease, antiinflammatory, and antifibrotic

compounds, and cellular growth factors are present in AM.(2,5,11,12) It is a thin but strong biomaterial with a good cell-basement membrane structure that is critical for epithelial proliferation and differentiation.(2,5,11-14) The amniotic membrane may also function by providing exogenous collagen as a deviant substrate for the tear film proteases, and by acting as an alternative attachment site for tear film neutrophils. If the allantoic stromal side of the AM faces the cornea, the corneal epithelial cells will migrate along the membrane, the AM graft will adhere to the corneal stroma, and the AM will be incorporated into the cornea. If the basement membrane of the AM faces the cornea the AM will be expected to slough in 7-10 days.

Technique

The AM can be placed focally over an ulcer, or the AM can be placed limbus to limbus to cover the complete cornea. Several layers of amniotic membrane can be placed together to fill in a corneal defect.(14)

The AM is prepared and stored frozen on nitrocellulose paper in antibiotic solution.(11) Prior to corneal surgery, the AM is naturally thawed, and then rinsed with sterile saline. The recipient corneal site for the AM graft is prepared by removing loose epithelium and necrotic corneal tissues. The amniotic membrane is then cut on the paper according to the size of the corneal defect to be covered, and then slid from the paper to the cornea. (5) Amniotic membrane grafts should cover the corneal defect with little tension present before the suture placement in order to reduce premature graft retraction. The amniotic membrane is then sutured to the cornea with simple interrupted sutures of 7-0 to 8-0 absorbable suture material.

Complications

17

Bulging of the AM can occur several days postoperatively due to accumulation of debris between the nonattached AM and cornea. It resolves spontaneously. Premature release of the AM to cause exposure of the corneal lesion can occur but is not always a problem if the AM had been there for a week or longer. Suture abscesses require removal of the suture with topical anesthesia and the abscess evaluated for infection.

Penetrating Keratoplasty

Indications

Corneal transplantation is a viable and successful surgical technique in the horse.(2,15,16) Full thickness penetrating keratoplasty (PK) may be performed for melting ulcers, iris prolapse/descemetoceles, and full thickness stromal abscesses. Deep lamellar endothelial keratoplasty (DLEK) and posterior lamellar keratoplasty (PLK) are split thickness penetrating keratoplasties utilized for deep stromal abscesses (DSA) with clear overlying anterior stroma. Corneal transplants in horses are associated with high success rates, good visual outcomes (>88%) and shorter treatment times than medical treatment of these eye problems alone, (2,16) but the corneal transplants in horses do vascularize, have some degree of opacity, and thus exhibit some degree of graft rejection.

Corneal transplantation can be performed for optical, therapeutic, tectonic, and cosmetic reasons.(17) Optical transplants restore or improve vision in cases of corneal edema. Therapeutic grafts attempt to control medically refractory corneal disease by removing necrotic and infected tissue. Tectonic grafts are done to preserve or restore the structural integrity of the eye when corneal tissue is missing, and cosmetic grafts improve the appearance of the eye without necessarily improving vision. (2,15-17)

Technique for Penetrating Keratoplasty

Penetrating keratoplasty (PK) involves full thickness removal and replacement of a portion of the cornea. Donor corneal material is harvested preferentially from fresh or frozen equine cadaver eyes (i.e., within 24 hours of death). A full thickness button of cornea that is 1 mm larger than the recipient bed is trephined from the endothelial to the epithelial side of the donor cornea. The ideal graft size in horses is 6-8 mm diameter, but larger grafts are possible. The donor button is grasped with fine-toothed forceps, placed on a gauze swab, and kept moistened with lactated Ringer's solution. A corneal trephine of appropriate size is centered over the diseased area of the recipient globe and then rotated with minimal downward pressure to obtain a clear-cut, round incision with vertical sides to just near the level of Descemet's membrane. A #65 Beaver blade is used to enter the anterior chamber, being careful to avoid the iris, corpora nigra and lens, and the button of diseased tissue is then removed with corneal section scissors. Bulging of the iris and the corpora nigra into the incision site may occur. Adhesions or synechia between the corneal lesion and iris may be present. The anterior chamber is reformed by injecting viscoelastic solution (hyaluronate sodium, 10 mg/ml, Hylartin V^{TM}, Pfizer Animal Health, New York, NY) into the anterior chamber. The viscoelastic will also move the iris posteriorly, and break down any adhesions between the cornea and the iris. Iris membranes should be removed with caution due to the risk of hemorrhage. Direct contact with the lens capsule is also avoided by reforming the anterior chamber with the viscoelastics. The donor cornea is removed from the moistened swab and placed in the recipient bed, and four cardinal sutures of 8-0 polyglactin 910 (Vicryl; Ethicon Inc, Somerville, NJ) or 9-0 nylon (Ethilon; Ethicon Inc, Somerville, NJ)) placed at the 12-, 6-, 9-, and 3-o'clock positions. Simple interrupted sutures are placed to fill in the remaining

sectors in each quadrant, or alternatively, a simple continuous suture pattern can be placed to hold the graft. Once the donor cornea is sutured into place, viscoelastic solution may again be injected via a limbal incision to further reform the anterior chamber. (2,15,16) The incision is checked for leaks with the Seidel's test.

A conjunctival pedicle transplant graft may then be sutured over the keratectomy/graft site in those eyes with evidence of infection or vascularization to achieve more rapid assimilation into the cornea. A temporary tarsorrhaphy is performed to minimize eyelid trauma to the PK. Autogenous serum to decrease tear film proteinases attacking the graft and sutures, and cyclosporine A to reduced graft rejection are added to the other medications postoperatively.

Complications

Suturing in the vascular, inflamed corneal environment of the horse is associated with most corneal transplant complications. Penetrating keratoplasty suffers from the inherent problem of creating a vertical stromal wound that requires surface corneal sutures. (2,15,16) The incised stroma never develops the structural integrity and strength of normal stroma. The corneal sutures utilized to heal the vertical stromal PK incision induce some alteration of the topography of the corneal surface. (2,15,16) The PK graft epithelium often sloughs leaving the graft open to infection and melting. The sutures loosen as stromal edema resolves and the tissue contracts to allow aqueous leakage. (15,16,18,19) Vertical incisions are less prone to leak at the low IOP levels found postoperatively. (20) Vascularization and edema of the grafts, indicating rejection, begins at 5 to 10 days postoperatively. Pupil occlusion and anterior synechiation occurs in some eyes but is rarely a major problem. Excessive anterior chamber fibrin can be cleared with

tissue plasminogen activator. Suture abscesses can delay healing. Penetrating sutures and incision dehiscence result in microleaks and are very common following PK in horses.(15,16)

Split Thickness Penetrating Keratoplasties

Indications

The inherent philosophy of split thickness or lamellar transplant corneal surgery is to replace only the diseased portion of the cornea, leaving the normal tissue intact. In other words, to do the least amount of tissue resection for the greatest amount of benefit. (2,15,16,18,19) Both the PLK and DLEK surgical methods are forms of split thickness PK as they preserve the superficial normal tissue and remove the deep stromal or endothelial abscesses with anterior chamber invasion in horses.(2,15,16,18,19)

Technique for Posterior Lamellar Keratoplasty

Posterior lamellar keratoplasty (PLK) is recommended for deep stromal abscesses in the central cornea that are 8-mm or less in diameter, and have a clear overlying normal anterior stroma.(15,16) A rectangular, anterior lamellar corneal flap, hinged on one side, is constructed by hand dissection to two-thirds stromal thickness over the stromal abscess. (15,16) A Martinez corneal dissector is used to undermine and elevate the superficial corneal layers to expose the abscess. The flap is gently elevated, and a trephine, #65 Beaver blade and corneal transplant scissors used to remove the posterior stromal abscess, Descemet's membrane and endothelium. A retrocorneal posterior collagenous layer with attachment to the iris may be present. The anterior chamber is reformed with viscoelastic solution. A circular graft of posterior stroma, Descemet's membrane and endothelium 1 mm larger than the defect is cut from donor tissue using a

21

trephine. The graft is placed in the corneal defect, and sutured every 2 mm using 8-0

absorbable suture material in a simple interrupted pattern. The 3-sided superficial flap is

then sutured in place using 8-0 absorbable suture material. The viscoelastic can be safely

left in the horse anterior chamber. Partial temporary tarsorrhaphies are placed in all eyes

to protect the graft during recovery.

Complications for PLK

Complications of PLK include superficial suture abscesses, suture microleaks,

incision microleaks, and superficial flap ulcers and edema. The donor graft remains

transparent for up to seven days and then opacifies. (15,16) Partial graft rejection and scar

formation has been unavoidable for both the PLK procedure. The resulting scar is

typically vascularized and eventually opaque. (15,16) The retrocorneal and iris

membranes can spontaneously resolve in many cases. Pupil occlusion and synechia often

occur. Cataract formation from fibrin on the anterior lens capsule, and focal lens capsular

rupture from entering the anterior chamber improperly can occur. Excessive anterior

chamber fibrin can be cleared with tissue plasminogen activator.

Technique for Deep Lamellar Endothelial Keratoplasty

Deep lamellar endothelial keratoplasty (DLEK) is recommended for deep stromal

abscesses in the peripheral cornea that are 6 mm or less, and have a clear overlying

anterior stroma. It avoids the superficial incisions and suturing of the central cornea. The

DLEK transfers healthy endothelium while preserving the corneal surface integrity. A

fully intact epithelium with no corneal sutures is present postoperatively. (15,16)

A two-thirds depth, limbal incision up to 23 mm in length is made with a #64

Beaver blade. A stromal pocket is formed over the DSA with a Martinez corneal

dissector. Bleeding from the vascularized cornea is controlled with electrocautery. The superficial corneal flap is gently retracted and the abscess removed with a trephine, #65 Beaver blade and corneal scissors. The anterior chamber is reformed with viscoelastic. The anterior two-thirds of the donor cornea is removed by hand dissection, and a trephine 1 mm larger in diameter than the recipient site used to obtain the circular donor graft from the remaining split-thickness cornea. The superficial corneal flap is partially sutured with 8-0 polyglactin 910. The donor graft is inserted into place with Utrata forceps, and the limbal incision closed. The graft self adheres to the recipient stroma by action of the endothelial pump, but may need to be positioned in place by a needle inserted between the flap sutures, or at the limbus. The graft is supported by the viscoelastic in the anterior chamber. The viscoelastic can be safely left in the horse anterior chamber. Partial temporary tarsorrhaphies are placed in all eyes to protect the surgical site during recovery.

Complications for DLEK

Suturing in the vascular, inflamed corneal environment of the horse is associated with most corneal transplant complications. Too few sutures yield incisional compression zones that are not contiguous. Sutures too close or too far from the incision also affect incision strength and watertightness. Incisional tissue swelling affects watertightness as sutures placed in this condition loosen and the incision gapes when the swelling decreases. (15,16, 20) Gaping wounds occur at incision angles less than 90° at low IOP. Incision angles in the cornea should be perpendicular to the surface for best closure at the low IOP present postoperatively. Suture loops must be circular in the cornea and not

penetrate to the anterior chamber or wound gaping and aqueous leakage can occur. (15,16, 20)

Other complications of the DLEK procedure include suture abscesses, incision edema, and graft slippage and misalignment. Infection of the incision and contaminated corneal donor tissue are also associated with incisional microleaks and graft failure, and persistent uveitis respectively. (15,16, 20) Lens capsule rupture and focal cataract formation can occur when dissecting the button of Descemet's membrane and endothelium. The donor graft remains transparent for up to seven days and then vascularizes and opacifies. (15,16) Excessive anterior chamber fibrin can be cleared with tissue plasminogen activator.

LENS

Cataract Surgery

Indications

The purpose of cataract surgery is visual rehabilitation.(2, 21) Recent advances in cataract surgical techniques and equipment have increased the success of equine cataract surgery. Most veterinary ophthalmologists recommend surgical removal of cataracts in foals less than 6 months of age if the foal is healthy, no uveitis or other ocular problems are present, and the foal's personality will tolerate aggressive topical therapy. Early return of vision is paramount in foals for development of the higher visual centers.(2, 21) Foals are easiest to do because the globe size is small enough that the standard cataract surgical equipment is of satisfactory size, general anesthesia is generally less of a risk in foals, and foals heal very quickly following cataract surgery. (2, 21) Foals should be carefully evaluated for the presence of subclinical infectious systemic diseases such as

Rhodococcus and Streptococcal pneumonia. (2, 21)

Adult horses with visual impairment due to cataracts are also candidates for cataract surgery, but are more difficult due to the large size of the adult horse eye, and the frequent presence of uveitis in adult horse eyes with cataracts. (2,21) If the horse is healthy, has controlled uveitis, and has the personality and temperament to tolerate aggressive postoperative topical therapy and repeat postoperative ophthalmic examinations, the adult horse with uveitic cataracts can be a good candidate for cataract surgery.

Phacoemulsification is the preferred cataract extraction technique for the foal and horse. Immature, mature, and hypermature equine cataracts have been successfully removed with this technique.(2,21) Foals and horses generally begin to see immediately postoperatively. Subluxated or partially luxated lenses may also be successfully removed in some horses using phacoemulsification.

Equine Phacoemulsification Cataract Surgery Technique

General anesthesia is required for equine cataract surgery. Neuromuscular paralysis is also highly recommended but not essential.(2,21) The horse is positioned in lateral recumbency, and the periocular skin cleaned with 1:50 povidone-iodine solution and appropriately draped. A Castroviejo eyelid speculum is used to retract the lids. The globe is entered dorsally with a 3.2 mm keratome blade through a scleral tunnel under a limbal based conjunctival flap. The peripheral anterior chamber of the horse is quite narrow so care is used to not touch the iris. The keratome blade is entered to one side of the corpora nigra, as the corpora nigra can hemorrhage quite severely if touched. The corpora nigra should be cauterized intraoperatively if they begin to slowly hemorrhage.

Two ml of air are injected into the anterior chamber, and then trypan blue injected to stain the anterior lens capsule. Viscoelastic (hyaluronate sodium, 10 mg/ml, Hylartin V^{TM}, Pfizer Animal Health, New York, NY) is quickly injected into the anterior chamber to remove the trypan blue dye and maintain anterior chamber depth. A 20 gauge cystotome is used to incise the anterior capsule and a 6-10 mm diameter piece of anterior capsule removed with Utrata forceps. The thin posterior capsule is generally left intact. Irrigation/aspiration with lactated Ringer's solution containing epinephrine (0.5 ml of 1:1000 epinephrine per 500 ml LRS) and heparin (2 IU/ml) is utilized to maintain the anterior chamber during phacoemulsification, and to remove any remaining cortex after most of the lens has been removed. The 30º, 0.9 mm diameter phacoemulsification needle tip is kept parallel to the iris in the anterior chamber and only carefully angled posteriorly. Viscodissection with viscoelastics, or a two-handed surgical technique using a second incision and a lens manipulator can be used to move large pieces of the lens closer to the phacoemulsification needle so it can be emulsified and aspirated. The posterior capsule tears quite easily, and can rapidly move anteriorly and posteriorly with the vitreous when the eye is open in horses. Lens cortex that remains attached to the posterior capsule of foals and horses after removal of the cortex and nucleus can be aspirated through a 0.3 mm aspiration needle on an irrigation-aspiration handpiece. Larger cataract pieces may only pass through the larger diameter phacoemulsification needle. An intraocular lens of suitable size can be placed in the capsular bag. The scleral and conjunctival incisions are closed with 8-0 absorbable suture in a simple interrupted pattern. The incisions are carefully checked for leakage with a Seidel's test. (2,21)

Complications and Expectations of Cataract Surgery

Intraoperative complications of cataract surgery in the horse include iris protrusion into the incision, miosis, hyphema or vitreal hemorrhage, corpora nigra hemorrhage, lens nucleus dislocation to the vitreous, vitreous presentation into anterior chamber, posterior capsular tears, choroidal hemorrhage, and retinal detachment. Opacification of the anterior and posterior capsules may be present intraoperatively. Retinal swelling and retinal folds may be noted intraoperatively during the profound hypotony found with the open incision. The retinal folds soon disappear as the IOP returns to near normal postoperatively.

Slight corneal edema, especially near the incision, is usually present from 24 to 72 hours postoperatively. Flare is generally slight and clears in days. Fibrin in the anterior chamber occurs infrequently. The anterior chamber is shallow due to the posterior capsule bulging forward for 3-5 days postoperatively. Lens fragments can be noted in the anterior chamber or vitreous, but slowly resorb and do not seem to cause serious harm. The vitreous can appear yellow for a week or so postoperatively. The tapetal reflection may also be more yellow than that found preoperatively. The foal tapetum may appear "granular" intraoperatively and normal a few days later.

One week after surgery, the pupil should be functional, any fibrin in the anterior chamber resorbing, and the fundus visible. Postoperative infectious endophthalmitis may result 7-10 days following surgery if the subclinical Rhodococcal and Streptococcal infections are not detected and treated prior to cataract surgery. (2, 21) Three weeks after surgery, the eye should be nonpainful, the patient visual, pupillary movement normal, and the ocular media clear. Medications should be maintained for at least 2 months postoperatively to minimize posterior capsule opacification and suppress subclinical

signs of iridocyclitis.

Late term postoperative complications include persistent iridocyclitis and plasmoid aqueous, hyphema, hypotony leading to phthisis, fibropupillary membranes, synechiae, iris bombé, corneal ulceration, persistent corneal edema due to endothelial cell damage, corneal fibrovascular infiltrates, mild to severe anterior and posterior capsular opacification, retained lens cortex, wound leakage, incision dehiscence, vitreous presentation into the anterior chamber, surgical light retinopathy, retinal degeneration, and retinal detachment. Pieces of cataract lost intraoperatively can result in retinal detachment several weeks postoperatively.

Postoperative hypertension and glaucoma have been noticed in some horses with IOL implantation.

Intracapsular Surgery for Cataract or Luxated Lens

Intracapsular lens removal for luxated lenses and extracapsular cataract removal are no longer recommended for the horse. Both of these surgeries require a corneal or limbal incision over half the circumference of the cornea. The horse eye does not tolerate the intraoperative hypotony of such a procedure. Hyphema, incision dehiscence, infectious endophthalmitis, and retinal detachment are common complications.

SURGICAL THERAPY FOR UVEITIS

Sustained release cyclosporine A delivery devices

Indications

The use of cyclosporine A (CsA) in ERU patients has come into favor as the inflammatory reaction has been further characterized in affected horses. CsA is a cyclic peptide that specifically blocks interleukin-2 (IL-2) production. Decreasing IL-2

minimizes T-lymphocyte activation that is the source of elevated cytokines in the uveitic equine ciliary body.(2,22-24) Topical CsA preparations have been shown to penetrate the cornea poorly, preventing sufficient intraocular concentrations.(22,24) A polyvinyl alcohol/ethylene vinyl acetate-coated CsA delivery device has been used to allow for sustained release of the drug in the horse.(22,24,25) In one study, the recurrence rate decreased to less than 1 uveitic episode/ year as compared to the 7.5 episodes/year prior to the surgery.(24)

Technique

For surgical implantation, general anesthesia is essential to minimize intra-operative complications.(22) After sterile preparation of the eye, a conjunctival incision is made parallel to and approximately 10-12 mm caudal to the limbus that exposes the anterior insertion of the dorsal rectus muscle. A 7 mm deep scleral flap exposing the underlying uvea is then created. The CsA device is placed under the scleral flap in contact with the pigmented uveal tissue. The scleral flap is closed, followed by closure of the conjunctiva overlying the sclerotomy using 7-0 absorbable suture. Horses are treated with systemic antibiotics and nonsteroidal antiinflammatory drugs, as well as topical mydriatic, corticosteroids and antibiotic therapy for 5-10 days postoperatively.(22, 24)

Complications

Intraoperative hemorrhage can be substantial for ophthalmic surgeries due to the inflamed conjunctiva and sclera. Care should be taken to not perforate the uvea during the procedure. Complications in the immediate post-surgical period include scleral hemorrhage, and mild increases in intraocular vitreal inflammation that appear to resolve

within 3-5 days with medical therapy. Dislocation of the implant into the anterior chamber or vitreous can occur. Since levels of cyclosporine do not reach adequate levels until 35-40 days post-operatively, recurrent episodes of uveitis in this period should be addressed with traditional ERU treatments.(22, 24) The progression or development of secondary glaucoma and cataract maturation can occur.(22, 24) Vitreal degeneration can progress, despite control of uveitic episodes, to retinal detachment.(22,24) Infectious endophthalmitis can occur that requires implant removal. (22, 24)

Pars Plana Vitrectomy for ERU

Indications

The purpose of the vitrectomy surgical approach for treatment of ERU stems from its ability to remove infectious organisms, vitreal debris, fibrin, toxic metabolites and vitreal opacities that may affect visual acuity.(22,26) Postoperatively, horses are reported to have a decreased frequency and severity of the uveitic episodes, or have remained free of clinical signs. (22, 26)

Technique

The single (described here) or dual port pars plana vitrectomy is performed under general anesthesia with the horse in lateral recumbency.(22,26) A limbal based conjunctival flap 10 to 15 mm in length is performed to expose the sclera. A penetrating sclerotomy is made approximately 10 mm caudal to the limbus in order to enter through the pars plana of the ciliary body in an attempt to avoid trauma to the retina and ciliary body. The vitrectomy probe is inserted through the sclerotomy incision. Magnification is required. Care is taken not to contact the posterior lens capsule or retina during the procedure. The vitreal cavity is irrigated during vitrectomy with a balanced salt solution

(BSS, Alcon Laboratories, Inc., Fort Worth, Texas) with 0.2mg/mL of gentamicin added to the fluid. A majority of the vitreous should be removed. Closure of the sclerotomy is performed in a continuous pattern with 6-0 polyglactin 910 (Vicryl, Ethicon, Inc., Somerville, NJ), followed by closure of the bulbar conjunctival flap.

Complications

Complications of horses having pars plana vitrectomy for ERU are less common and less severe in European horses, but more so in the USA where the etiology of ERU may be different.(2,22,26)

Most horses experience mild discomfort manifesting as an adverse reaction to ophthalmic examination the first 1-3 days post-operatively. Anterior chamber fibrin is noted in approximately 60% of the cases.(22, 26) Mild to moderate vitreal fibrin formation and slight vitreal hemorrhage occurs occasionally. More serious complications in the early post-operative period include severe vitreal hemorrhage, hyphema, and retinal detachment. Progression of cataract formation present prior to surgery can occur and is a major problem. Chorioretinal scarring also progresses in some horses.(22,26)

SURGICAL TREATMENT FOR GLAUCOMA

Indications

When medical therapy is inadequate, surgery should be utilized to control IOP and preserve vision in the horse with glaucoma. The surgical options for a visual eye in a horse include transcleral laser cyclophotoablation, and gonioimplant filtration procedures. (2,27-29) Cyclocryoablation, ciliary body ablation, instrascleral prostheses and enucleation are indicated for blind, chronically painful, and buphthalmic horse eyes. (27-29)

Transcleral Cyclophotocoagulation

Indications

When the IOP cannot be controlled with medical therapy, contact neodymium: yttrium-aluminum-garnet (Nd: YAG) or diode laser transcleral cyclophotocoagulation (TSCPC) may be a viable alternative for long-term IOP control. Lasering the ciliary body damages the ciliary body and supraciliary spaces, and the IOP eventually declines in most horse eyes. The glaucomatous globe of horses responds to laser therapy better in controlling IOP and maintaining vision than other species in my experience. (2,27-29) Laser cyclophotocoagulation is least efficacious at lowering IOP and maintaining vision in horse eyes that are atropine responsive, suggesting that these eyes are utilizing their unconventional aqueous humor outflow pathways.

Technique

I recommend that laser therapy not be performed until any uveitis or corneal edema present is controlled with corticosteroids. Forty to 70 sites 4-6 mm posterior to the limbus, except nasally, should be lasered.(29) The settings for the Nd:YAG laser are: 10 W, 0.4 sec.(29) The settings for the diode laser are 1500 mW power, 1500 mSec duration. (29) A mean drop of 17 mmHg can be expected the first few days following Nd:YAG laser TSCPC in the glaucomatous horse eye. (29) The target IOP lowering effects occur 2-4 weeks after diode lasering and should be at least 25 mmHg less than before TSCPC at twenty weeks post-laser.(29)

Complications

Uveitis and corneal edema will increase initially following TSCPC. The IOP may also spike immediately after lasering. Medical therapy must be maintained till the

iridocyclitis is reduced and the IOP diminished post-laser. Paracentesis may be necessary immediately post-laser to reduce the IOP. The corneal edema of the horse with glaucoma may become permanent following laser cyclophotocoagulation due to increased uveitic damage to the corneal endothelium. (29) Superficial corneal ulcers may develop from reduced corneal sensation from the TSCPC, or corneal exposure during the procedure. Hyphema, retinal detachment, cataract and corneal ulcers are complications postoperatively.

Gonioimplants

Gonioimplant filtration surgeries to bypass the obstructed iridocorneal angle and direct the outflow of aqueous humor to the subconjunctival space have been successful for only brief periods in horses with glaucoma.(29) The several available gonioimplant types commonly have a tube in the anterior chamber that drains aqueous humor to an attached plate under the conjunctiva. Aqueous humor thus bypasses the blocked drainage angle to drain into a bleb surrounding the footplate. They have a short functional lifespan in the horse due to fibrosis and blockage of the drainage tube and/or filtration bleb. Implant extrusion can occur.

Cyclocryosurgery

Blind, buphthalmic eyes can benefit from cyclocryotherapy, or nitrous oxide induced cryodestruction of the ciliary body. A 3 mm diameter cryoprobe is placed on the conjunctiva/sclera 6 mm posterior to the limbus for 1 minute freeze-thaw cycles in six locations. Cyclocryotherapy is associated with severed iridocyclitis postoperatively and should only be utilized in blind eyes.(29) The IOP lowering effects may only last six weeks and may need to be repeated. Severe uveitis associated with transient elevations in

IOP is a major postoperative complication that is treated with topical and systemic antiinflammatories.

Ciliary Body Ablation

Intravitreal injection of intravenous gentamicin (25mg with 1mg dexamethasone) can induce phthisis in a painful, blind horse eye to result in varying degrees of pain reduction. The gentamicin induces a local uveitis and the dexamethasone minimizes discomfort from the injection.(27, 29) A single injection is typically sufficient for pain reduction but a second may be necessary in some cases.

Technique

Following sedation, frontal nerve block, instillation of topical anesthetic and phenylephrine (2.5% to vasoconstrict conjunctival vessels), and with appropriate restraint, the ciliary body ablation is performed with a 20-gauge needle on a 3-cc syringe. The needle is positioned dorsolaterally approximately 7 mm posterior to the limbus at a 45-degree angle (toward the optic nerve and away from the lens). (29)   Prior to injecting the gentamicin/dexamethasone, an equal volume (or greater) of vitreous is aspirated. If no vitreous can be aspirated, an aqueous paracentesis can be used to decrease the intraocular volume and thereby temporarily decrease IOP. Progressive increases in globe size (buphthalmos) may be prevented.

Complications

Hyphema, cataract formation, retinal detachment, intraocular infection, persistent elevated IOP, and entropion due to extreme phthisis can occur postoperatively with the ciliary ablation technique. Careful monitoring is required. This salvage technique is reserved for blind eyes only!

GLOBE SURGERY

Exenteration

Indication and Surgical Technique

Orbital exenteration is a surgical technique used to remove large malignant

tumors of the orbit.(30) In this procedure the entire orbital contents, including periorbita

and globe, are surgically removed. The eyeball or globe is enucleated first. Periosteal

elevators may be needed to remove the periorbital fascia. The remaining tissue is excised

using scalpel or scissors. Bleeding is controlled with ligation and cautery. A permanent

tarsorrhaphy is performed to cover the orbital cavity if the lids were not involved in the

disease process. A skin graft can be used to cover the open socket if excessive eyelid skin

must be removed, or the socket can be left in rare cases to granulate.

Complications

Postoperative care should include pressure dressings on the head to reduce

swelling and tamponade bleeding if hemorrhage was severe. Systemic antibiotics and

nonsteroidal anti-inflammatories are indicated to prevent infection. Inadvertent entry into

a paranasal sinus may require trephination of the sinus, and sinus lavage and drainage.

(30)

Evisceration and Intrascleral Prosthesis Implantation

Indications

Evisceration refers to the surgical removal of the iris, lens, ciliary body, choroid,

vitreous and retina. The cornea, sclera and their extraocular muscle attachments are left

intact. (30) This is performed prior to placement of an intrascleral silicone implant or

prosthesis. Evisceration is not generally recommended in an eye suspected of having an

intraocular tumor or infection, or eyes with severe corneal disease. Horses beginning to

undergo globe atrophy or phthisis bulbi are good candidates for evisceration and

intrascleral prostheses placement.

The intrascleral (ISP) or intraocular silicone prostheses has been used in horses as

a cosmetic alternative to enucleation. (30) The ISP replaces the intraocular contents

which are removed by evisceration. Implants of 34-44 mm in diameter are recommended

for adult horses, but should not be placed in eyes with severe corneal disease, intraocular

neoplasia or infectious endophthalmitis. The ISP provides a cosmetically acceptable,

nonpainful eye, which has normal lid movements, normal tear function and normal globe

motility. (30)

Technique

A 180° limbal peritomy is performed with tenotomy scissors. A #15 blade is used

to make a 180° full thickness scleral incision four to five mm from the limbus. Suction

and cautery are used to control hemorrhage and visualize the incision. A lens loop or

evisceration spoon is used to remove all the intraocular contents. Care is taken to avoid

scraping the corneal endothelium. A silicone implant of suitable size is inserted through

the scleral incision into the globe so that suturing the sclera can be accomplished without

undue tension. Preoperative ultrasound measurement of the normal eye can aid selection

of the proper sized implant.(30) Simple interrupted sutures of 7-0 absorbable suture are

placed in the sclera and a simple continuous pattern of 7-0 absorbable suture placed in the

conjunctiva. A temporary tarsorrhaphy can be used to protect the cornea while

postoperative eyelid swelling subsides. Healing time of intrascleral implants is typically

six to eight weeks.

Complications

The main complications of evisceration and intrascleral implants are extrusion of the implant and corneal ulcers. Protective eyecups will help prevent irritation from head rubbing. The scleral incision can dehisce to reveal the prosthesis and necessitate implant removal.(30)   The silicone implants can be rejected due to intrascleral infection and necessitate removal of the globe. Corneal ulcers can occur due to reduced corneal sensation.

Placement of too small an implant will result in a cosmetically unacceptable eye. Owners should also be warned that corneal opacification and vascularization will occur in some animals such that cosmesis is not completely normal. Corneal opacification in show horses can be masked for short times with tinted contact lenses. x

Enucleation

Indication and Types

Enucleation refers to surgical removal of the globe, conjunctiva and nictitating membrane because of severe corneal infection and endophthalmitis, severe iris prolapse, corneal or adnexal neoplasia, orbital neoplasia, or severe ocular trauma causing a painful, blind eye. (30)   This procedure does not necessarily indicate a failure of ophthalmic care, but may be a necessary and planned treatment for specific conditions. There are two basic approaches to enucleation in the horse, the transpalpebral and subconjunctival techniques. (30)   Orbital silicone implants may be placed with either method to reduce the profound postenucleation eyelid skin "pitting" in horses. (30)

Transpalpebral EnucleationTechnique

The transpalpebral technique is most useful for cases of severe corneal infection, endophthalmitis, and widespread neoplasia of the conjunctival, nictitating membrane, cornea or orbit. It does leave a large orbital soft tissue defect. (30) In this approach, dissection into the orbit is made external to the extraocular muscles. All the secreting tissues of the conjunctiva, globe and nictitating membrane are completely removed en masse.

The eyelids are sutured together with a simple continuous suture and the ends held with hemostatic forceps. An incision 5 mm from the eyelid margin (where the skin hair begins) is made with a #15 blade. The angularis oculi vein located near the medial canthus should be avoided. Blunt subcutaneous dissection with Metzenbaum scissors is performed posteriorly, taking care to avoid breaking into the conjunctival sac. The medial and lateral canthal ligaments are transected with the blade. A large curved Rochester-Carmalt hemostat (8-10 inch) or Satinsky vascular clamp (27.3 mm) is used to crush the optic nerve, and curved scissors used to transect the optic nerve between the globe and clamp. The optic nerve is best approached from the nasal side of the orbit. Care should be taken not to pull on the optic nerve as tension at the optic chiasm can result in damage to the contralateral eye. A ligature may be placed on the transected optic nerve stump, and the nerve tissue cauterized. Soft tissues of the orbit are closed in a simple continuous pattern with 3-0 absorbable suture to minimize postoperative "pitting" of the eyelids. A silicone prosthesis can be inserted prior to closure of the muscle, fascial and eyelid skin layers to reduce the postenucleation orbital tissue defect. Simple interrupted sutures of 4-0 nylon or silk are used to permanently close the skin incision.

Subconjunctival Enucleation Technique

The subconjunctival approach is quicker and associated with less hemorrhage but some secreting tissue may be indadvertently left. (30) It should be used when a cosmetic shell is to be placed in order to maintain the integrity of the lid margin. A lateral canthotomy may be necessary to increase exposure. A 360° limbal peritomy is performed using sharp scissors. All four quadrants are undermined posteriorly with tenotomy or Metzenbaum scissors. Extraocular muscles are isolated, and transected. The medial and lateral canthal ligaments are transected with a blade. Cautery is used to control bleeding.

A large curved Rochester-Carmalt hemostat (8-10 inch) or Satinsky vascular clamp (27.3 mm) is used to crush the optic nerve, and curved scissors used to transect the optic nerve between the globe and clamp. The optic nerve is best approached from the nasal side of the orbit. Care should be taken not to pull on the optic nerve as tension at the optic chiasm can result in damage to the contralateral eye. A ligature may be placed on the transected optic nerve stump, and the nerve tissue cauterized. The nictitating membrane and its gland are carefully removed with scissors. Three to five mm of the lid margins are excised with scissors. The conjunctiva is stripped from the remaining lid, and the subcutaneous fascia and orbital septum closed with a simple continuous suture pattern of 3-0 absorbable suture material to produce a tissue bridge across the front of the orbit. This will minimize postoperative eyelid "pitting". The lid incision is permanently closed with simple interrupted sutures of 4-0 nylon or silk. A silicone prosthesis can be inserted prior to closure of the muscle, fascia and skin layers to reduce the orbital pitting defect. (30)

Complications

Complications of enucleation include intraoperative rupture of the globe causing orbital contamination with microbes and/or tumor cells into the orbit and circulation, severe intraoperative and postoperative hemorrhage, orbital cyst formation from failing to remove all secreting orbital and ocular tissues, and blindness due to stretching of the contralateral optic nerve from intraoperative pulling on the optic nerve. The contaminated orbit should be irrigated with povidone iodine solution and intraoperative cultures obtained. (30) Broad spectrum systemic antibiotics should also be administered and the regimen modified according to the sensitivities of the organism isolated. A drain can be placed if contamination is severe. Surgical transection of the optic nerve vessels can result in severe intraoperative hemorrhaging. Wet field cautery or careful ligation should result in hemostasis. Metal hemaclips can also be used to control bleeding of the optic nerve and other orbital tissues. Epistaxis is generally slight but may occur postoperatively for a few days. Eyelid tamponade and head bandaging will suppress slight postoperative orbital swelling and hemorrhaging. An orbital silicone implant should not be placed if infection or a tumor is found in the orbit at enucleation. Failure to remove gauze can incite a terrible reaction. Cyst formation can occur days to months postoperatively due to failure to remove all secreting tissues such as conjunctiva and the nictitans. The skin incision can dehisce after surgery to reveal the granulating orbital tissues or the implanted prosthesis.

Intraorbital Prostheses

Intraorbital prostheses are used to prevent severe pitting of the skin over the orbital cavity following exenteration or enucleation. (30) The use of intraorbital implants with orbital neoplasia and or infection is controversial. Implants for horses are available

from Jardon Eye Prosthetics, Inc, 15920 W. 12 Mile Road, Southfield, MI 48076, USA; 248-424-8560. A silicone orbital implant specifically designed to reduce postenucleation eyelid skin "pitting" in horses is now available from Veterinary Ophthalmic Specialties, PO Box 8572, Moscow, ID 83842 USA; 208-882-9350; vos@vetospec.com. Despite being biologically inert, these can be rejected and necessitate removal. The skin incision can dehisce to reveal the granulating orbit and prosthesis.

REFERENCES

1. Plummer CE. Equine Eyelid Disease. Current Techniques in Equine Practice 2005; 4(1): 95-105.

2. Brooks, DE, Matthews AG. Equine Ophthalmology. In Gelatt, KN (ed.), Veterinary Ophthalmology, 4th ed., Blackwell Pub, Ames, IA; 2007. p 1165-1274.

3. Brooks, DE. Ocular Emergencies and Trauma. In Equine Surgery, Auer, JA, Stick JA (eds), 3rd ed, W.B. Saunders, St Louis;m2006. p 767-774.

4. Severin GA. Principles of ocular surgery. In Severin's Veterinary Ophthalmology Notes, 3rd ed. Fort Collins, CO; 1996, pp 139-150.

5. Ollivier FJ. Medical and Surgical Management of Melting Corneal Ulcers Exhibiting Hyperproteinase Activity in the Horse. Current Techniques in Equine Practice 2005; 4(1): 50-71.

6. Denis HM. Equine corneal surgery and transplantation. Vet Clin North Am (Equine Pract) 2004; 20:361-80.

7. Brooks DE. Equine Ophthalmology-Made Easy. Jackson Hole, WY, Teton NewMedia, 2002.

8. Ollivier FJ. The precorneal tear film in horses: its importance and disorders. Vet Clin North Am (Equine Pract) 2004; 20:301-318.

9. Brooks DE, Andrew SE, Biros DJ, et al. Ulcerative keratitis caused by beta-hemolytic Streptococcus equi in 11 horses. Vet Ophthalmol 2000; 3:121-125.

10. Nasisse MP, Nelms S. Equine ulcerative keratitis. Vet Clin North Am (Equine Pract). 1992; 8(3):537-55.

11. Ollivier FJ, Kallberg ME, Plummer CE, et al. Amniotic membrane transplantation for corneal surface reconstruction after excision of corneolimbal squamous cell carcinoma in nine horses. Vet Ophthalmol 2006; 9(6): 404-413.

12. Tseng SC, Prabhasawat P, Lee SH. Amniotic membrane transplantation for conjunctival surface reconstruction. Am J Ophthalmol 1997; 124: 765-774.

13. Azuara BA, Pillai CT, Dua HS. Amniotic membrane transplantation for ocular surface reconstruction. Br J Ophthalmol 1999; 83: 399-402.

14. Kruse FE, Rohrschneider K, Volcker HE. Multilayer amniotic membrane transplantation for reconstruction of deep corneal ulcers. Ophthalmol 1999; 106: 1504-1510.

15. Brooks DE. Penetrating keratoplasty, deep lamellar endothelial keratoplasty, and posterior lamellar keratoplasty in the horse. Current Techniques in Equine Practice 2005; 4(1): 37-49.

16. Brooks DE, Plummer CE, Kallberg ME, et al. Corneal Transplantation for Inflammatory Keratopathies in the Horse: Visual Outcome in 206 Cases (1993-2007). Vet Ophthalmol 2008; 11(2): 123-133.

17. Whittaker CJG, Smith PJ, Brooks DE, et al. Therapeutic penetrating keratoplasty for deep corneal stromal abscesses in eight horses. Vet Comp Ophthalmol 1997; 7(1): 19-28.

18. Terry MA. Endothelial replacement: the limbal pocket approach. Ophthalmol Clin N Am 2003; 16(1): 103-112.

19. Terry MA, Ousely PJ. Replacing the endothelium without corneal surface incisions or sutures. Ophthalmol 2003; 110(4): 755-764.

20. Taban M, Rao B, Reznik J, Zhang J, Chen Z, McDonnell PJ. Dynamic morphology of sutureless cataract wounds--effect of incision angle and location. Surv Ophthalmol 2004; 49 Suppl 2:S62-72.

21. Brooks DE. Phacoemulsification cataract surgery in the horse. Current Techniques in Equine Practice 2005; 4(1): 11-20.

22. Keller RL, Hendrix, DVH. New surgical therapies for the treatment of equine recurrent uveitis. Current Techniques in Equine Practice 2005; 4(1): 81-86.

23. Gilger BC, Malok E, Cutter KV, et al. Characterization of T-lymphocytes in the anterior uvea of eyes with chronic equine recurrent uveitis. Vet Immunol Immunopathol 1999; 71:17-28.

24. Gilger BC, Wilkie DA, Davidson MG, et al. Use of an intravitreal sustained-release cyclosporine delivery device for treatment of equine recurrent uveitis. Am J Vet Res 2001; 62:1892-1896.

25. Gilger BC, Michau TM. Equine recurrent uveitis: new methods of management. Vet Clin North Am (Equine Pract) 2004; 20:417-427.

26. Werry H, Gerhards H. Surgical Treatment of Equine Recurrent Uveitis (ERU). Tierarztl Prax 1992; 20: 178-186.

27. Lassaline ME, Brooks DE. The enigma of equine glaucoma. In Gilger B: Equine Ophthalmology, Elsevier, St Louis, MO, 2005. p 323-340.

28. Brooks DE. Equine Glaucoma, In Robinson NE (ed): Current Therapy in Equine Medicine, 5th ed. Philadelphia, PA, W.B. Saunders, 2003, pp 486-488.

29. Brooks DE. Hypertensive uveitis and glaucoma of horses. Current Techniques in Equine Practice 2005; 4(1): 72-80.

30. Brooks DE. Orbit. In Equine Surgery, Auer, JA, Stick JA (eds), 3rd ed, W.B. Saunders, St Louis; 2006; p 755-766.

SYNOPSIS

Corneal transplantation, amniotic membrane transplantation, phacoemulsification cataract extraction, and laser glaucoma therapy are routine ophthalmic surgical procedures in horses. This article discusses the indications, techniques and postoperative complications of these and other ophthalmic surgical procedures in horses. Meticulous and accurate anatomical repair can minimize postoperative complications to maintain positive visual outcomes in ophthalmic surgery of the horse.