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The use of porcine small intestinal submucosa for the repair of full-thickness corneal defects in dogs, cats and horses

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Abstract

Objective To evaluate the efficacy of using a porcine small intestinal submucosa (SIS) graft covered by a conjunctival flap for the surgical repair of full-thickness corneal wounds in dogs, cats and horses.

Procedure All records dating from August 1999 to February 2003 from Purdue University Veterinary Teaching Hospital of patients that had undergone ophthalmic surgical procedures and received a SIS corneal graft for a full-thickness lesion were reviewed. Fifteen cases were identified including six dogs, two cats and seven horses. Requirements for inclusion in this study were that SIS was used as a corneal graft in a full-thickness corneal defect and that the graft was completely covered with a conjunctival flap.

Results Of the 15 cases, one canine patient had received SIS following removal of an epibulbar melanocytoma. The remaining five canine patients had undergone this surgical procedure for the repair of corneal perforation. The two feline patients had been presented for corneal perforation following chronic ulceration. One equine patient had been presented for a deep melting ulcer, three for stromal corneal abscesses, and three for corneal perforations. Complications encountered postoperatively included aqueous leakage, conjunctival flap dehiscence, synechia, cataract and fibrin in the anterior chamber. Fourteen out of 15 patients were visual at the final re-evaluation.

Conclusion SIS is an inexpensive, easy-to-handle biomaterial that appears to be suitable for the repair of full-thickness corneal wounds in dogs, cats and horses. Results of our study support the conclusion that this relatively new product is an effective alternative to traditional implantation materials utilized in veterinary ophthalmology.

Key Words: cornea, corneal repair, small intestinal submucosa, xenograft

INTRODUCTION

Corneal diseases may progress to threaten globe integrity and vision. Although serious corneal diseases may respond to medical management, a number of patients require surgical intervention. Several surgical procedures have been reported using grafting techniques to preserve corneal integrity, maintain vision, or salvage a globe for cosmetic purposes.[1–8] One of the most commonly used corneal graft materials in veterinary ophthalmology is frozen or fresh corneal tissue.[5] In the past decade, porcine small intestinal submucosa (SIS) has gained popularity and has been used as a natural bioscaffold in many different *in vivo* environments, including the eye. The use of SIS is one of the newer grafting methods used to surgically manage severe corneal disorders. It acts as a scaffold for repair and provides valuable tectonic support. Reports of the use of SIS for ocular grafts include the removal of a limbal melanoma in a canine patient,[9] a case series of cats with corneal disorders,[10] and experimental models of corneal transplantation in rabbits and dogs.[9–14]

Small intestinal submucosa is a biomaterial derived from porcine small intestine. The SIS is composed of three layers: the tunica muscularis mucosa, tunica submucosa, and the stratum compactum layer of the tunica mucosa. It is derived from jejunum from which all the mesenteric tissues, tunica mucosa, serosa and tunica muscularis are mechanically removed using an abrasion technique. Following mechanical debridement, the few remaining resident cells (endothelial cells and fibrocytes) are lyzed with a hypotonic wash leaving a sheet of collagen.[15,16] Stabilization of the SIS is achieved by lyophilization. The remaining tissue is approximately 100 μm thick. Sterilization is achieved with ethylene oxide. The final commercially available products are 10 cm × 7 cm sheets and 10- and 15-mm-diameter round ophthalmic discs (Global

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Veterinary Products Inc., New Buffalo, MI, USA). The tunica muscularis mucosal surface is represented by the 'rough surface', and the stratum compactum surface of the tunica mucosa by the 'smooth surface'.

This retrospective study evaluates the efficacy of using a SIS graft covered by a conjunctival flap for the surgical repair of full-thickness corneal wounds in dogs, cats and horses.

MATERIALS AND METHODS

All medical records from August 1999 to February 2003 of patients that had undergone ophthalmic surgical procedures and received a SIS corneal graft for a full-thickness lesion at Purdue University Veterinary Teaching Hospital were reviewed. Fifteen cases were identified including six dogs, two cats and seven horses. Requirements for inclusion in this study were that SIS was used as a corneal graft and that the graft was covered with a conjunctival flap that completely covered the biomaterial.

Each record was reviewed for the following information: signalment, description and size of the ocular lesion (when available), results of microbial culture and sensitivity, results of histopathology, type of conjunctival flap, postoperative complications, postoperative medical treatments, and time between surgery and resection of the conjunctival flap. Outcome data included corneal integrity and healing, the presence or absence of cataracts, synechiae and pupillary light reflexes. Vision was evaluated by the menace response.

All surgical procedures were performed under general anesthesia. Samples for bacterial and/or fungal cultures were submitted from all but the one patient that was being treated for canine epibulbar melanocytoma. Histopathologic evaluation of excised corneoscleral and corneal tissues were available in one canine and three equine patients, respectively. Corneal perforations and full-thickness lacerations were repaired with SIS in five dogs, two cats and four horses. The standard procedure for these 11 cases included debridement (via keratectomy) of the necrotic and collagenolytic corneal tissue as well as excision of necrotic iridal tissue if present. Anterior synechiae were freed using a cyclodialysis spatula, and viscoelastic material (sodium hyaluronate 1%; Pharmacia & Upjohn Co., Kalamazoo, MI, USA) was then injected into the anterior chamber to reposition the iris and reform the anterior chamber prior to suturing the SIS graft in place. All cases were treated postoperatively with topical and systemic antibiotics and topical atropine. Cats were also treated postoperatively with idoxuridine and dogs were sent home with an Elizabethan collar. Horses were hospitalized and treated additionally with topical antifungals and systemic anti-inflammatories (flunixin meglumine; Fort Dodge Animal Health, Ft Dodge, IA, USA or phenylbutazone; Phoenix Pharmaceuticals, St Joseph, MO, USA).

Corneal stromal abscesses were treated in three equine patients using a penetrating keratoplasty (PK) and placement of SIS into the corneal defect. In two of these horses, purulent, collagenolytic and edematous corneal tissue was removed using a corneal trephine large enough to completely encircle the abscess. The PK in the third patient was performed using a #64 Beaver blade due to the large size of the abscess. A similar procedure was used to treat the canine epibulbar melanocytoma using a limbal penetrating keratoplasty and full-thickness sclerectomy. Viscoelastic material was injected to maintain a formed anterior chamber. The PK was completed by removal of the corneal button using Castroviejo corneal scissors. The excised corneal tissues were submitted for culture and histopathologic evaluation. A SIS graft was sutured into the defect in a manner similar to that utilized for the corneal perforations as described subsequently.

Fixation of SIS graft

After trimming the SIS disc or sheet to obtain a diameter of 1–1.5 mm greater than the corneal defect, the graft was rehydrated in sterile saline for 1 min as recommended by the manufacturer. Four cardinal sutures were placed to affix the graft into the recipient site and a simple interrupted and/or a simple continuous suture pattern using polyglactin 910 (Johnson and Johnson, Somerville, NJ, USA) was used to secure the graft to the cornea. The suture material sizes were 8.0 or 9.0 in dogs and cats, and 7.0 or 8.0 in horses. Figures 1 and 2 show intraoperative photographs following suturing of the SIS onto the corneal defect in a feline and equine patient, respectively. The surgical goal was for the SIS to seal the corneal defect prior to covering with a conjunctival flap. Either an advancement ($n = 1$), bridge ($n = 1$), or rotating pedicle conjunctival graft ($n = 13$) was used to cover the SIS graft. Four cardinal sutures were also used to anchor the conjunctival graft to the cornea, followed by a simple continuous suture pattern. The same suture material was used for the placement of the conjunctival graft as that for suturing the SIS into place.

Follow-up

Dogs and cats were re-evaluated 1 day, 1 week, 2–3 weeks, and 2–5 months post surgery. Horses were hospitalized to allow frequent treatment via a subpalpebral lavage system.[17] One patient (no. 13) was re-evaluated only once, 1 week post operatively, and was lost to follow-up. Resection of the conjunctival flap was performed in a total of nine patients after a minimum of 1.5 months post surgery.

RESULTS

Canine

Patient no. 1 had a history of an epibulbar melanocytoma that had been surgically debulked and treated with a diode laser (Table 1). When the mass recurred, it was treated by full-thickness surgical excision that resulted in a corneoscleral defect of 11 mm × 10 mm. SIS was sutured into the defect and an advancement conjunctival flap was positioned over the graft. Three-and-a-half years post surgery, this patient remained visual and no recurrence was reported by the owner.

Table 1. Signalment and outcome of patients treated with full-thickness SIS grafts

Patient no. & breed	Age & gender	OD/OS	Primary lesion	Bacteriology/ histopathology	Complications	Outcomes	Conjunctival graft resection (months)
1. Golden Retriever	7 years MN	OS	LM extending into cornea (7 × 5 mm)	Epibulbar melanocytoma	None	Visual, No recurrence	NR
2. Pug	2 months M	OS	CP (2.5 mm)	*Pasteurella aeruginosa*, *Staphylococcus intermedius*		Limited vision, AS	4
3. Pekingese	7 years M	OS	CP, KCS	*Streptococcus* group G, *Pasteurella aeruginosa*, *Escherichia coli*		Blind, Severe corneal pigmentation	1 1/2
4. Boston Terrier	3 years M	OS	CP, IP, hyphema (2 × 3 mm)	*Staphylococcus epidermidis*	Distal edge of conjunctival graft dehisced, but did not require second surgery	Visual, AS, Cataract, Vitreous AC, Fibrin in AC,	2
5. Pug	3 years M	OD	CP, KCS, AS Negative menace	No growth	None	Visual, AS	NR
6. Beagle	7 years MN	OS	CL, IP, hyphema	No growth	AH leakage for 48 h, required 2nd procedure along with 2nd layer of SIS and reposition of conjunctival graft	Visual, Corneal edema, Fibrin on ALC	NR
7. DSH	13 years FS	OD	CP	No growth	Conjunctival graft dehisced and SIS laceration. 2nd surgery to reposition the conjunctival graft at 1-week recheck	Visual	3 1/2
8. DSH	16 years MN	OD	CP (5 × 4 mm) Purulent corneal infiltrate	No growth	Fibrin in AC at 1-week recheck. TPA injection was required	Visual, AS, Negative PLR, Negative for virus	2
9. Quarter horse	1 year F	OD	Melting ulcer 5 mm in diameter	No growth. Histology: suppurative keratitis	Fibrin in AC 1 week post op. TPA injection was required	Visual, PS, Fibrin on ALC, TPA 1 week post op	2
10. Thorough-bred	9 years MN	OD	SA	No growth. Histology: neutrophilic/lymphocytic keratitis GMS stain: negative for fungal organism	Chronic uveitis (7 week post op) Hyphema Corneal ulcer due to subpalpebral lavage system	Visual, AS	NR
11. Quarter horse	16 years F	OD	SA 15 × 10 mm	*Burkholderia cepacia*, *Staphylococcus epidermidis*, *Morganella morganii*, *Corynebacterium* sp. Histology: mycotic keratitis	AH leakage at 3-week recheck. Excessive granulation tissue around and under conjunctival graft. Linear retinal detachment (folds). Fibrin in AC	Visual, PS, Cataract	6
12. Quarter horse	18 years F	OD	SA	No growth. Histology: suppurative keratitis	None	Visual, PS	2
13. Tennessee Walker	3 weeks F	OS	CP (5 mm), IP, ulcer (10 mm)	No growth	None	Visual	NR
14. Quarter horse	10 years F	OS	CP, foreign body, IP, hypopyon	AH: *Bacillus licheniformis* Cornea: gram + coccus	AH leakage for 48 h	Visual, AS, Cataract	2
15. Quarter horse	14 years F	OD	CP, IP	α-hemolytic *Streptococcus* sp.	AH leakage for 48 h. Superficial corneal ulcer 1 week post op	Visual, AS/PS, Cataract, Negative PLR, Fibrin	2

M, male; N, neutered; F, female; S, spayed; OD, right eye; OS, left eye; AS, anterior synechia; PS, posterior synechia; CL, corneal laceration; CP, corneal perforation; IP, iris prolapse; LM, limbal mass; AH, aqueous humor; SA, stromal abscess; GMS, Gomori's methenamine silver; ALC, anterior lens capsule; NR, no resection; AC, anterior chamber; KCS, keratoconjunctivitis sicca; TPA, tissue plasminogen activator; PLR, pupillary light response.

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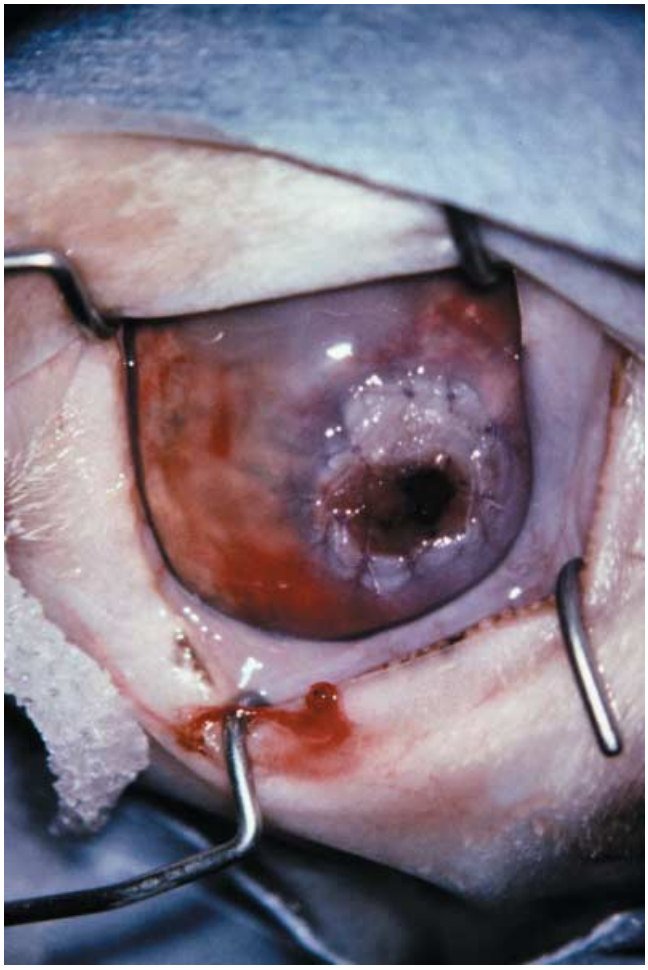

Figure 1. Intraoperative photograph of feline patient no. 8 with SIS sutured into the corneal defect. Simple interrupted corneal sutures have been placed and the cornea is sealed.

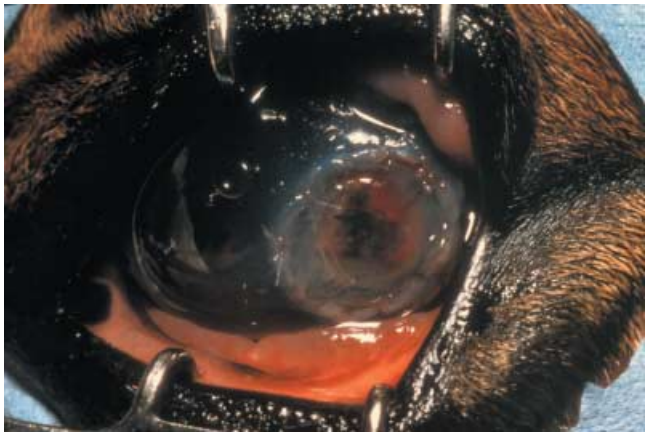

Figure 2. Intraoperative photograph of equine patient no. 13 following suturing of the SIS graft into a much larger defect.

Five canine patients (nos 2–6) received SIS grafts to repair a corneal perforation. Two of these had an iris prolapse and three had positive bacterial cultures. One or more species of bacteria were isolated from corneal samples in four dogs

Figure 3. Photograph (a) shows anterior synechia 1 month after conjunctival resection in feline patient no. 8. Photograph (b) shows the axial corneal leukoma.

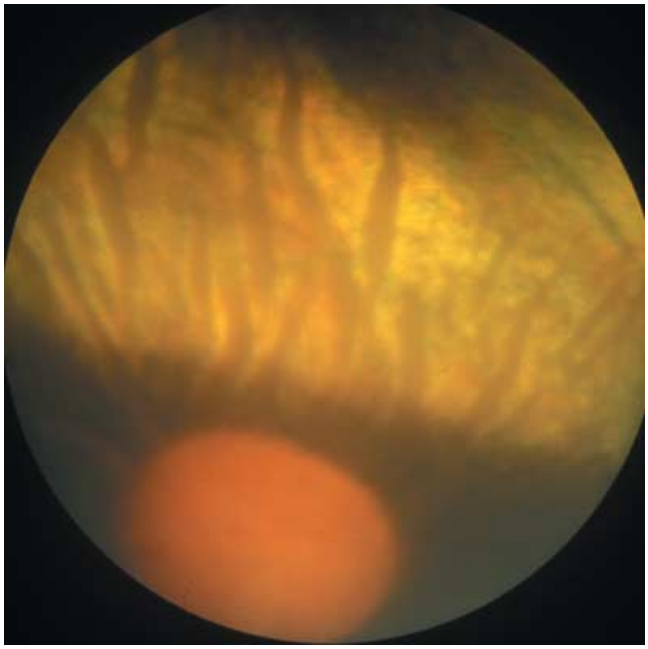

Figure 4. Fundus photograph taken 6 weeks following penetrating keratoplasty from equine patient no. 11. Multiple linear streaks radiating out from the optic nerve head and areas of hyper-reflectivity can be appreciated secondary to probable previous detachment.

(Table 1). Despite efforts to break down anterior synechia at the time of surgery, these adhesions reformed in three of five patients postoperatively. Patient no. 2 had extensive anterior synechia and limited vision. Following resection of the conjunctival graft vision improved (as assessed by using menace responses from various visual fields). Patient no. 3 was blind due to excessive corneal pigmentation secondary to KCS and anterior synechia. Patient no. 5 was blind on presentation and regained vision following resection of the conjunctival flap.

All canine patients with corneal perforations received a conjunctival rotating pedicle flap.

At the 1-week recheck examination of patient no. 4, the distal edge of the conjunctival flap had dehisced (Table 1). The SIS material was slightly exposed but no enhancement procedure was required. Patient no. 6 required a second procedure due to aqueous leakage for a period of 48 h after surgery. A second SIS layer was sutured over the initial graft and the pedicle conjunctival flap was reapposed over the double layer of SIS graft.

The conjunctival flap was trimmed in three of six patients by resecting the base at an average of 2.5 months after surgery. Trimming the flap decreased the size of the corneal leukoma. The advancement flap was not amenable to resection. At of the time of submission of this article, the conjunctival flap of patient no. 6 had not yet been resected. The results of the canine cases are summarized as no. 1 to no. 6 in Table 1.

Feline

Two feline patients (nos 7 and 8) were presented for corneal perforation following 1-week histories of deep corneal ulcerations. Neither of the patients had a positive bacterial culture from their cornea, but both were on topical antibiotics upon presentation. Polymerase chain reaction (PCR) testing for feline herpesvirus was negative for patient no. 8. A PCR test performed on a corneal swab from a superficial ulcer in the contralateral eye was also negative. The conjunctival flap of patient no. 7 had dehisced at the 2-week recheck examination and was surgically replaced. A tear was noted in the SIS layer; however, a second layer of SIS was not used. At the 1-week recheck, patient no. 8 had a moderate amount of fibrin in the anterior chamber and, consequently, tissue plasminogen activator (TPA; Genentech, South San Francisco, CA, USA) was injected into the anterior chamber. Both patients remained visual but patient no. 8 had a negative PLR due to anterior synechia. The conjunctival flaps were trimmed at 3.5 and 2 months after surgery for patient no. 7 and no. 8, respectively. Figure 3 (a, b) shows the anterior synechia and corneal leukoma 1 month following resection of the conjunctival graft.

Equine

Equine patients (nos 9–15) were presented for a melting corneal ulcer, stromal abscesses, and corneal perforations (Table 1). Patient no. 9 was initially diagnosed with a 5-mm diameter melting corneal ulcer. Bacterial and fungal culture results were negative and histopathology confirmed a suppurative keratitis. A 7-mm trephine was used to perform a PK. One week after surgery, TPA was injected into the anterior chamber to remove a fibrin clot. Patient nos 10, 11 and 12 were presented with corneal stromal abscesses. Only patient no. 11 had a positive bacterial culture. Fungal cultures were negative in all horses. Histopathologic findings on corneal tissue from these three patients included lympho-neutrophilic keratitis in patient no. 10, severe fungal keratitis in patient no. 11, and suppurative keratitis in patient no. 12.

Patient no. 10 developed hyphema after the surgery and a corneal ulcer secondary to the subpalpebral lavage system. Mild signs of uveitis were still noted in this patient 7 weeks postoperatively. Patient no. 11 was the only patient to receive a bridge conjunctival flap over the SIS graft. All other patients were treated with pedicle flaps. Patient no. 11 had aqueous humor leakage 3.5 weeks after surgery that was not present 1 week earlier at discharge. A second surgery was not performed as the leakage stopped spontaneously and the anterior chamber reformed. The bridge graft in this patient became very thick from granulation tissue. All three patients with corneal stromal abscesses were visual postoperatively; however, all had some synechiae. A total of six horses had either posterior or anterior synechia, and three of them had a cataract. Only patient no. 15 had a negative pupillary light response in the operated eye.

The three remaining equine patients (nos 13–15) had corneal perforations and iris prolapse at the time of presentation. A corneal foreign body and hypopyon were also noted in patient no. 14. In addition, this horse had positive bacterial cultures from the aqueous humor and cornea (Table 1). Patient no. 15 also had a bacterial keratitis (Table 1). Two of the three patients that underwent surgery for corneal perforation had minor aqueous leakage for 48 h postoperatively but neither of them required a second procedure. While hospitalized, patient no. 15 was the second horse in this study to develop a superficial corneal ulcer but no cause was found and it healed without complications. All equine patients were visual at their last recheck which was at least 2 months post surgery except for patient no. 13 which was lost to follow-up after the 1-week recheck examination.

Three out of seven horses had aqueous leakage. Two of them started to leak following surgical recovery and the remaining one approximately 3 weeks after surgery (patient no. 11). Fundic examination of this same patient 6 weeks postoperatively displayed signs of retinal scarring and vitreal degeneration. The retinal lesions appeared as multiple linear streaks radiating out from the optic nerve head and were possibly thought to be from a previous retinal detachment (Fig. 4). A panuveitis following the surgical procedure and/or intra and post surgical hypotony were suspected as causes of these lesions, as the retina had been examined before surgery and had been normal.

DISCUSSION

Corneal repairs have been achieved using various surgical techniques and graft materials.[1–6,18–25] This retrospective study

reports the successful use of SIS to repair full-thickness lesions from infected corneal ulcers, corneal abscesses and corneal perforations in cats, dogs and horses. Success was defined as complete corneal repair, integrity, and the presence of vision at the last re-evaluation. All patients' corneas were repaired and 14 of 15 (93%) were visual. The success rate reported in this study is similar to that achieved with other graft techniques. Two reports on the use of frozen corneal grafts resulted in vision in 84% and 100% of dogs and cats, respectively.[6,20] Whittaker *et al*. reported 100% of patients with vision following penetrating keratoplasty for deep corneal stromal abscesses in eight horses.[25] This is similar to our results, where all but one of our patients were visual at their last re-evaluation.

Complications in these patients included aqueous leakage, conjunctival graft dehiscence, synechia, cataracts, and fibrin in the anterior chamber. These complications were similar to those reported in other studies on corneal surgery in clinical patients.[10,25] Aqueous leakage may be seen following inadequate number or inappropriate suture placement. Conjunctival flap dehiscence from self-trauma, uncontrolled infections or excessive restraint during application of medications may also be responsible for leakage. Two patients required a second procedure to seal the leak by resuturing the edge of the conjunctival flap. Both of these patients, despite this complication, remained visual. None of the horses with aqueous leakage immediately after surgery required a second procedure, as their defects sealed spontaneously after approximately 48 h. In Featherstone's report regarding the use of SIS in feline corneas, one cat underwent enucleation due to progression of keratomalacia and a second cat needed an enhancement procedure (conjunctival flap), to seal the aqueous humor leakage.[10] Anterior synechia may occur secondary to aqueous humor leakage and/or pre or post-surgical uveitis. Anterior uveitis is the main cause of posterior synechia, cataract and fibrin formation.[26]

The complications encountered in equine patients with stromal abscesses were similar to those reported by Whittaker *et al*. with penetrating keratoplasty for stromal abscesses.[25] The most common postoperative sequela in our study was the presence of synechia in six horses. This was seen in all of our stromal abscess patients ($n = 3$). The most common complication in the Whittaker series was also synechia but was seen in only three out of eight cases. Subcapsular cataracts also developed in all three of our stromal abscess patients.

All the patients included in this study received a conjunctival graft over the SIS graft. The main advantages to covering SIS with conjunctiva are providing more structural support and bringing a readily available blood supply to a compromised cornea.[24] Vascular grafts offer significant antimicrobial and anticollagenase activities that help control bacterial infections and corneal liquefaction.[19,27] In Featherstone's study, only one patient received a conjunctival graft at the initial surgery and a second one 72 h after the initial procedure due to aqueous humor leakage around the SIS.[10] Conjunctival grafts will, in many patients, help to seal the corneal-graft defect by contributing to the deposition of fibrin, and by bringing in fibroblasts and collagen. The main disadvantage of conjunctival grafts is the residual corneal leukoma that can impair vision, especially when located axially. This disadvantage can be minimized by trimming the graft pedicle 3–4 weeks postoperatively or once the corneal condition has healed.[5]

Other techniques that produce less scarring have been described to treat full-thickness corneal lesions. The use of a corneal-scleral-conjunctival transposition minimizes the axial corneal opacity as healthy adjacent partial thickness cornea is utilized for the repair.[4,5] This technique creates a peripheral corneal leukoma caused by transposing the limbus and conjunctiva into the cornea. Due to the autologous nature of the graft, no rejection is observed. More advanced surgical skills are required to perform this technique; however, no postoperative trimming of the conjunctival base is necessary because it becomes incorporated into the corneal stroma. Compared to the use of SIS, the main limitation is that a corneal-scleral-conjunctival transposition cannot be used for large corneal defects because of the need for healthy surrounding cornea to serve as the autologous graft.[5,6] Lamellar keratoplasty, in which the anterior stroma and epithelium are removed, may be repaired with autologous, homologous, xenologous and biomaterial grafts.[5,9,10,28] In feline patients the graft may transmit viral infections such as feline leukemia.[5,29] Penetrating keratoplasty involves removal of a full-thickness corneal button that is replaced by either donor corneal tissue or other types of bioscaffolds such as SIS.[10,20,25] This technique has the advantage of providing good support and translucency if not used in conjunction with a conjunctival graft. Freshly harvested corneas are more commonly used in human penetrating keratoplasty in order to obtain maximal corneal clarity. In veterinary medicine, fresh and frozen grafts are used, but the latter is more practical due to a readily available frozen corneal bank. Frozen corneal grafts offer good support for small and large defects as well as some visual potential. However, a scarred and vascularized cornea usually results due to graft rejection and the absence of viable endothelial cells.[20]

As shown in this retrospective study, SIS represents a good alternative for graft material. This collagen-based material has the advantage of being cost effective, commercially available, and easy to handle. When compared to fresh or frozen corneal grafts, SIS is very easy to store because it comes in individual packages, including ophthalmic discs that can be opened separately. The manufacturer ensures that the product is sterile and free of pathogens, thereby eliminating the risks of disease transmission.

Small intestinal submucosa is primarily protein with secondary carbohydrates and lipids. This natural biomaterial retains the natural composition of matrix molecules such as collagen (type I, III and VI), glycoaminoglycans (hyaluronic acid, chondroitin sulfate A and B, heparin, and heparan sulfate), proteoglycans, and glycoproteins (fibronectin), which are known to have important roles in host tissue repair and

remodeling.[15,16,30–32] Growth factors known to influence tissue development and differentiation such as fibroblast growth factor (FGF-2) and transforming growth factor β (TGF-β) have been identified in SIS and probably influence the mechanisms by which this biomaterial modulates wound healing and tissue remodeling.[15] Small intestinal submucosa is capable of inducing host tissue proliferation, remodeling, and regeneration of tissue structures following implantation in the lower urinary tract, body wall, tendons, ligaments and blood vessels.[15,16,33–36] Badylak *et al*. reported that, following implantation, cellular infiltration and rapid neovascularization are observed. The SIS extracellular matrix is remodeled into host tissue with the specific structural and functional properties of the host tissue.[16] A veterinary ophthalmology report describing the preliminary evaluation of the biocompatibility of SIS in rabbit cornea suggests that SIS is incorporated into corneal tissue during the healing process.[13] After 15 days, remodeling of SIS in rabbit cornea resulted in a relatively clear corneal stroma leaving only moderate amounts of scar tissue. Moreover, re-epithelization occurred after 7 days and by 14 days after lamellar corneal transplantation with SIS in rabbits and dogs, respectively.[11,13] Epithelization of SIS was thought to occur because its collagenous nature mimics the stromal surface.

Small intestinal submucosa was reported to be resistant to persistent infection with *Staphylococcus aureus* in arterial autografts when compared to polytetrafluoroethylene arterial prostheses.[37] There are no studies that report how SIS tolerates infection in the cornea. One cat in Featherstone's study was enucleated 48 h post surgery due to progressive keratomalacia, and histopathology of the globe showed an intact SIS graft within a malacic cornea but the presence of an infectious agent was not reported.[10] Although SIS appears resistant to anticollagenase activity, a surrounding healthy cornea is still required to support the graft material. Neovascularization of the cornea following implantation of SIS is probably due to the surgery, initial traumatic event, and to corneal repair rather than an immune rejection. Many publications report that SIS does not appear to stimulate cellular immune rejection in animal models.[16,38,39]

SIS is a relatively inexpensive, easy-to-handle biomaterial that appears to be suitable for the repair of full-thickness corneal wounds in dogs, cats and horses. Results of our study support the conclusion that this relatively new product is a safe and effective alternative to traditional implantation materials utilized in veterinary ophthalmology.

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