Use of 360 degree conjunctival flaps in a peregrine falcon

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Introduction

Treatment of corneal ulcers and keratitis in mammals and man involves topical medication and for more severe cases corneal bandaging techniques; with wide application of third eyelid flaps in domestic small animals, tarsorrhaphy used more in large domestic animals, and occasional use of conjunctival flaps. Scarified third eyelid flaps and conjunctival flaps have the advantage of exposure of the damaged cornea to blood, serum, immunoglobulins and serum anticollagenase as well as providing some physical support to the cornea to aid healing (conjunctival flaps providing more corneal support than third eyelid flaps). Third eyelid flaps are used much more in preference to conjunctival flaps in small animals due to being a very simple rapid technique to perform.

For birds, there is little written in the literature about use of corneal bandaging techniques - the only technique mentioned with any frequency is temporary tarsorrhaphy. Due to the different anatomy and function of the avian third eyelid, third eyelid flaps are not recommended by several authors. There is very brief mention of bulbar conjunctival grafts as being difficult to perform (6), due again to differences in anatomy and the small size of the avian patients.

This case report describes use of 360 degree conjunctival flaps made using palpebral conjunctiva in a peregrine falcon with bilateral severe keratitis (presumed due to irritant chemical spray exposure), and highlights some points of avian eye anatomy and treatment of avian corneal problems.

Case Report

13/1/00: A wild female peregrine falcon was presented by a rehabilitator with history of found and easily caught on the ground the day before with the third eyelid stuck to the eyeballs and a white film, not the third eyelid, over both eyes. White frosting was also reported on the eyelids, and both the white film and frosting had gone by time of presentation. All fluorescein examinations and surgeries for this case were done under isoflurane gaseous anaesthetic.

Examination revealed the bird slightly thin; the left eye had mild graze lesions on the lower medial eyelid (apparently this was frosted white the day before); fluorescein staining of the left eye was positive over most of the cornea, and for the right eye less staining but still a large positive area, with central distribution as if an exposure problem. It was suspected the bird had chemical irritant damage to both corneas and mildly affecting the left lower eyelid, possibly due to flying through irritant chemical spray.
Initial treatment was to flush both eyes with copious saline; then optigentin (gentamycin) eyedrops applied 2 hourly, antibiotics (amoxycillin 100mg/kg s/c), an anti-inflammatory (ketoprofen 2mg/kg ie 0.1cc ketofen 10mg/ml) and fluid therapy (20cc 5%glucose s/c) were given.

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14/1/00: Reexamination under isoflurane revealed both eyes staining equally extensively but no deeper. Some superficial eyelid dermatitis was present, presumed due to the irritant. Amoxycillin, ketoprofen, and glucose injections were repeated and gentamycin drops continued. Temporary tarsorrhaphy was contemplated if there was no improvement in another 24 hours, but concern was on the feasibility of bilateral tarsorrhaphy. An email was sent to a Middle Eastern falconry hospital (pers. communication Jaime Samour) for opinion on closing both eyes and the effects on the bird, having recalled seeing reference to a falconry practice called "sealing" where both eyes are sutured shut for a few days.

15/1/00: Reexamination - slightly less intense but still extensive fluorescein staining of both corneas - bilateral tarsorrhaphy was performed, with for each eye a single horizontal mattress suture of 3/0 gut to close the eyelids passed through plastic strips (cut from examination gloves) to protect the eyelids from suture damage. Ketoprofen, amoxycillin and glucose injections were repeated and gentamycin drops continued. An email reply that evening confirmed the plan of action, warning that scarring of the eyelids from the sutures was a possible complication. It was planned to leave the sutures in 2 weeks but the rehabilitator was warned to return earlier if she thought the eyelids were getting damaged. Gentamycin drops were to continue 2-3 times daily.

2/2/00 (2 1/2 weeks later): fluorescein staining still extensive but less opaque. The eyelids were re-sutured closed.

10/2/00 (3 weeks later): fluorescein staining similar, though cornea unscarred. Prognosis was becoming very guarded for unscarred sight. Very early bumblefoot (slight blunting of the papillae of the underside of the feet) was noted despite astroturf covered perching and cage floor, and was a concern for the next few weeks as the bird was moving around very little with both eyes closed. Eyelids both re-sutured another 2 weeks.

23/2/00 (at 5 weeks): finally some progress with the left eye staining 60% of the original area, the right eye much the same. Eyelids were starting to get damaged from sutures, early bumblefoot still present. Concern was the length of time the eyes could be kept closed (and the bird confined for topical medication) while risking worsening bumblefoot. Bilateral 360 degree conjunctival flaps using palpebral conjuctiva were performed, hoping the exposure to blood, serum and immunoglobulins via the conjunctival surface exposed would speed corneal healing which was very slow.

15/3/00 (at 8 weeks): flaps opened, much progress noted. Only 20-25% fluorescein staining left eye, right eye had similar or mildly reduced staining from 3 weeks earlier. Left eye was left open, right eye had 360 degree conjuctival flap repeated. It was hoped the bird would move around more with one eye open, reducing the progress of bumblefoot.

5/4/00 (at 11 weeks): left eye no change in staining after 3 weeks left open, right eye much improved and only 5-10% flourescein staining once opened. Bumblefoot slowly worsening with early scab on one toe (nearing Stage II). Both eyes were finally developing corneal scarring/opacity - white spots and one area involving 2-5% dorsal cornea left eye. The carer reported the bird adjusted it's head to look through ventral cornea down at things rather than directly at them. The impression was that the conjunctival flaps had certainly accelerated healing compared to the tarsorrhaphies. Left eye had a new 360 degree conjunctival flap, and the right eye was left open. A permanent home for the bird was arranged as perfect sight fit for release back to the wild was now not expected.

18/4/00 (at 13 weeks): both eyes finally fluorescein -ve and left open. the bird was put out in an aviary due to badly needing to move around and off its feet flying as the bumblefoot was worse with scab but not swelling on the underside of the feet, the undersides skin becoming quite red and inflamed. Worsening bumblefoot through further confinement for topical eye treatment was decided not worth risking, risking crippling the bird when scarring of sight had already occurred negating it's chance of release anyway. Gentamycin plus cortisone drops were to be applied occasionally when the bird was caught up a few times weekly in the aviary.

25/4/00 (at 17 weeks): right eye had faint linear scar only, left eye a 3mm scar at 11 o'clock faintly fluorescein staining. Redness of the feet had settled, scabs present on underside of the feet.

End of July '00 (At 22 weeks): incidental recheck - bumblefoot had resolved with bird flying in small flight aviary, faint fluorescein staining corneas, small scars present still not compatible with perfect enough sight to release.

CONJUNCTIVAL FLAP TECHNIQUE

Incisions were made in the palpebral conjuctiva of the upper and lower eyelids approx. 3-4mm away from the lid margins and extended the length of the lids. The conjunctiva was undermined toward the lid margins with iris scissors to free upper and lower flaps of conjunctiva, which were left attached at the lid margins. The flaps were reflected out from under the lids to meet over the central cornea, and sutured together forming a horizontal suture line with 4/0 catgut continuous horizontal mattress suture, avoiding sutures rubbing on the cornea.

Discussion

In mammals, several surgical methods are used to help protect damaged corneas and aid healing; namely tarsorrhaphies, third eyelid flaps and conjunctival flaps or grafts (28). There is limited information in the literature about use of such techniques in birds, as well as limitations for use in birds because of some anatomical differences and patient size. Small focal corneal defects in mammals can also be repaired and protected with use of spot application of cyanoacrylate tissue adhesive which is later sloughed by the cornea once healed (27). This technique has been reported in birds (6,7) but is not useful for extensive corneal damage such as seen in this reported case.

Relevant and Comparative Anatomy and Physiology

The eyeball in mammals is spherical and mobile within the orbit (many authors), and third eyelid retraction is passive associated with retraction of the globe by the retractor bulbi muscle attached to the posterior of the globe (26). The eyelids contain dense connective tissue (tarsal plates) which maintain eyelid shape and rigidity of the eyelid margins (26) but the tarsal plates are not well defined in mammals (23). Modified sebaceous glands within the eyelid margins (Meiobomian glands) provide an oily coating which mingles with tears preventing evaporation (26).

Conjunctiva in mammals is divided into two layers - the epithelium, and the substantia propria which consists of glandular and fibrous tissue. The glandular tissue is a connective tissue network enclosing lymphocytes, plasma cells, and active lymphoid follicles. There are three distinct regions of conjunctiva - palpebral, bulbar and the fornixes. Bulbar conjunctiva is freely moveable over the sclera in mammals, except where it is bound near the limbus; palpebral conjunctiva is bound at the lid margins but more movable towards the fornixes, though less mobile than bulbar conjunctiva. The loose attachment of conjunctiva to the globe accommodates eye movement. Overall the conjunctiva is very mobile and elastic (21,24,26). The conjunctiva is a protective and immunologic shield for the eye and rapidly regenerates, having a high density of blood vessels and lymphatics - many lesions heal without suturing (21,26).

Birds' eyes have structures similar to reptiles and mammals plus unique features, some probably being adaptions for flight (4). The eyeball is not spherical and is relatively much larger in the skull than in mammals, sitting tightly in the orbit; the concavity around the cornea saves much space and weight without loss of optical efficiency (1,3,4). The area of weakness due to the concavity at the limbus is compensated by a ring of bony plates, the scleral ossicles (1,3,4). Head movements generally compensate for reduced globe mobility (1,5,16) - owl eyes can't move at all, but most other birds are capable of forward convergence to the beak tip (1). Extraocular muscles are reduced and the retractor bulbi muscle is absent, unlike reptiles and mammals - this and the tight fit of the globe in the orbit results in birds not being able to retract the globe (5,6,11,16). Bulbar conjunctiva is relatively immobile in birds (6). the conjuctiva in general is morphologically similar to mammals (16).

The third eyelid is well developed and very mobile in birds. Movement is generally dorsomedial to ventrolateral, with the third eyelid's dorsal temporal edge firmly attached to assocaited conjuctiva and sclera (17). Movement of the third eyelid in birds is achieved through active voluntary muscle action of two muscles at the posterior globe (the pyramidalis and quadratus muscles) transmitted to the third eyelid via the tendon of the pyramidalis muscle which passes round the globe ventrally then anteriorly to attach to the medial ventral margin of the third eyelid (5,6,11,14,16, and especially 17). Thus movement of the third eyelid is active, not passive to globe retraction as in mammals - this strong active movement, and the delicacy of the third eyelid, is why third eyelid flaps are not recommended in birds due to sutures pulling through resulting in ineffectiveness and third eyelid damage (many authors eg 6,7,8,9,12,13,14). Murphy warns that care must be taken to preserve the tendon of the pyramidalis muscle when doing conjunctival surgery (11).

The palpebral reflex in birds typically results in the third eyelid crossing the cornea before the eyelids close (17), actively crosses the eye during blinking (12), and often crosses the eye when a raptor pulls it's food (10). In all birds the need for true blinking is reduced because of the ability of the third eyelid to spread the precorneal tear film adequately across the cornea (11). Upper and lower eyelids only close in sleep in most birds (4,5). In general the upper eyelid is short and thick, the lower is thinner, longer, and highly mobile (5,6,7,12); the main exception in owls where the upper eyelid is larger and closed during blinking, with the lower closed in sleep and anaesthesia (10,15). The lower lid is mainly responsible for closing the eyes (4, 6,7,9,11,15), and contains a variably developed fibrous tarsal plate (9,16). Meiobomian glands are absent in the eyelids of birds (6,7,16). The third eyelid is more important than the upper eyelid and avulsion of the upper lid can be compensated if third eyelid function is normal (8).

The avian cornea is histologically similar to mammals except for varying development of Bowmans capsule layer (3,4,5,6,7,14,16). Corneal ulcers mostly heal readily paralleling uncomplicated mammalian ulcers, and corneal vascularisation is reported to occur less readily and rarely in birds in contrast to mammals (8,11,13,14). Corneal ulcers are assessed with fluorescein as in mammals (6,7,13,14).

TREATMENT OF CORNEAL DAMAGE IN BIRDS

Due to the active muscle control, important role of the third eyelid, and delicacy of the third eyelid, third eyelid flaps are not recommended in birds by many authors (as above) - permanent damage to the third eyelid may have disastrous long term consequences (again, many authors). Temporary tarsorrhaphy is discussed and recommended for treatment of non-responsive corneal irritation and ulcers by several authors (6,7,8,9,11,12,13,14), and reported useful for severely irritated eyes seen when birds fall into chimney hearths receiving soot associated inflammation and burns to the cornea (11).

Tarsorrhaphy technique described involves 1-3 simple interrupted or horizontal mattress partial thickness sutures of 6/0 silk, 4/0-6/0 nylon, or 5/0-6/0 absorbable or non-absorbable sutures (8,9,11,12,13); with stents of pieces of rubber bands to protect the eyelids (13) or without stents (6). Topical anaesthesia in calm birds by holding the eyelids between cotton buds soaked in proparacaine is mentioned (9,11). Eyelid damage and swelling associated with tarsorrhaphy was reported by one paper (17). Bilateral tarsorrhaphy is mentioned as used to calm excitable birds such as accipiters when hospitalised, preventing self-inflicted trauma (11). This is reported as having the same effect as "hooding" birds. A similar technique of "sealing" has been used by falcon trappers to calm newly caught birds, where a suture is placed in each lower eyelid and tied over the head for the first few days in captivity (9,11). Eyelid damage from the sutures is a complication of this method (9, Samour pers. communication).

Conjunctival flaps in mammals are reported to promote healing of deep or slow healing corneal lesions through support of lesions and provision of vascularisation, fibroblasts, serum containing anticollagenase, and immunoglobulins and neutrophils (20, 21, 22, 23,27,29). There are several types used in mammals, being hood, bridge, complete 360 degree and pedicle flaps and grafts (21,23,27)., with 360 degree flaps the easiest and covering large areas (20). Conjunctival flaps can be harvested from bulbar conjunctiva, with palpebral conjunctiva from the upper eyelid reported used by one author when bulbar conjunctiva is unavailable or diseased (27), though they report the potential for graft movement making it less useful surgery. For the 360 degree conjunctival graft incision is made in the bulbar conjunctiva near the limbus and extended around the limbus 360 degrees, conjunctiva is superficially dissected from the underlying fibrous tissue and undermined to form two flaps which are stretched over the cornea to meet in the middle horizontally. The flaps are then sutured together with simple interrupted or horizontal mattress 5/0-6/0 sutures (21,22,23,25,29).

Use of conjunctival flaps in birds has been briefly mentioned in the literature. Kern (6) considers them technically difficult or impossible in birds due to the small size of the patients and the relatively immobile bulbar conjunctiva. Bright (7) cites this reference to not recommend them. Davidson (14) regards deep or infected corneal ulcers in birds challenging to treat as conjunctival grafts (a mainstay of treatment in small animals) are more difficult to perform because of the absence of loose conjunctival tissue results in undue tension on grafts after placement, but despite this mentions that it is possible to successfully do them when treating ulcers in raptors.

Due to the tight adherence of bulbar conjunctiva in birds, we tried using 360 degree conjunctival flaps from palpebral conjunctiva instead. We found the technique reasonably simple in a bird the size of the peregrine; with flaps easy to undermine and mobilise. Species differences in the development of the fibroelastic tarsal plate of the lower eyelid may make the surgery difficult to do in some birds e.g. this plate was very developed in a square-tailed kite examined in comparison to the peregrine. Adhesion of the flap to the cornea did not occur, possibly associated with eyelid and third eyelid mobility - this was actually an advantage rather than having conjunctiva incorporated into corneal scarring as can happen with bulbar conjunctival flaps. The technique using palpebral conjunctiva would still be very difficult to use in quite small birds.

CASE SUMMARY

In this case reported, severe bilateral keratitis in a peregrine falcon showed little response to topical medication in the first two days of treatment, and little more to bilateral tarsorrhaphy for five weeks. Use of conjunctival flaps for 2-3 week periods at a time certainly gave the impression of much more dramatic resolution and reduction of fluorescein staining. A major complication of surgical closure of the eyes was the bird moved around very little though feeding well, resulting in development of marked inflammation of the undersides of the feet i.e. bumblefoot, which imposed a time limitation on treatment by surgical closure of the eyes. Eventually, as the eyes were developing scarring which would affect sight preventing release (and as a permanent place in captivity was found for her), eye treatment was stopped so the bird could be placed out in an aviary to move around and fly more. Placement in the aviary resulted in resolution of the bumblefoot, which prior to then was starting to rapidly worsen risking permanent crippling of the bird.

There was uncertainty at first on how the bird would cope with bilateral eye closure, however the bird ate well and was calm once it was performed. Falconers overseas have been reported using a technique called sealing to calm newly caught wild birds, suturing eyelids closed for around a week. At times this technique caused eyelid damage, a complication we were warned about. In this case eyelid sutures (tarsorrhaphies) were used over 5 weeks, and both eyes closed for 8 weeks, with mild eyelid damage. Unilateral closure of one or the other eye by conjunctival flaps were used for a further five weeks. The eyelid damage settled once change was made to conjunctival flaps which avoided sutures through the skin. Conjunctival incisions were left to granulate when conjunctival flaps were reopened.

A striking feature was the long period till any corneal opacity or scarring occurred, despite the extensive fluorescein staining. First opacity wasn't noticed till eleven weeks.

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