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Modified lamellar keratoplasties for the treatment of deep stromal abscesses in horses

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Abstract

Objective To describe a surgical modification of deep lamellar endothelial keratoplasty (DLEK) and posterior lamellar keratoplasty (PLK) procedures, to facilitate surgery on standing horses under-sedation.
Animals studied Four client-owned horses, for which the owners declined surgery under general anesthesia, underwent standing corneal lamellar keratoplasty procedures for the treatment of deep corneal stromal abscesses.
Procedures All four horses were placed in stocks and sedated with detomidine. Local eyelid and retrobulbar blocks were performed to provide local analgesia and akinesia, and each horse's head was stabilized and supported by soft pads placed on a mobile cart. Deep lamellar endothelial keratoplasties (DLEKs) and posterior lamellar keratoplasties (PLKs) were performed on two horses each, for the treatment of deep stromal abscesses (DSA). Following the first DLEK, a mid-stromal two-step anterior lamellar keratectomy modification was used to facilitate rapid closure of the anterior chamber immediately following removal of the abscess.
Results Each of the four horses had similar cosmetic and postoperative visual outcomes, compared to previously published results. Intra-operative complications were most prevalent in the first DLEK case (i.e., focal iris and lens damage and postoperative anterior chamber collapse) and were all but eliminated in the remaining three cases. Similar to previously reported findings, greater postoperative corneal fibrosis was observed in the DLEK cases.
Conclusions In horses with deep stromal or endothelial abscesses, for which general anesthesia is not an option, both the modified DLEK and PLK corneal procedures may be performed as an alternative to enucleation on the standing, sedated horse.

Key Words: deep lamellar endothelial keratoplasty, deep stromal abscess, equine ophthalmology, posterior lamellar keratoplasty, sedation, standing surgery

INTRODUCTION

Equine corneal deep stromal abscesses (DSA) can be very frustrating to manage for both the owner and veterinarian, often requiring intense and prolonged topical and systemic medical therapy to control.[1–3] Although DSA are often controlled with medical therapy, in many instances, they cannot be completely eliminated and tapering of medications may result in a resurgence of clinical signs indicating the presence of active inflammation. Surgical intervention is usually indicated when this occurs.[3] Surgical intervention is also indicated if the abscess and associated anterior uveitis worsen during the course of medical therapy.[3]

Keratoplasty in the horse is performed both for therapeutic and tectonic reasons.[4–9] Diseases addressed using keratoplasty include inflammatory keratopathies (e.g., endotheliitis, deep stromal abscess), keratomalacia, and corneal perforations. Four surgical techniques for corneal transplantation in DSA have been described in the horse: penetrating keratoplasty (PK), posterior lamellar keratoplasty (PLK), deep lamellar endothelial keratoplasty (DLEK), and deep anterior lamellar keratoplasty (DALK).[4–7,9–11] Partial thickness keratoplasties (PLK and

Table 1. Patient profiles. Age is given in years. Intraoperative complications are described. Follow-up is given in months

Case	Sex	Age	Breed	Eye	Location	Lesion size (mm)	Surgical	Material	Complications	Follow-up
1	MC	5	Warmblood	OD	V/N	5 × 5	DLEK	None	Iris, lens damage	25
2	F	20	Percheron	OS	T/V	3 × 3	DLEK (M)	Frozen Cornea	None	59
3	MC	19	Cleveland Bay	OS	PA/D	7 × 7	PLK (M)	Frozen Cornea	CN incarceration	27
4	MC	20	Thoroughbred	OS	PA/N	3 × 3	PLK (M)	BioSISt	None	26

V, Ventral; T, temporal; D, dorsal; PA, paraxial; N, nasal; M, modified; CN, corpora nigra.

DLEK) may be employed when the corneal stroma overlying a deep abscess is intact and free from structural weakness (i.e., superficial stromal defect, dissolution of tissue, iris prolapse). A PLK is indicated for more axially located DSA, and a DLEK is indicated for more peripherally located DSA.[4,7,9] All techniques except the DALK require entrance into the anterior chamber and loss of chamber stability and have, up to this point, been described in horses only under general anesthesia and in lateral recumbency.

Many horses cannot undergo corrective surgical intervention under general anesthesia for a variety of reasons including financial, age and age-related problems, underlying medical complications (e.g. orthopedic, prior postoperative complications, etc.), and the owner's concern (both real and perceived) regarding general anesthesia. General anesthesia is associated with morbidity and mortality in horses.[12,13] Horses undergoing general anesthesia for ophthalmic procedures have been shown to suffer anesthetic complications, including hypotension and difficult or prolonged recoveries, more frequently than do horses anesthetized for other types of surgery.[12,14,15] Although ophthalmic procedures performed with horses under standing sedation are becoming more common, microsurgical ophthalmic surgical procedures are routinely performed under general anesthesia by veterinary ophthalmologists with training and experience in advanced corneal microsurgery in horses.[16,17] The procedures described herein were performed by veterinary ophthalmologists with extensive equine microsurgical experience, as well as in a wide variety of ophthalmic surgical procedures in the standing sedated horse.[16–18] Similar results should not and cannot be expected from individuals without extensive microsurgical training and should not be attempted by such individuals.

The purpose of this report was to describe the surgical intervention and outcome of four horses with DSA treated by DLEK or PLK performed under standing sedation.

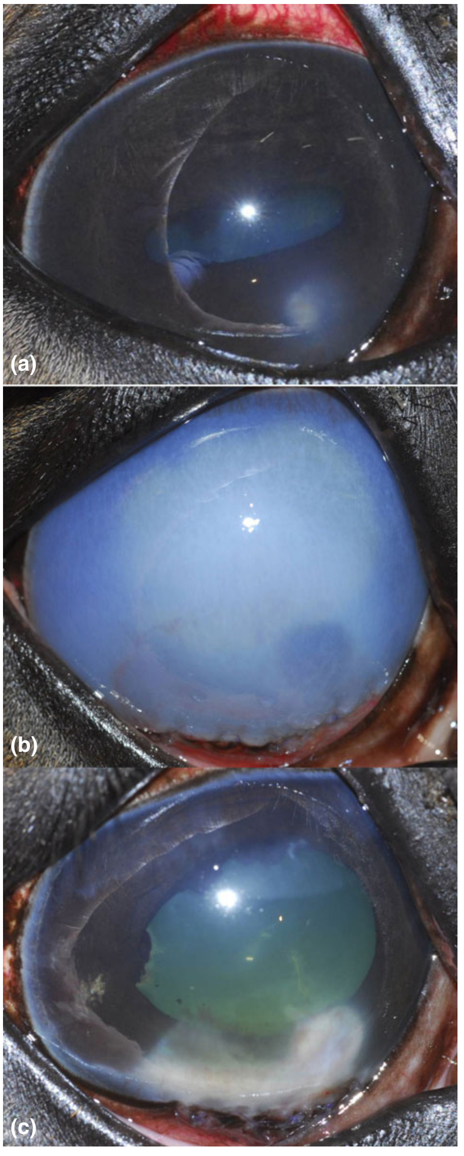

Figure 1. (a–c). Case 1 photomontage. (a) Pre-operative image of the deep stromal abscess located within the ventral cornea OD. (b) Twenty-four hours postoperatively showing significant diffuse corneal edema following DLEK. (c) Photograph from 6 weeks postoperatively showing marked localized fibrosis, including areas undergoing only superficial keratectomy (superficial flap) adjacent to the deep stromal biopsy location.

MATERIALS AND METHODS

The medical records of four horses diagnosed with a unilateral deep corneal stromal abscess and treated with either a DLEK (cases 1 and 2) or a PLK (cases 3 and 4) under standing sedation at the North Carolina State University (NCSU) Equine Ophthalmology Service between November 2009 and November 2011 were reviewed. The signalment, ophthalmic examination findings, diagnostic test results, surgical method and description, healing, complications, and visual outcome

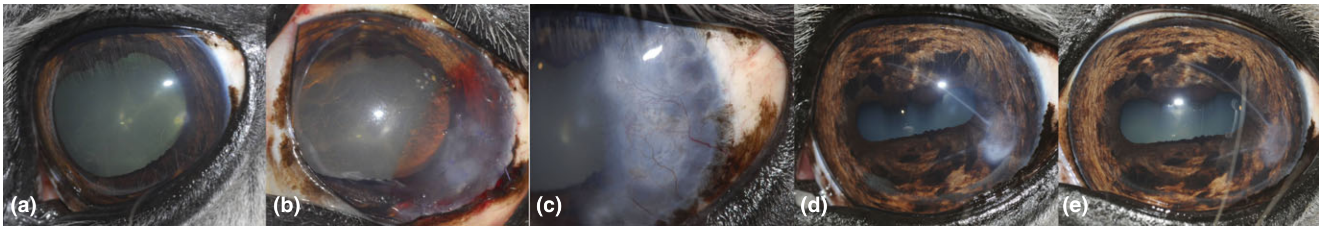

Figure 2. (a–e). Case 2 photomontage. (a) Pre-operative photograph of the ventrotemporally located deep stromal abscess OS. (b) Photograph from 24 h postoperatively showing accumulation of red blood cells under the larger superficial keratectomy following modified DLEK but minimal corneal edema. (c) Photograph of case 2, 6 weeks postoperatively showing marked fibrosis in the entire area of the DLEK. (d) Photograph taken at the 46-month follow-up examination. The corneal fibrosis is concentrated at the site of the full-thickness corneal biopsy, and an endothelial band opacity obliquely traversing the axial cornea from 4 to 10 o'clock. (e) Photograph taken at the 59.5-month follow-up examination. Note the further reduction in corneal fibrosis.

were recorded. The owners declined surgical intervention under general anesthesia, but consent was given to perform lamellar keratoplasty under standing sedation rather than pursue standing enucleation following extensive discussion of the potential risks involved with this procedure under standing sedation and local anesthesia and analgesia.

Signalment and medical history

Individual patient signalment and case information are presented in Table 1. A complete ophthalmic examination was performed on each horse including evaluation of the menace response, dazzle reflex, direct and consensual pupillary light reflexes, corneal and facial sensitivity, palpebral reflex (nasal and temporal), orbital symmetry, and retropulsion. Examination of the eyelids, cornea, anterior chamber, iris and lens with diffuse and focal slit-lamp biomicroscopy was performed in both eyes prior to and following mydriasis. Evaluation of the cornea was also performed following application of fluorescein dye. Direct and indirect binocular ophthalmoscopy prior to and following mydriasis was performed in all horses. A deep corneal stromal abscess was diagnosed in one eye of each horse based on the ocular examination findings (Figs 1a, 2a, 3a and 4a).[3] All abscesses were located in the posterior stroma adjacent to Descemet's membrane; however, the location and diameter of the abscess varied (Table 1). Medical therapy had been attempted for 1 week to 3 months prior to recommended surgical intervention. Surgical removal of the lesion was recommended based upon one or more of the following factors: (i) the depth of the lesion, (ii) no response to medical therapy, or (iii) persistence or worsening of secondary uveitis despite appropriate anti-inflammatory and mydriatic/cycloplegic therapy. Isolation of the lesion to the posterior corneal stroma allowed for performance of a PLK or DLEK instead of PK.

General anesthesia was declined by the owner of case 1 due to financial constraints, and by the owner of case 2 due to perceived risk associated with the horse's age and history of chronic lameness. The owners of cases 3 and 4 preferred euthanasia to enucleation, and therefore, corneal microsurgery was elected in the standing horse as an alternative to euthanasia.

Anesthesia and sedation

Each horse was placed in stocks and sedated with detomidine hydrochloride (Dormosedan®, 10 mg/mL; Orion Pharma, Espoo, Finland), either via a constant rate infusion (CRI) for the DLEKs or bolus injections for the PLKs.[19–21] For the DLEKs, CRIs were started at 0.05 mcg/kg/min and maintained on 0.01–0.015 mcg/kg/min. Bolus IV injections of 5–10 mcg/kg were administered as needed to control head movements in

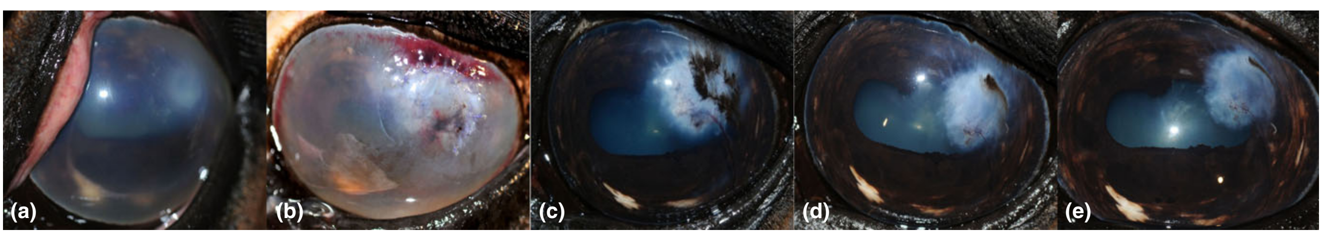

Figure 3. (a–e). Case 3 photomontage. (a) Photograph of the dorsotemporally located deep stromal abscess OS. (b) Photograph at 24 h postoperatively showing mild-to-moderate diffuse edema and iris tissue incarceration into the surgical site. (c) Photograph taken at 4 months postoperatively showing dense fibrosis and pigmentation localized to the PLK site. (d) Photograph taken at the 14-month follow-up examination. (e) Photograph taken at the 27-month follow-up examination. Note the reduction in superficial corneal pigmentation. The area of corneal fibrosis remains relatively unchanged.

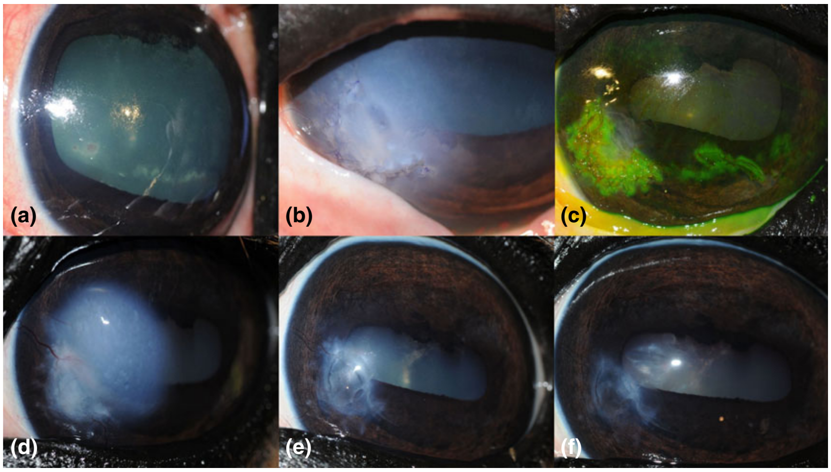

Figure 4. (a–f). Case 4 photomontage. (a) Preoperative photograph of ventromedial deep stromal abscess OS. (b) Photograph from 24 h postoperatively showing mild-to-moderate lesional and perilesional corneal edema associated with the surgical site. Note the broken continuous suture at roughly 9 o'clock. (c) Photograph of postoperative corneal ulcer temporal to the surgical site. (d) Photograph from the 4-month follow-up examination showing dense fibrosis localized to the PLK site and perilesional corneal edema with bullae formation. (e) Photograph taken 13 months postoperatively. (f) Photograph taken at the 26-month follow-up examination. Corneal fibrosis is restricted to the area of the deep corneal biopsy.

the DLEKs. Bolus IV injections of 10–20 mcg/kg were administered for the PLKs, and repeat injections administered (5–10 mcg/kg) as needed.

Figure 5. Horse sedated in stocks with its head resting on soft pads for support.

Lidocaine HCL 2% (Sparhawk Laboratories, Inc., Lenexa, KS, USA) was used for local auriculopalpebral (1 mL) and frontal (0.5 mL) nerve blocks, and for retrobulbar (10–12 mL) nerve blocks to provide analgesia and akinesia to the eyelids and extraocular muscles, respectively. The retrobulbar block was administered using a 20-gauge 2.5-inch spinal needle inserted in the orbital fossa just caudal to the caudal aspect of the bony dorsal orbital rim.[21,22]

General surgical preparation

Routine aseptic preparation of the globe for surgery was performed, and the surgical field draped with four sterile permeable towels held in place by towel clamps.[3] Proparacaine HCL 1.0% 0.1 mL (Akorn, Lake Forest, IL, USA) was applied topically prior to and throughout the surgery as needed. Topical application of epinephrine (1 mg/mL; Hospira, Inc., Lake Forest, IL, USA) was utilized to provide vasoconstriction and minimize intra-operative hemorrhage. Magnification was achieved with 2.5× loupes (Heine MD500 and HK6000 light source; Herrsching, Germany) (cases 1, 2, 4) or a head-mounted ophthalmic 2.0–9.0× microscope (Varioscope® Acrivet; Leica Microsystems Inc., Buffalo Grove, IL, USA) (case 3). The head

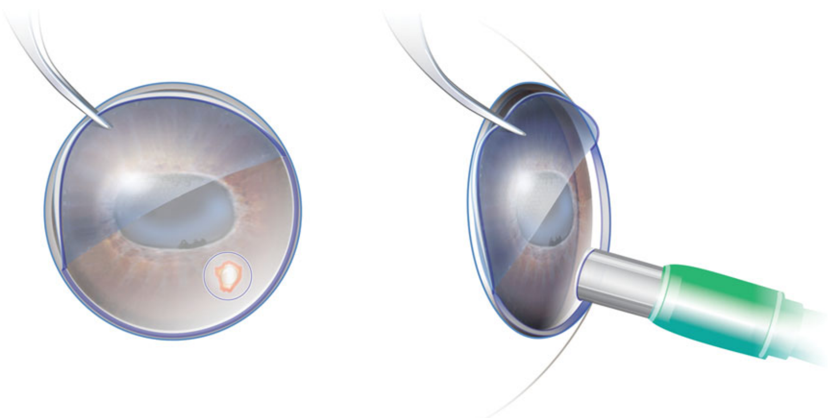

Figure 6. Diagram of the partial thickness anterior stromal keratectomy, with the superficial flap reflected, started with biopsy punch 2 mm wider than biopsy punch used to remove the lesion during DLEK.

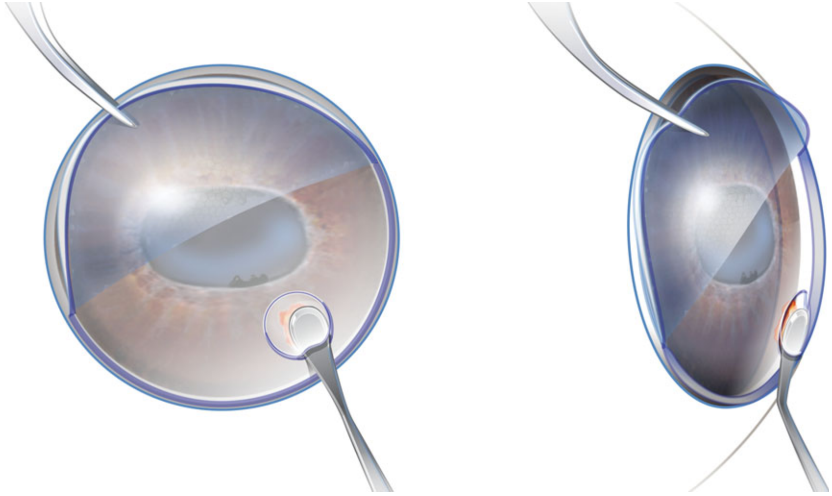

Figure 7. Diagram of the dissection and removal of a partial thickness stromal button over the abscess with a Martinez corneal dissector during DLEK.

was placed in a resting position on a padded mobile cart (Fig. 5) with the surgical plane perpendicular to the ground. An eyelid speculum was placed in all horses (Equine eye speculum; Acrivet, Salt Lake City, UT, USA)

Frozen (−80 °C) corneal allografts were used in cases 2 and 3.[3] The corneal grafts were harvested from horses humanely euthanized for reasons other than ocular, infectious, or neurologic disease. Prior to entry into the anterior chamber, a partial thickness corneal button was prepared by removing the corneal epithelium and anterior stroma from the posterior stroma and Descemet's membrane via dissection with a No. 64 microsurgical blade (BD Ophthalmic Systems, Waltham, MA, USA). A graft derived from the submucosal layer of porcine small intestine (Bio-SISt, Smiths SurgiVet, Waukesha, WI, USA) was used in case 4.

Medical therapy

Pre- and postoperative medical therapy for all of the eyes included placement of a subpalpebral lavage system (Mila, Inc, Erlanger, KY, USA). Topical therapy included voriconazole (Vfend®; Pfizer, Inc., New York, NY, USA), moxifloxacin hydrochloride (Vigamox® 0.5%; Alcon, Inc., Fort Worth, TX, USA), and atropine (Atropine sulfate 1%; Bausch & Lomb, Inc., Tampa, FL, USA). Systemic therapy included flunixin meglumine (Banamine®, 50 mg/mL; Schering Plough, Kenilworth, NJ, USA) 1 mg/kg PO (q12 h), an antibiotic (Trimethoprim–sulfamethoxazole 960 mg; Mutual pharmaceutical Co., Inc., Philadelphia, PA, USA) 30 mg/kg PO (q12 h), and antifungal therapy with fluconazole (Diflucan®, 200 mg; Pfizer, Inc.) 15 mg/kg loading dose PO followed by 5 mg/kg PO (q24 h). An oral H_2-receptor antagonist ranitidine (Zantac®; Boehringer-Ingelheim, Ridgefield, CT, USA) 6.6 mg/kg PO (q 8 h) and omeprazole (Gastroguard®; Merial Limited, Duluth, GA, USA) 2 mg/kg PO (24 h) were also administered.

Surgical description and procedures

The DLEK and PLK procedures were carried out as described previously except for the modifications.[4,7] The

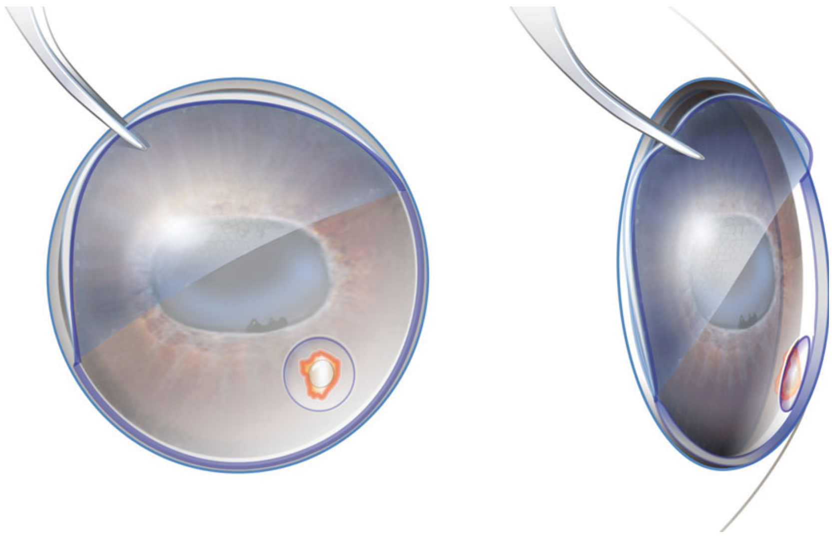

Figure 8. Diagram of the completed partial thickness keratectomy over abscess and under the larger superficial DLEK flap.

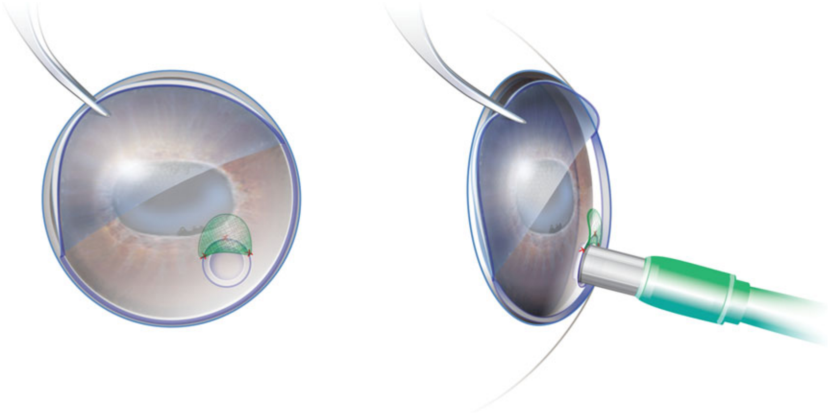

Figure 9. Diagram of the corneal graft partially sutured in place with three simple interrupted sutures at 10, 12, and 2 o'clock in the bed of the deeper keratectomy of the modified DLEK. An almost full-thickness corneal groove is then created with a biopsy punch 1 mm larger than the abscess.

initial perilimbal incision length (DLEK) and semi-circular incision length (PLK) and depth varied based on DSA location and degree of superficial corneal flap reflection necessary to provide access to the lesion. The initial incisions were created using a No. 64 microsurgical blade (BD Ophthalmic Systems). The semi-circular PLK incision was oriented with the flap nearest to the limbus. A Martinez corneal dissector (Martinez double-ended corneal dissector knife 3 × 11 mm; Bausch & Lomb Storz, Rochester, NY, USA) was utilized to perform the lamellar dissections over and surrounding the DSA in both DLEKs and PLKs. The perilimbal or limbal-oriented portion of the superficial corneal flap was then completed with corneal section scissors, as necessary.

Deep lamellar endothelial keratoplasty (cases 1 and 2)

In case 1, approximately 1 mL of viscoelastic material (Acrivet Syn 2%, Salt Lake City, UT, USA) was injected into the anterior chamber with a 21-gauge needle via tunneling at the temporal limbus prior to the beginning of surgery. Following completion of the superficial flap, it was retracted and the underlying DSA was measured with straight Castroviejo calipers (Bausch & Lomb Storz, Rochester, NY, USA). An appropriately sized disposable biopsy punch (Miltex, York, PA, USA) was then used to create a deep groove around the lesion. The biopsy punch used to remove the lesion was 1–2 mm larger in diameter than the measured size of the lesion.

A No. 65 microsurgical blade (BD Ophthalmic Systems) was then used to make a stab incision through the remaining layer of posterior cornea within the groove created by the biopsy punch. Following entry into the anterior chamber, removal of the abscess was completed with left and right corneal scissors. The viscoelastic completely effluxed from the anterior chamber at this time, and the chamber was collapsed with iridal and corneal endothelial contact. An attempt was made to suture a donor corneal button, endothelial side facing the anterior chamber, with 4–6 simple interrupted sutures with 7–0, polyglactin-910 (Vicryl, Ethicon, Inc., Somerville, NJ, USA) resorbable suture material. This was unsuccessful due to anterior chamber collapse and iris prolapse, and further attempts were abandoned. The superficial corneal flap was then repositioned and sutured along the limbus with 7-0

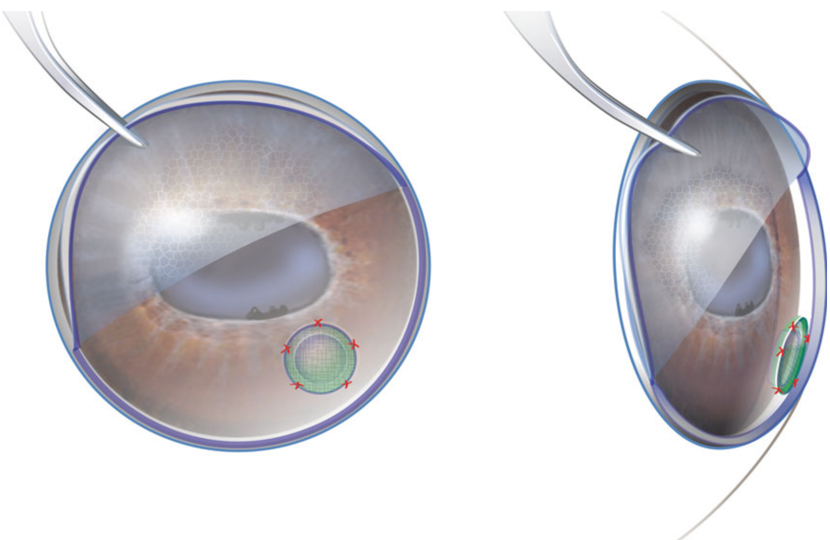

Figure 10. Diagram of the corneal graft reflected down and the remaining 2–3 simple interrupted sutures placed securing the graft into the bed of the deeper partial thickness keratectomy of the modified DLEK.

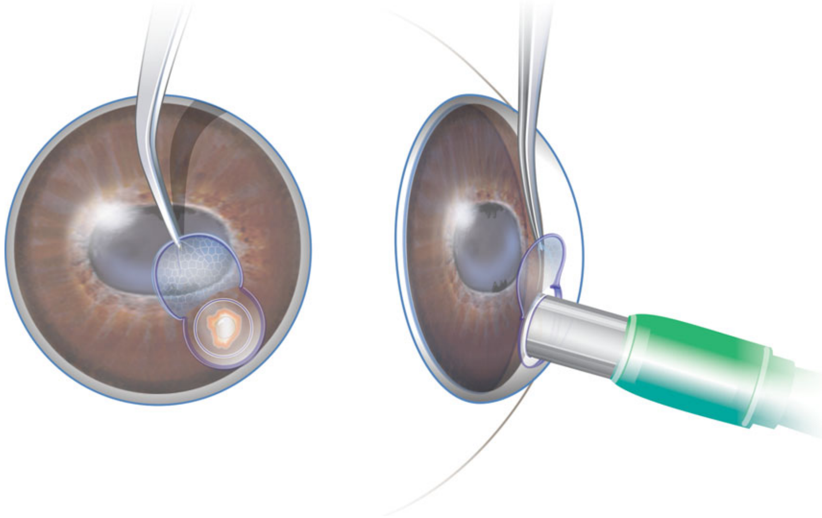

Figure 11. Diagram of the partial thickness stromal keratectomy started with a biopsy punch 1-2 mm wider than biopsy punch used to remove the lesion during the modified PLK.

polyglactin-910 in a reverse sawtooth continuous suture pattern (Fig. 1b).

In case 2, in an attempt to minimize/prevent the severity and duration of anterior chamber collapse experienced in the first DLEK, a modification of the surgery was planned. Following preparation and reflection of the superficial DLEK flap, a partial thickness (approximately one-quarter corneal thickness) mid-stromal corneal groove was created with a biopsy punch 3 mm wider than the DSA (i.e., 2 mm wider than biopsy punch used to remove the lesion) (Fig. 6). As in the more superficial flap, the mid-stromal lamellar keratectomy was also completed with a Martinez corneal dissector and corneal scissors if needed and that layer removed (Figs 7 and 8). The corneal graft was then partially sutured in place with 3 simple interrupted sutures (7-0 polyglactin-910) at 10, 12, and 2 o'clock in the bed of the larger more superficial keratectomy. With the bottom half of the corneal graft elevated dorsally, an almost full-thickness corneal groove was then created with a biopsy punch 1 mm larger than the abscess (Fig. 9). A No. 65 microsurgical blade (BD Ophthalmic Systems) was again used to make a stab incision through the remaining layer of posterior cornea within the groove created by the smaller biopsy punch. Following entry into the anterior chamber, removal of the abscess was completed with left and right corneal scissors. The corneal graft was reflected down, and the remaining 2–3 simple interrupted sutures placed rapidly (Fig. 10). Viscoelastic was injected using a 27-gauge cannula through the suture gaps in the corneal graft and resulted in a formed anterior chamber with no leakage from the surgical site. The superficial corneal flap was then repositioned and sutured along the limbus with 7-0 polyglactin-910 in a reverse sawtooth continuous

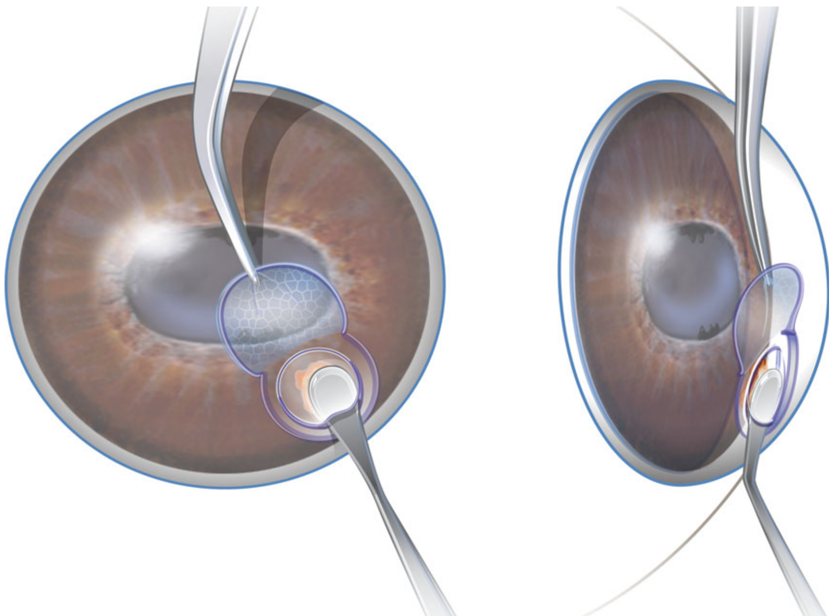

Figure 12. Diagram of the dissection and removal of a partial thickness stromal button over the abscess with a Martinez corneal dissector during the modified PLK.

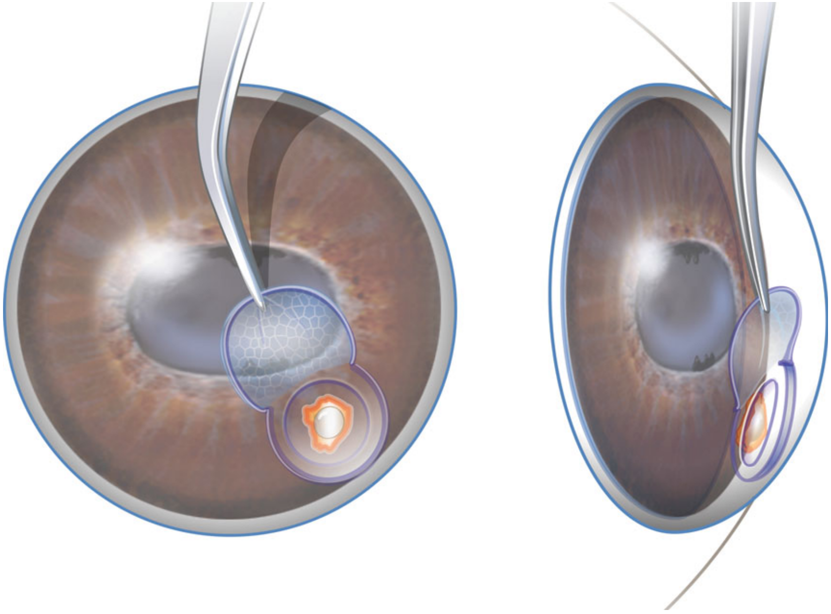

Figure 13. Diagram of the completed partial thickness keratectomy over the abscess and under the larger superficial PLK flap.

suture pattern as previously described (Fig. 2b). The apposition of the corneal graft with the 2-mm 'ledge' of deeper stroma allowed for a rapid seal of the anterior chamber.

Posterior lamellar keratoplasty (cases 3 and 4)

The limbal-based superficial semicircular flap was completed as previously described. The superficial flap was reflected, and a partial thickness (approximately one-quarter corneal thickness) mid-stromal corneal groove was created with a biopsy punch 3 mm wider than the DSA (Fig. 11). The mid-stromal lamellar keratectomy was completed with a Martinez corneal dissector and that layer removed (Figs 12 and 13). The corneal allograft (case 3) or BioSISt disk (case 4) was then partially sutured in place with 3 simple interrupted sutures at 10, 12, and 2 o'clock in the bed of the larger more superficial keratectomy (Fig. 14). With the bottom half of the corneal graft elevated dorsally, the abscess was removed as previously described. The corneal graft was then sutured rapidly in place with 2–3 additional simple interrupted sutures (Fig. 15). In both cases, the apposition of the corneal graft with the 2 mm 'ledge' of deeper stroma allowed for a rapid seal of the anterior chamber. Viscoelastic was injected using a 27-gauge cannula through the suture gaps in the corneal graft and resulted in a formed anterior chamber with no leakage from the surgical site. The superficial corneal flap was then repositioned and sutured with 7-0 polyglactin-910 (case 3) or 9-0 polyglactin-910 (case 4) in a reverse sawtooth continuous suture pattern as previously described (Figs 3b and 4b).

Corneal biopsy samples from cases 1, 2, and 3 were submitted for histological evaluation. Due to the deep corneal location of the abscesses, cytology was not attempted in any of the cases. Cultures were not performed due to financial restrictions.

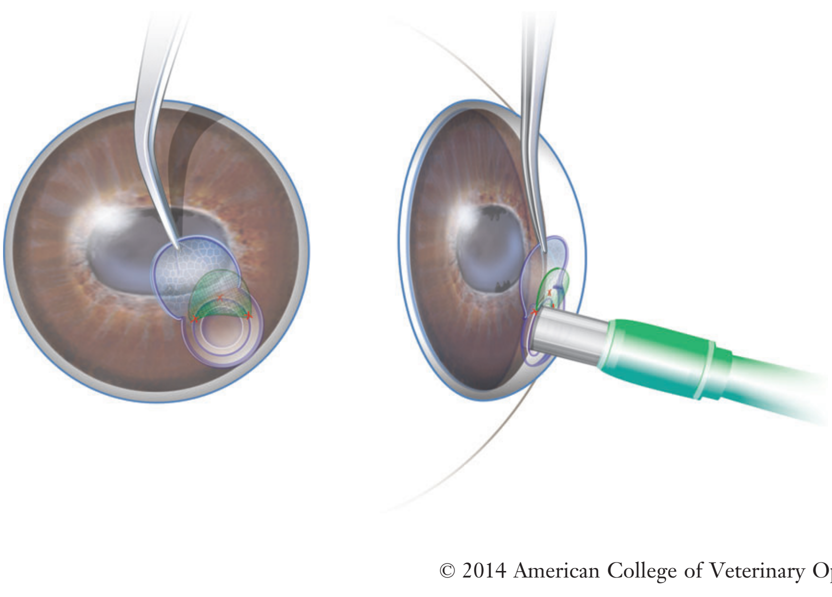

Figure 14. Diagram of the corneal graft partially sutured in place with three simple interrupted sutures at 10, 12, and 2 o'clock in the bed of the larger more superficial keratectomy of the modified PLK. An almost full-thickness corneal groove is then created with a biopsy punch 1 mm larger than the abscess.

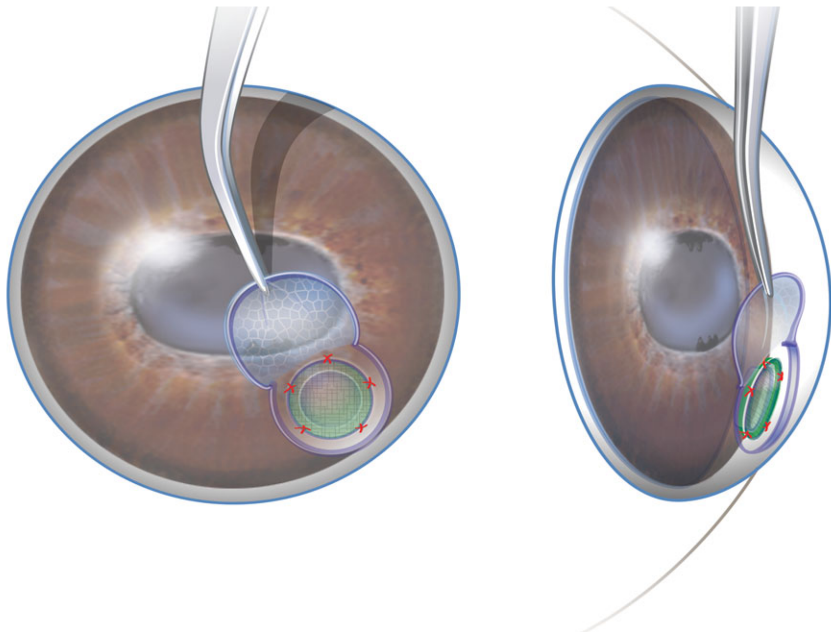

Figure 15. Diagram of the corneal graft reflected down and the remaining 2–3 simple interrupted sutures placed during modified PLK.

RESULTS

Standing sedation

A CRI of detomidine was used initially in cases 1 and 2 to allow for smoother control of the horse's sedation in anticipation of a longer surgical time. The depth of anesthesia was difficult to finely control by making changes in the CRI rate and allowed for either over-sedation (e.g., very wobbly) or under-sedation (e.g., head movement). Complicating it further, fine head movements secondary to ataxia could not be easily identified as over-sedation vs. under-sedation. Unfortunately, by the time signs were apparent that the depth of anesthesia was changing and the CRI rate altered, movement of the head from under-sedation or over-sedation had already occurred. A better overall plane of anesthesia for corneal surgery was obtained with the bolus injections. Detomidine boluses were therefore used in cases 3 and 4 in an attempt to minimize those movements and once the length of the surgeries could be better estimated and it was realized that a single-injection boluses would efficiently provide enough sedation and analgesia for the entire surgery.

Intra-operative complications

In case 1, abrupt movement of the head during presurgical placement of the viscoelastic via a limbal injection occurred. This resulted in focal penetration of the iris and anterior lens capsule and resulted in immediate focal iridal hemorrhage. The anterior chamber could not be reformed at the time of surgery due to continued leakage of the viscoelastic through the opening of PK, but reformed slowly over the next 12–24 h.

In case 3, the corpora nigra prolapsed into the surgical wound and became incarcerated. Mild fibrin accumulation within the anterior chamber occurred during suturing of the graft. The iris dilated away from the graft site in case 3, but left some remnant of corpora nigra within the surgical site.

Histology

Neutrophilic keratitis was diagnosed in all three corneal samples (cases 1, 2, and 3) submitted for during routine hematoxylin and eosin stain (H&E). Pale, basophilic, clear ovoid tubular structures, consistent with fungal hyphae, were identified in case 1. Special staining with periodic acid–Schiff stain (PAS) or Grocott's methenamine silver stain (GMS) failed to identify etiological agents in any of the three cases evaluated.

Postoperative follow-up

Twelve to 24 h postoperatively, the anterior chambers were formed and of normal depth in all horses. Case 1 (DLEK) had moderate-to-severe diffuse corneal edema (Fig. 1b), but had a normal menace response. Case 2 had mild corneal edema, mild anterior chamber fibrin accumulation, and red blood cell accumulation under the superficial flap (Fig. 2b). Case 3 had moderate corneal edema; the focal anterior synechia/iris incarceration remained (Fig. 3b). Case 4 had moderate localized corneal edema and developed a superficial corneal ulcer in the area where the eyelid speculum had been in contact with the cornea that healed without complications (Fig. 4b and c).

At 5–6 weeks postoperatively, cases 1 and 2 (DLEK) had significant amounts of fibrosis present at the surgical site (Figs 1c and 2c). Focal posterior synechia, iris depigmentation, and a focal anterior cortical cataract were apparent at the temporal iridal margin where the iris and lens had been injured by the viscoelastic needle in case

1. At 4 months postoperatively, significant fibrosis was present at the surgical site of case 3 (PLK) (Fig. 3c) but was located in a smaller area than the DLEK. Case 4 had an area of full-thickness edema present at the nasal surgery site, that was likely due to the bioSISt layers' inability to maintain an effective watertight barrier (Fig. 4d). All 4 horses had comfortable visual eyes within 1 month following surgery and required no long-term medical management. A minimum of 2-year (24 months, range 25–59 months) follow-up is available for all four cases. Corneal fibrosis became much more transparent and the affected areas much smaller. Corneal pigmentation was also reduced over time (Figs 1c, 2d, 2e, 3d, 3e, 4e, and 4f).

DISCUSSION

Standing ophthalmic procedures in the horse have been treated in the past as salvage procedures.[23] Eyelid surgery can be routinely performed, and standing enucleations are becoming more common.[24–28] Improvements in modern sedatives, good microsurgical skills, and attention to patient positioning and restraint allow for a wider range of standing ophthalmic surgical procedures in the horse and provide a viable alternative to general anesthesia.[16,18,21,29] However, these procedures should only be performed by individuals with appropriate ophthalmic microsurgical training. In addition to the necessity for good microsurgical skills, the surgeon must have realistic expectations regarding complications and have the patience and wherewithal to perform the procedure on a standing sedated horse, which is very different when compared to surgeries performed under general anesthesia. Also, a thorough discussion with the horse owner regarding the pros (e.g., avoiding complications associated with general anesthesia) and cons (e.g., inability to use proper microsurgical technique during surgery, movement, etc.) of standing surgery must occur prior to deciding to proceed with surgery.

Detomidine hydrochloride is an alpha-2-adrenergic agonist used commonly in the horse for sedation and analgesia.[30–33] A profound lethargy and characteristic lowering of the head with reduced sensitivity to environmental stimuli (sound, pain, etc.) are seen with detomidine. A short period of reduced coordination/ataxia is characteristically followed by immobility and a firm stance. The use of detomidine has been described for standing surgical procedures in the horse.[21,25,30] The addition of butorphanol tartrate in combination with detomidine is frequently described, but was not administered in these cases due to its propensity to cause unexpected head movements in the horse.[27,30]

The difficulty in maintaining an anterior chamber in a standing horse following full-thickness incision through the cornea is considerable. 2% viscoelastic material still effluxes rapidly through the penetrating surgical wound when the horse's eye is perpendicular to the ground. Collapse of the anterior chamber results in contact of the iris and lens with the corneal endothelium resulting in damage to the iris (incarceration), lens, and corneal endothelium. Fibrin also forms rapidly in the anterior chamber of the horse when the chamber stability is compromised. The longer the iris remains in contact with the cornea, the more difficult it is to break the adhesions that form via the fibrin.

Preplacement of the viscoelastic through a limbal injection has been shown to minimize anterior chamber collapse and protect the intra-ocular structures (iris, lens) during PK using biopsy punches in the horse.[34] This was performed in case 1 and proved to be of no benefit as it effluxed within 5–15 s following entry into the chamber. It also resulted in iris and lens injury. Shortening suturing time of the corneal allograft and achieving a viscoelastic tight seal was the next goal of the surgery. In cases 2–4, this was achieved with the dissection of the 'ledge' keratectomy and partially suturing the graft in place prior to entry into the chamber. In only 1 case (case 3) was there still a problem with prolapse of iridal tissue into the wound. In that case, the proximity of the abscess to the corpora nigra resulted in the tissue prolapse. Both frozen corneal allografts and BioSISt were effectively used and resulted in stable closure of the wound site. BioSISt was chosen over a corneal allograft due to the level of difficulty in dissecting the partial thickness corneal grafts. However, the BioSISt may have been responsible for the prolonged presence of postoperative corneal edema in case 4.

Corneal scarring is typically significant in the horse following corneal injury or surgery.[3,9] Minimizing the resultant surgical scar is another therapeutic goal following successful surgery. In the first two cases, the cornea became fibrotic throughout the area where the superficial lamellar dissection had been performed for the DLEK. This in effect permanently scarred what had been a previous area of normal cornea. Usually, PLKs are indicated for abscesses that are more axial in location. A PLK was performed in cases 3 and 4 in an attempt to minimize the size of the resulting fibrosis.

In conclusion, standing DLEKs and PLKs were successfully performed in four horses with deep corneal stromal abscesses by highly trained ophthalmologists with extensive experience in advanced corneal microsurgery. All four horses had comfortable visual eyes within 1 month following surgery and required no long-term medical management. The surgical modification described allowed for more rapid re-establishment of the anterior chamber and shortened the surgical time. In horses with DSA, where general anesthesia is not an option, modified DLEK and PLK procedures may be considered as an alternative to standing enucleation when performed by trained ophthalmologists with extensive experience in equine ophthalmology.

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