Incidence, Treatment, Outcome And Complications Of Racing-related Corneal Injuries In Thoroughbred Horses

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Abbreviations:
RREI - Racing related eye injuries

ABSTRACT

OBJECTIVES: To describe the incidence and range of racing related corneal injuries, determine the prevalence of complicated healing post ulceration, identify risk factors for delayed healing, and determine time until re-epithelialisation, return to racing and whether visual or not.

METHODS: All runners sustaining racing related eye injuries (RREI) over a 31-month period were included retrospectively or prospectively. For each runner, signalment, racing surface, delay until initial examination, ocular findings, treatment, clinical outcome, and interval until the next race were recorded. Data were analyzed using logistic regression to perform univariate and multivariate analysis.
Results: Corneal ulceration was the predominant racing-related eye injury, occurring in 295 of 304 eyes (97.0%) in 287 runners. Most ulcers (269 of 295, 91.1%) were initially classified as simple and in 243 of these eyes (90.3%) the defect healed within days with medical treatment. In 26 eyes (9.7%) a complication developed that required >7d medical treatment or surgical treatment despite initial routine therapy. In an additional 26 eyes of 25 runners, complicated corneal ulceration was present initially. For complicated ulcers, presumptive diagnoses included bacterial keratitis, keratomycosis, stromal abscess, keratomalacia, and delayed corneal healing. Risk factors for complications included a delay until treatment beyond 24 hours, stromal involvement and greater initial ulcer diameter. Horses with complications returned to racing a mean 52.1 d after injury with no reported visual deficits.

CONCLUSIONS: Prophylactic treatment for corneal ulcers should be initiated rapidly. Frequent monitoring of even simple ulcers is recommended because 9.7% developed complications despite routine initial therapy.

INTRODUCTION

In an earlier study, racing-related eye injuries (RREI) were reported relatively frequently (in 2.1% of runners) at Singapore Racecourse, particularly before a revised turf management program was

introduced (Steel and Robertson 2007). Despite early initiation of treatment in most cases, some horses developed complicated corneal ulcers that required prolonged medical treatment with or without surgical intervention, prompting us to consider risk factors for complications or delayed corneal healing. We assume that most RREI are caused by trauma from airborne sand or dirt as 'kick back' from the racing surface, although trauma in the barrier or from a whip during racing is possible. The risk of sustaining a RREI is significantly greater on a turf than on a fibre-sand racing surface, and, as expected, these injuries are more prevalent under conditions when more divot damage would be expected, including when the track condition is rated yielding or soft, with increasing field size and with races later in the day (Steel and Robertson 2007).

All horses that race at Singapore Racecourse are housed on site under the care of Singapore Turf Club veterinarians, and corneal injuries are often seen when still simple or uncomplicated. This offered a unique opportunity to determine the incidence of complicated corneal healing in this population, and the progress and outcome of a large number of corneal injuries that included cases in which complications developed despite routine treatment.

We hypothesized that corneal defects were more likely to become complicated if treatment was not initiated within 24 hours or if the corneal stroma was involved. In addition, we were interested in determining whether the occurrence of infectious keratitis was higher when corneal injury was sustained on the turf track because of its increased organic matter content compared to the fibre-sand track.

The purposes of the current study were to describe the relative frequency and nature of various RREI, the frequency of complicated healing of corneal defects sustained during racing, and to identify any factors that increased complication rate of injures. We also aimed to determine the outcome in terms of time until corneal re-epithelialization and return to racing and whether visual or not for horses with corneal defects sustained during racing.

PROCEDURES

Animals

All runners that sustained a RREI at Singapore Racecourse between 1 May 2002 and 1 December 2004 were included in the study. A runner was excluded from the study if there was reasonable doubt that the injury had been sustained during racing. Most horses had multiple race starts during the period of study, and consequently we refer to runners rather than horses. It was possible that an individual horse could sustain an eye injury on more than one occasion during the study and thus be represented as more than 1 runner.

Data retrieval

As a retrospective study, the medical records from 1 May 2002 through 28 February 2004 were searched for horses with RREI and from 1 March 2004 until 1 December 2004 data was recorded prospectively. Data collected included the horse's Malayan Racing Association registration number, the date of presentation, eye(s) affected (left, right or both), the size and depth of any corneal defect, the presence of any complications at initial examination, the probable cause of the initial trauma (barrier incident, whip injury or 'kick back' injury), treatment protocol and duration, complications encountered during treatment and the outcome (vision present, number of days until corneal re-epithelialisation and number of days until return to racing). The date of racing when the injury was sustained, the track surface (turf or fibre-sand) and the date of the next race after injury were obtained from the Trackform race summaries published by the Malayan Racing Association.

Examination methods

At the initial examination horses were restrained, the eyes were inspected from a distance and the menace and palpebral reflexes were assessed. Sedation and/or an auriculopalpebral nerve block were used subsequently if necessary to facilitate examination (Manning and St.Clair 1976). Inspection of the anterior and posterior segment structures was performed with focal illumination and a direct monocular ophthalmoscope. The cornea was then re-examined following the application of

fluorescein dye. Horses were examined daily or on alternate days until corneal healing was advanced, as determined by absence of ocular pain and fluorescein uptake within the ulcer bed. In some cases, mainly dependent on the veterinarian's preference, if the ulcer was malacic or appeared infected (Maggs 2003a), samples for bacterial isolation were obtained prior to the application of topical anaesthetic using sterile culture swabs that were later inoculated onto 5% sheep blood agar plates and cultured at 35°C under aerobic conditions. Kirby-Bauer disc diffusion method sensitivity tests were used and antimicrobials included bacitracin, ampicillin, gentamicin, chloramphenicol, polymixin B, tobramycin and enrofloxacin. Samples of affected cornea were collected for microscopic examination following the application of topical anaesthetic (Alcaine® 0.5%, Alcon Inc., Forth Worth, TX, USA) or under general anaesthesia using the handle-end of a sterile scalpel blade and slides were prepared that were later stained using Gram's stain and a Diff-Quik method.

Description of corneal defects

Corneal ulcers were classified based on the extent of the lesion and the presence of complications. Ulcers that were superficial, non-infected and present for 7 days or less were described as simple, and those that were present for longer than 7 days, had oedema, were melting, deep or appeared infected were classified as complicated (Maggs 2003a).

In the later, prospective part of the study the diameter was measured and the depth of the ulcer was estimated using transillumination from multiple viewing angles and after consideration of the fluorescein staining pattern, the extent of stromal oedema surrounding the ulcer and the degree of pain (Maggs 2003a). The diameter of the ulcer was classified as 2 mm or less, greater than 2 but less than 5 mm, or 5 mm or greater, and the depth of the corneal injury as superficial (involving the epithelium +/- superficial stroma), moderate (at least one third but less than two thirds depth of stroma) or deep (at least two thirds stromal depth). If more than 1 ulcer was present, the most extensive corneal defect was described.

Treatment of simple ulcers

In cases with simple ulceration, therapy involved the topical application of triple antibiotic ointment containing neomycin sulfate, polymixin B sulfate and bacitracin zinc, (Tricin® , Jurox Pty Ltd, Rutherford, NSW, Australia) 3 or 4 times daily until corneal re-epthelialisation was complete. When topical mydriatic/cyclopegic (1% atropine sulfate ophthalmic solution, Optopics Laboratories Corp., Fairton, NJ, USA) was used, it was either applied only once at the time of initial examination, or 2 or 3 times daily, with tapering of dose frequency as adequate mydriasis was achieved. Systemic anti-inflammatory medications administered included flunixin meglumine (Finadyne®, Heriot AgVet Pty. Ltd., Rowville, VIC, Australia; 0.5-1.0 mg/kg intravenously once daily for 1-5 days), phenylbutazone (Butasyl®, Novartis Animal Health Australasia Pty. Ltd., NSW, Australia; 2.2-4.4 mg/kg intravenously once daily for 1-3 d) or ketoprofen (Ketofen 10%®, Merial Animal Health Ltd., Harlow, Essex, UK; 2.2 mg/kg intravenously once daily for 1-3 d).

Treatment of complicated ulcers

In all cases of complicated ulceration, topical atropine (2 or 3 times daily, with tapering of dose frequency as mydriasis was achieved) and systemic flunixin meglumine (0.5-1.0 mg/kg intravenously once daily) were administered. Treatment of keratomalacia also included topical application of triple antibiotic (Tricin® , Jurox Pty Ltd, Rutherford, NSW, Australia), and either gentamicin (Gentacip® Alcon Inc., Forth Worth, TX, USA), tobramycin (Tobrex® Alcon Inc., Forth Worth, TX, USA) or ciprofloxacin (Ciloxan® Alcon Inc., Forth Worth, TX, USA) 4 to 8 times daily. In some cases, particularly later in the study, autogenous serum was also used topically (undiluted, 4 times daily). If stromal abscessation was diagnosed, treatment also included topical chloramphenicol (0.5% Chloroptic Ophthalmic solution, Allergan America, Hormigueros, PR) 4 to 8 times daily. Cases of confirmed or suspected keratomycosis were treated with 5% natamycin (Natacyn® Alcon Inc., Forth Worth, TX, USA) topically 4 times

daily in addition to topical antibiotic therapy. In selected cases with superficial keratomalacia, débridement was performed using a sterile cotton-tipped swab following application of topical anaesthetic. If an ulcer appeared non-infected, superficial, with a rim of redundant non-adherent epithelium that débrided easily, a grid keratectomy was performed as described elsewhere (Maggs 2003a). In all cases of complicated ulceration, therapy was modified depending upon the clinical response and laboratory results.

A conjunctival graft was surgically placed if an ulcer was initially deep, became progressively deeper or was "melting" rapidly, if a descemetocele or small corneal perforation was present, or in certain other cases not responding well to medical treatment. Surgery to apply a bulbar conjunctival graft was performed under general anaesthesia. The eye was prepared for surgery and the ulcer bed was débrided as described elsewhere (Maggs 2003a). A rotational pedicle flap, advancement flap (for peripheral lesions) or island graft (for a central lesion) was carefully harvested from the bulbar conjunctiva and sutured in place using 7-0 polyglactin 910 (Vicryl, Ethicon, Inc., Sommerville, NJ, USA) in a simple interrupted pattern. Débrided material from the ulcer was submitted for bacterial culture and microscopic examination. In the event of a small (<2 mm diameter) corneal perforation and iris prolapse, the prolapsed iris tissue was excised if it had been prolapsed for more than 24 hr, the margins of the corneal defect were sharply débrided and sutured to the conjunctival graft with 7-0 vicryl using a simple interrupted pattern. Immediately before placement of the last suture the anterior chamber was re-inflated with 2 ml sodium hyonate (Hyonate® Bayer Corp., Shawnee Mission, KS, USA).

To facilitate treatment in cases that were difficult to medicate, and for treatment following conjunctival graft surgery, a single entry silicon subpalpebral lavage system (Cook Australia, Eight Mile Plains, QLD, Australia) was placed either through the upper lid under sedation and local anaesthesia or under general anaesthesia (Severin 1998), or in the lateral aspect of the lower lid during general anaesthesia.

If prevention of self-trauma was required, a hood with an eye cup or protectors (Pelling Pacifiers, The Finish Line of Oklahoma, Inc., Claremore, OK, USA) were used, and if reduction of light to the eye was required, tape was applied over the goggle of the pacifier covering the affected eye.

After surgery, or with medical treatment, the degree of blepharospasm, intensity of corneal vascularisation and the ease of maintaining mydriasis were assessed to determine the duration of treatment. Medication was gradually reduced as these parameters improved.

On conclusion of treatment, vision in the affected eye was assessed by menace response directed from each quadrant and the cosmetic appearance of the eye was noted.

Data analysis

Data were entered into a spreadsheet and statistical analysis was performed using SPSS 12.0.1 for Windows. The effect of each variable on whether corneal healing was simple or complicated was determined. Discrete data were analyzed with a chi-square test for independence and odds ratios and their 95% confidence intervals calculated. An ANOVA was used in the analysis of continuous data.

RESULTS

During the 31-month study period, a RREI was reported in 287 runners, of which 278 runners (96.9%) had corneal ulceration. RREI occurred in a total of 237 horses on 1 (198 horses), 2 (30 horses) 3 (7 horses) or 4 occasions (2 horses).

In 147 runners the right eye only was affected (51.2 % of affected runners), in 119 the left eye only was affected (41.5 % of affected runners), and in 4 runners with unilateral ulceration the eye affected was not specified in the medical record. Corneal ulceration occurred in both eyes in 17 runners (5.9 % of affected runners), giving a total of 304 eyes injured of which corneal ulceration

was diagnosed in 295 eyes (97.0%) and in the remaining 9 runners there was evidence of ocular trauma without ulceration.

In 1 case a fracture of the zygomatic process of the frontal bone and corneal ulceration was diagnosed after racing. The horse was reported to have reared in the barrier and that incident was reported as the cause of trauma. One horse had an obvious whip welt across the upper eyelid, and in the remaining cases, 'kick back' injury was considered the most likely cause of the trauma.

At the initial examination of the 295 eyes with ulceration, aside from fracture of the zygomatic process of the frontal bone in 1 case, additional findings included eyelid swelling (7 cases) and chemosis (2 cases) with or without corneal oedema. Abnormalities of the posterior segment were not identified. In 1 case, anterior uveitis was described as severe at initial examination and in all other cases slight to moderate blepharospasm, photophobia, miosis and epiphora were present consistent with mild to moderate uveitis.

There was a single corneal ulcer in 279 eyes and 2 or more corneal ulcers in 16 eyes. In 269 eyes a simple corneal ulcer was evident and examination was performed within 24 hr of racing in all but 6 of these runners. In 26 eyes of 25 runners, complicated ulceration was evident at initial examination: in 12 eyes of 11 runners there was moderate to severe keratomalacia, in 9 eyes there was mild keratomalacia evident as loss of stromal integrity resulting in a tear-drop shaped mass of cornea at the lowest aspect of the ulcer and in 5 eyes the ulcer bed and surrounding cornea was cloudy or opaque and infection was suspected. In these complicated cases, initial examination occurred within 24 h of racing (17 runners), 24-48 h after racing (3 runners), 48-72 h (3 runners), 72-96 h (1 runner) or 96-120 h after racing (1 runner).

Corneal ulcers remained simple and healed uneventfully within 7 d in 228 runners (243 eyes, 90.3%). Of these, treatment was initiated within 24 h after racing in 222 cases and between 24-48 h after racing in 6 cases. The use of atropine varied with veterinarian's preference, and its application was reported in 108 runners. The use and choice of systemic anti-inflammatory medication also varied, with flunixin meglumine, phenylbutazone or ketoprofen given in all but 2 cases.

Twenty-six eyes (9.7%) in 25 runners that had a simple corneal defect when treatment was initiated developed a complication to corneal healing. In these cases, complications included keratomalacia (15 eyes in 14 cases, of which 1 later also developed a corneal abscess, 1 later also developed fungal keratitis and 1 case progressed to a decemetocoele and subsequently corneal perforation), corneal opacity (6 eyes, of which 2 were suspect bacterial keratitis, 2 were suspect fungal keratitis and 2 were diagnosed as a corneal abscess) and idiopathic, delayed corneal healing (5 eyes). Of these, treatment was initiated within 24 h of racing in 21 runners, between 24-48 h after racing in 2 runners and between 72-96 h after racing in 2 runners.

There were a total of 52 eyes in 50 runners with complicated corneal ulcers that either were present at initial examination or developed despite first-line prophylactic treatment for simple ulceration (table 2). Of these, a conjunctival graft was performed in 15 eyes of 14 runners and the remaining 37 eyes were managed by medical therapy alone, with or without débridement of the ulcer bed on one or more occasions. Initial examination was delayed longer after racing for horses that had or developed a complicated lesion (mean 1.6 days, SD 0.14) than for those with simple ulcerations (mean 1.0 day, SD 0.2) ($P<0.001$).

There was no significant difference ($P=0.32$) between the mean age of runners with complications (4.3 years, SD 1.1) and those without complications to corneal healing (4.5 years, SD 1.1). Furthermore, there was no significant difference in the percentage of runners with complicated corneal healing in the different gender groups ($P=0.97$) or between runners racing on the different track surfaces ($P = 0.40$). Excluding the 4 cases in which the eye affected was not recorded, complications to corneal

healing were recorded in 46 of 266 unilateral cases (17.3 %) compared to 4 of 17 bilateral cases (23.5 %).

Effect of lesion size and depth

The diameter was measured and the depth of the ulcer was estimated in 36 runners (Table 1). Ulcers that were moderate to deep at initial examination were significantly more likely to develop complications (61.5%) than ulcers that were initially superficial (13.0%) ($P < 0.01$). Ulcers that developed complications to healing had a wider diameter (mean 3.7 mm, SD 1.3) than ulcers that did not develop a complication (mean 2.2 mm, SD 0.7) ($P < 0.001$).

Bacterial culture was positive in only 2 of 20 corneal defects from which samples were obtained. In both cases the organisms isolated were sensitive to all antimicrobials but bacterial identification was not performed. Microscopic examination of corneal scrapings from 18 eyes revealed fungal hyphae in 1 case and in the other cases a causative organism was not identified. Cytologic findings were not described.

Of the 31 eyes with keratomalacia, a conjunctival graft was performed to treat 13 eyes from 12 runners on average 8.7 days (range 4-17 d) after the initial presentation. In the cases managed without grafting, treatment was continued until fluorescein uptake was negative at a mean of 15.8 d (range 10-24 d), and in those grafted, treatment continued for a mean 21.2 d after surgery (range 14-32 d) and 28.7 d (range 21-49 d) after initial presentation.

Keratomycosis was diagnosed based on microscopic findings in 1 case and was suspected based on the presence of a chronic non-responsive ulcer with feathery perilesional infiltrates in the cornea in an additional 3 eyes (Mathews 1997). In 2 runners, a conjunctival graft was performed (on day 35 and day 46) and treatment continued for 21 and 12 d after surgery respectively. In the 2 cases managed without grafting, treatment was discontinued at 19 and 20 d.

In 2 eyes in which stromal abscessation occurred as a complication of corneal ulceration, healing occurred with medical therapy that continued for 13 and 30 d respectively.

In the remaining 14 eyes, healing was delayed more than 7 d but there was no apparent underlying cause. In some cases the cornea surrounding the ulcer appeared cloudy but translucent and in others there was a lip of undermined epithelium and a relatively transparent cornea. All cases healed with medical management and grid keratectomy within an average of 13.1 days (range 10-16 d).

A rotational pedicle (12 eyes), advancement (2 eyes) or island (1 eye with central ulceration) conjunctival graft was performed in 15 eyes from 14 runners (14 individual horses). A subpalpebral lavage system was used in all eyes that had a conjuctival graft, and in 4 runners that were treated medically and was removed after 5 to 31 d (median 12 d). Following healing, the pedicle flap was excised in 1 case.

Complications reported following surgery included minor dehiscence of the graft in 6 eyes (31.6%) and loss of skin sutures resulting in migration of the lavage system foot-plate from the superior conjunctival fornix and secondary ulceration of the cornea (3 eyes). In an additional 3 runners, loss of skin sutures occurred and although resuturing of the tabs to the horse's head was required the tube did not slip. In 1 case presenting with eyelid swelling the footplate of the catheter was found to have pulled back to a subconjunctival site. Using ultrasound guidance, a small incision was made through the upper eyelid and the lavage system was removed. An anterior synechia persisted in the eye treated for iris prolapse.

OUTCOME

Vision, as determined by intact menace response, was preserved and the result was a pain-free globe in all injured eyes. Focal loss of corneal transparency occurred after healing of stromal defects. Minor conjunctival graft dehiscence and complications associated with ocular lavage catheter use did not preclude successful outcome. All but 10 horses raced again following treatment for RREI. Trainers

reported that these 10 horses were either exported to race elsewhere, or were retired from race training for reasons other than ocular problems. Runners with complicated corneal ulcers returned to racing significantly later (52.1 d, SD 54.6) than those without complications (mean 31.2 d, SD 34.6) ($P < 0.01$). For horses that raced again following application of a conjunctival graft, including 1 horse in which a graft had been performed on both eyes, the presence of the graft, including the non-excised pedicle, was not reported to interfere with their subsequent racing ability.

DISCUSSION

The normal cornea, which is avascular, is protected by the eyelids as well as by lysozymes, secretory imunoglobulins, and leukocytes in the tear film. The intact corneal epithelium is the most important barrier to opportunistic infection. Antibacterial prophylaxis for simple corneal injuries is generally recommended to avert infection of exposed corneal stroma by preventing colonization by opportunistic organisms (Neaderland et al 1987; Moore et al 1995), but to our knowledge the current study is the first reported large scale clinical study to support this claim. Triple antibiotic is a good choice for prophylaxis (Moore et al 1995) and was routinely used in these cases because of its broad spectrum of activity. The ointment formulation has prolonged contact time necessitating fewer daily treatments. We also found that a single application of atropine and a single dose of a systemic non-steroidal anti-inflammatory drug were usually adequate to interrupt the development of uveitis which occurs as an axonal reflex initiated by sensory nerves of the cornea. As expected, the majority of cases of simple, superficial ulceration healed within a few days.

The factors identified that increased the risk of complicated corneal healing were a delay in the initiation of treatment and the size and depth of the lesion. This finding highlights the importance of early, appropriate prophylactic therapy. However, complications to corneal healing developed in almost 10% of cases with simple ulceration despite routine first-line treatment. Possible causes for this are antimicrobial resistance, non-bacterial causes of complicated corneal healing and poor client compliance with the application of topical medications. The most common isolates from cases of equine bacterial keratitis referred to the University of Florida (Sauer et al 2003), and the University of Tennessee (Keller and Hendrix 2005) were Streptococcus
equi ssp. zooepidemicus followed by Pseudomonas aeruginosa. In those reports, organisms were cultured from some cases that had received neomycin-polymixin B-bacitracin before presentation and only 64% of Streptococcus.equi ssp. zooepidemicus were sensitive to bacitracin (Keller and Hendrix 2005). A decline in the susceptibility of Streptococcus spp. to bacitracin and of Pseudomonas spp to neomycin and polymixin B would result in triple antibiotic being less effective in situations where these organisms are likely to colonize the compromised cornea and could contribute to the progression of corneal ulcers in these cases. However, antimicrobial susceptibility of these organisms may well depend on geographical location. For example, increasing resistance of S.equi ssp.zooepidemicus to gentamicin and of P. aeruginosa to gentamicin and tobramycin has been reported by some authors (Sauer et al 2003) but not others (Wolf 1990). Unfortunately, in the current study, isolation of microorganisms was successful in only 2 of 20 cases, possibly due to suboptimal isolation techniques, prior administration of antimicrobial agents, lack of repeat sampling for culture and the finding that melting ulcers can be sterile (Wolf 1990). Therefore, we were unable to describe the common isolates and their sensitivity patterns and are unable to conclude that resistant organisms were present.

When bacteria or fungi attach to the ulcer site and invade the corneal stroma, leukocytes in the tear film are induced to release proteases that elicit inflammatory and degradative processes. Although these enzymes help destroy the invading microbes, excessive levels of matrix metalloproteinases and serine proteases in the tear film can lead to rapid degeneration of the corneal stroma, keratomalacia or corneal 'melting' and corneal perforation (Strubbe et al 2000), and fewer cases of keratomalacia may

have occurred if aggressive therapy using equine serum or other antiprotease compounds had been initiated early in the course of disease to reduce the activity of tear proteases (Ollivier et al 2004).

Corneal ulceration was the most common diagnosis in horses with RREI. Corneal defects may be described as erosions or abrasions, superficial or deep ulcers depending on whether the injury involves the epithelium, epithelium and basement membrane, or whether there is additional involvement of variable depths of the corneal stroma. One limitation of this largely retrospective study was that it was not always possible to categorize the lesion because the size and depth of the defect was not reliably reported in the medical record. Ocular examinations were conducted using a direct ophthalmoscope and not slit lamp microscopy and consequently the depth of the corneal lesions was merely estimated. However, varying the viewing angles and lighting relative to each other, improved the examiners' ability to determine the lesion depth (Maggs 2003b). In our experience most corneal defects sustained during racing are small in diameter and involve only the superficial layers of the cornea. This is supported by the data on ulcer diameter and depth reported for 36 cases and by the finding that most cases healed within several days without loss of corneal transparency. Furthermore, at this clinic comments are not usually made on the medical record unless an ulcer is more extensive or complicated.

Another potential limitation of this study is that for horses that had multiple race starts during the study, each running event was considered independently. We assumed that runners with a RREI were not at increased risk of another eye injury in subsequent races and consequently races were taken as independent events. This could be an erroneous assumption if a horse repeatedly runs back in the field where the eyes are likely to be subject to more 'kick back' injury, repeatedly wears no protective eye gear when racing, or if complete epithelial-stromal attachment has not occurred, and a new ulcer is sustained in the same location. In order to determine the fairness of this assumption we would need to know the number of horses that had multiple starts yet didn't sustain a RREI for the duration of the study, and this data was not available to the authors.

Although it is probable that some cases that had a conjunctival graft would have healed without it, surgery had the advantages of shortening the recovery period until the horse could return to race training with a pain-free eye. Surgery was elected to increase the chance of a visual eye and to reduce intraocular effects such as uveitis. It also enabled corneal samples to be obtained that in some 1 case provided diagnostic information on which treatment decisions were based. Unfortunately, it was not possible to determine whether medical therapy alone was more likely to be successful if endogenous serum was used, however, our clinical impression is that it is useful in cases with keratomalacia. A conjunctival graft may limit serious complications such as corneal perforation that occurred in 1 case. Once corneal perforation occurred in this case, surgery was essential in saving vision. A conjunctival graft was used as the perforation was small, however, the mechanical strength of conjunctiva may be inadequate to bridge larger perforations (particularly those >5-6 mm diameter) and use of a corneal graft should be considered.

The pedicle of the graft was not excised following healing except in 1 case because this may have further delayed the return to race training and vision was judged to be acceptable with the pedicle intact. However, the pedicle size was based on width of the debrided ulcer bed and rarely exceeded 8 mm. Excision of the pedicle may be required following healing of larger conjunctival flaps to optimize visual outcome. The cosmetic appearance following healing was good, and in cases where pigmentation of the graft tissue occurred, cosmesis was excellent. Minor complications associated with the ocular lavage catheter and partial graft dehiscence were fairly common and lengthened duration of treatment but did not preclude a successful outcome in any case.

Preventive measures should be taken to reduce the risk of RREI by use of 'gear' that provides

some eye protection (pacifiers, or less effectively blinkers) and by implementing a turf management program that encourages increased surface stability (Steel and Robertson 2007). We suggest that if horses return from racing with 'kick back' from the track surface on their face, trainers should be encouraged to lavage the eyes post-race with sterile saline or lactated Ringer's solution to remove any remaining debris. The prophylactic topical application of an antiproteinase substance such as equine serum, 0.1% doxycycline, 10% N-acetylcysteine, or 0.2% diaminetetrataacetic acid (EDTA) (Haffner, Fecteau and Eiler 2003; Ollivier et al 2003) to inhibit collagen breakdown could also be considered in cases of simple ulceration in an effort to prevent corneal malacia which occurred in some cases despite first-line treatment. The effectiveness of either strategy in reducing the occurrence of complicated corneal healing remains to be determined. Even with possible trends towards resistance seen with triple antibiotic it is still recommended as a first-line therapy for corneal ulcers (Keller and Hendrix 2005) and we still use it at our clinic, reserving ciprofloxacin and tobramycin for resistant organisms. Corneal healing should be closely monitored and if a complication develops, samples should be obtained for cytology and culture and sensitivity. While awaiting results, and with knowledge of local sensitivity patterns, an antimicrobial to which S.equi ssp.zooepidemicus and P. aeruginosa are highly sensitive should be used. Efforts to more rigorously isolate the organisms involved in infectious keratitis at Singapore Turf Club and determining the local sensitivity pattern are indicated.

Ulcerative keratitis is a vision-threatening problem yet the prognosis for successful treatment in this report was excellent. Although focal loss of corneal transparency that can be assumed to cause minor visual defects occurred in some stromal defects and following conjunctival graft surgery, all affected eyes were visual as determined by positive menace response in at least 3 quadrants and were pain-free. Healing occurred without prolonged lay-up time and was aided by the prompt initiation of treatment in most cases, daily re-evaluation and surgical treatment when indicated.

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Table 1: Diameter and estimated depth of corneal ulcers in 36 runners

	Diameter of ulcer		
Depth of ulcer	≤2mm	>2 but <5 mm	>5mm
Superficial	17	5	3
Moderate	--	7	2
Deep	2	--	

Table 2: Effect of delay of initial examination after racing on the incidence of complicated corneal healing in 50 runners, compared to uncomplicated healing in 228 runners

	Complicated corneal healing	
Time of initial examination	**Yes**	**No**
<24 hr	38 (76%)	222 (97.4%)
24-48 hr	5 (10%)	6 (2.6%)
48-72 hr	3 (6%)	--
72-96 hr	3 (6%)	--
96-120 hr	1 (2%)	--