Clinical features of cats with aqueous tear deficiency:

a retrospective case series of 10 patients (17 eyes)

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Abstract

Objectives - To describe the clinical findings, diagnostic test results, and response to therapy of cats with Schirmer tear test-1 (STT-1) values below reference range.

Methods **-** The medical records of three institutions were searched for cats with ocular surface disease and STT-1 values < 9 mm/min, confirmed at ≥ 2 separate visits.

Results **-** Ten cats (17 eyes) were included. The mean ± standard deviation (range) age and STT-1 values in affected eye(s) were 6.1 ± 5.7 (0.2-16) years and 2.4 ± 3.1 (0-8) mm/min, respectively. Concurrent ocular surface disease was bilateral in 5/10 cats. Clinical signs included conjunctivitis (14/17 eyes), corneal ulceration (6/17 eyes), nonulcerative keratitis (4/17 eyes), symblepharon (4/17 eyes), eosinophilic keratitis (3/17 eyes), corneal sequestrum (3/17 eyes), corneal fibrosis (2/17 eyes), and meibomitis (2/17 eyes). Management included topically applied lacrimomimetics, antiviral drugs, corticosteroids, or immunomodulatory drugs; orally administered famciclovir; or surgical procedures in various combinations. Response to therapy (defined as an increase in STT-1 value of ≥ 5 mm/min) was transient (seen at a single reassessment) in 65% eyes and sustained (seen at ≥ 2 consecutive reassessments) in 18% eyes.

Conclusions and relevance **–** Clinical features seen in cats with low STT-1 values are described, although the association between aqueous deficiency and the reported ocular changes is unknown at this time. We encourage clinicians to assess the tear film in cats with ocular surface disease, and initiate therapy with lacrimomimetics if STT-1 values are repeatedly below normal. Such information will further define aqueous tear deficiency in cats, providing a better understanding of disease prevalence, pathogenesis, and treatment.

Introduction

Ocular surface diseases such as conjunctivitis, corneal ulceration, corneal sequestrum, and eosinophilic keratitis are among the most common disorders recognized in cats with ophthalmic complaints.[1] Due to the intimate relationship between the ocular surface and the tear film, it is possible that tear film deficiency is a serious co-morbidity in many of these clinical presentations, as is the case in dogs[2] and humans.[3] In fact, a qualitative tear deficiency - or alteration in the mucin and/or lipid component of the tears - is often recognized in cats infected with feline herpesvirus type-1,[4] and those with spontaneous ulcerative keratitis,[5] corneal sequestrum,[6] and conjunctivitis.[7]

In contrast, quantitative tear deficiency – i.e., a reduction in the aqueous portion of the tears – is seldom reported in cats. Although the paucity of feline reports may be due to low disease prevalence, aqueous deficiency may also be under-recognized in this species because veterinarians are primed to look for a syndrome similar to that seen in dogs with keratoconjunctivitis sicca (KCS) or "dry eye", or because testing the aqueous tear film was long assumed to be unreliable in cats because it could be artifactually lowered due to stress.[4] Recently, normative data for the Schirmer tear test 1 (STT-1) and other diagnostic tests for assessment of the tear film were established in healthy cats,[8] and a case report showed that aqueous tear dysfunction in a cat was associated with chronic keratitis, conjunctivitis, and impaired healing of corneal ulcers.[9]

The purpose of the present report, therefore, is to describe the clinical findings of a series of cats in which STT-1 values were below the reference range.[8] In so-doing we aim to encourage veterinarians to be more alert to the potential role of tear deficiency and the value of tear testing in cats with various ocular surface diseases. This, in turn, will enhance understanding of tear deficiency in cats and power prospective, case-controlled studies designed to better define the clinical appearance, establish the pathogenesis, and assess therapeutic protocols for dry eye disease in this species.

Material and methods

Medical records of Iowa State University's Lloyd Veterinary Medical Center (ISU-LVMC), the University of California-Davis' Veterinary Medical Teaching Hospital (UCD-VMTH), and Triangle Animal Eye Clinic (TAEC) in Tokyo, Japan were searched from 2006-2018 for cats with unilateral or bilateral ocular surface disease and STT-1

values < 9 mm/min[8] at presentation and on at least one subsequent examination. Signalment, ocular abnormalities, diagnostic test results, and management strategies were retrieved from the medical records. Response to therapy was defined as an increase in STT-1 value of ≥ 5 mm/min,[10, 11] and was further defined as "transient" or "sustained" if the improvement was noted at 1 or ≥ 2 consecutive follow-up visits, respectively.

Results

Animals – Seventeen eyes of 10 cats met all inclusion criteria (Table 1). The mean ± standard deviation (range) age, body weight and STT-1 values in affected eye(s) were 6.1 ± 5.7 (0.2-16) years, 4.3 ± 1.9 (0.6-6.7) kg, and 2.4 ± 3.1 (0-8) mm/min, respectively. Ocular surface disease was bilateral in 5 cats, one of which (Case 6) had a STT-1 value < 9 mm/min in only one eye. Disease was unilateral in the other 5 cats, three of which (Cases 4, 9, and 10) had STT-1 values < 9 mm/min in both eyes.

Clinical diagnoses – Concurrent ocular surface pathology included conjunctivitis (14 eyes), corneal ulceration (6), nonulcerative keratitis (4), symblepharon (4), eosinophilic keratitis (3), corneal sequestrum (3), corneal fibrosis (2), or meibomitis (2). Other ocular abnormalities seen included uveitis (3 eyes), glaucoma (1), iris hyperpigmentation (1), or retrobulbar abscess (1). The ocular surface was described as 'lackluster' in 10/17 affected eyes, and 3 cats had mild crusted discharge at the medial canthus (Figure 1).

Diagnostic testing – The STT-1 was performed in all eyes; mean ± standard deviation (range) value in affected eyes was 2.4 ± 3.1 (0-8) mm/min. The phenol red thread test (PRTT) was performed in Cases 1-4 and was within normal limits (≥ 15mm/15sec)[8] in all affected eyes but one (Case 2) despite these eyes all having low STT-1 values (Table 2). Corneal sensitivity was estimated using a Cochet-Bonnet aesthesiometer in four eyes (Cases 5 and 10) and was markedly reduced in all 3 affected eyes (Table 2).[12] Tear film breakup time (TFBUT) was performed in Case 5 only and was decreased bilaterally at 5-7 seconds. Fluorescein and rose bengal staining, corneal cytology, conjunctival histology and various infectious disease tests were completed in some cats (Tables 2 and 3).

Therapy – A wide range of management techniques was used throughout the clinical course of the 10 cats (Table 1). Topically applied lacrimomimetic agents were used in 15 eyes (10 cats) for between 14 and 628 days from 1-12 times daily depending on the severity of clinical signs. Most lacrimomimetic agents prescribed contained sodium hyaluronate; 5 eyes (4 cats) with severe aqueous deficiency also received autologous serum. Corticosteroids were applied topically in 5 eyes (4 cats) 1-3 times daily for 9-309 days. Other topical immunomodulatory drugs were used in 4 eyes (3 cats) for 35-244 days; these included 0.03% tacrolimus ophthalmic ointment (2 eyes), 0.2% cyclosporine ophthalmic ointment (1 eye), or 1% (1 eye) or 2% (1 eye) cyclosporine ophthalmic suspension compounded in corn oil. Both cats that received cyclosporine compounded in corn oil developed blepharitis. Famciclovir was prescribed in 7 cats for 22-294 days at doses of 35-50 mg/kg three times daily (4 cats), 86-90 mg/kg twice daily (2 cats) or 100 mg/kg once daily (1 cat). Topical antiviral drugs were prescribed in 4 eyes (4 cats) for 109-366 days; these included 0.5% cidofovir ophthalmic solution applied twice daily (3 eyes) or 0.1% idoxuridine ophthalmic solution applied 4-6 times daily (1 eye). Surgical procedures included bilateral dissection of symblepharon (Case 2), thermokeratoplasty for a non-healing ulcer (Case 5), or corneoconjunctival transposition following a lamellar keratectomy for sequestrum removal (Case 6). Other therapies included topically or systemically administered antibiotics, systemically administered corticosteroids, or warm compresses applied to the eyelids (Table 1).

Response to therapy - Mean ± standard deviation (range) follow-up time was 383 ± 320 (63-994) days. Complete resolution of clinical signs was documented in 3 cats (Cases 4, 5, and 9), whereas partial clinical improvement was noted in 5 cats (Cases 1, 2, 3, 7, and 8). At the last recheck examination, keratoconjunctivitis was still present in the remaining 2 cats (Cases 6 and 10). Figure 2 depicts representative images from follow-up examinations of Cases 2, 4, 5, and 8. The STT-1 value increased by ≥ 5 mm/min in 14/17 affected eyes; this increase was transient (seen at a single reassessment) in 11 (65%) of affected eyes and sustained (seen at ≥ 2 consecutive reassessments) in 3 (18%) of affected eyes.

Discussion

This report describes clinical signs of ocular surface disease in a series of 10 cats (17 eyes) with aqueous tear deficiency (STT-1 value < 9 mm/min). Although the association between aqueous tear deficiency and ocular surface disease is unknown based on this case series, tear film dysfunction would be expected to have a detrimental effect on

the ocular surface health of cats, similar to dogs and humans. Conversely, ocular surface diseases may have a negative effect on tear production and perpetuate dry eye. A STT-1 value < 9 mm/min (especially when confirmed on two separate occasions as required in this case series) should be considered abnormal in cats as the occurrence of low STT-1 values in ophthalmically normal cats is rare.[8, 13] Indeed, Paepe and colleagues found that only 2/100 normal cats had STT-1 values < 5 mm/min,[13] while Sebbag and colleagues showed that 0/135 normal cats had STT-1 values < 7 mm/min.[8] In addition to STT-1, the PRTT was also measured in 4 cats (8 eyes) but was normal in all but one affected eye. This supports previous data suggesting that the PRTT is less reliable than the STT-1 in cats.[8] For this reason, and because the STT-1 provides a measure of basal and reflex tearing as well as a coarse assessment of the neurologic function essential for a normal lacrimal functional unit,[14] these authors prefer using the STT-1 than the PRTT to assess the aqueous tear film in cats. Once reduced aqueous tear film is documented, vital stains such as fluorescein, rose bengal, or lissamine green can be particularly helpful in highlighting subtle changes in the corneal and/or conjunctival surfaces.[15] Finally, corneal aesthesiometry is an essential diagnostic tool in cats in which neurologic dysfunction is suspected, as exemplified by Cases 5 and 10 of this report and a cat from a previous report[9] in which corneal hypoesthesia likely contributed to their aqueous tear deficiency. By contrast, tear osmometry has not proven as reliable or helpful in dogs[16] or cats[8, 17] as it has in humans[3] with tear film deficiency.

Impaired tear production or release, or hastened tear loss, especially through evaporation should all be considered as potential causes for low STT-1 values. In some cats of the present series, impaired tear secretion onto the ocular surface because of obstructed lacrimal ductules seems likely to have contributed to the aqueous tear deficiency noted. This may be a transient consequence of conjunctival swelling as a result of conjunctivitis (as seen in many cases in the present study) or orbital cellulitis, or a more permanent consequence of adhesions from symblepharon or eyelid agenesis[18] (as seen in Cases 1 and 2 herein). Where possible, correction of these underlying causes may normalize STT-1 values. This is likely what happened in Case 8 in which successful treatment of the retrobulbar abscess was associated with a sustained increase in STT values. A neurogenic cause of aqueous tear deficiency should also be considered in cats. This is a recognized etiology in dogs[19] and humans[20] and has been reported in one cat.[9] Humans with chronic inflammation from herpes simplex virus-1 infection experience permanent damage to the trigeminal nerve with subsequent corneal hypoesthesia and decreased reflex tearing.[21] Although multiple causes of neurogenic dry eye exist, the high prevalence of herpetic disease in cats warrants consideration and further investigation of a metaherpetic form of dry eye disease, as described in humans.

In all cases of dry eye disease, absence of a confirmed etiologic diagnosis renders therapy challenging – as evident in the present case series. In such cases, therapy is limited to hydrating and lubricating the ocular surface with lacrimomimetic agents, and controlling concurrent ocular surface inflammation. This likely explains the generally poor responses observed in the cases presented here and highlights the need for future studies to determine the etiopathogenesis of qualitative and quantitative tear film deficiency in cats. We hope this report will heighten feline practitioners' awareness of the importance of performing the STT-1 in this species so that future studies might establish a more comprehensive definition of feline dry eye that better elucidates disease prevalence, clinical features, pathogenesis, and therapeutic strategies. Such studies should include larger cohorts than reported here, and inclusion of a control population in order to better understand the pathogenic role of tear film deficiency in feline ocular surface disease.

Conclusions

Aqueous tear deficiency can occur concurrently with common ocular surface diseases in cats. Although the causative association between aqueous tear deficiency and these diseases is not known, experience in other species suggests that tear film deficiencies would be, at the very least, contributory. We encourage clinicians to perform STT-1 in cats with ocular surface disease, and to initiate therapy with lacrimomimetics if tear film dysfunction is noted. Complementary tests such as vital stains, TFBUT, and corneal aesthesiometry can provide valuable information about the nature and sometimes the cause of the tear film deficiency, as well as the extent of ocular surface damage. Such data will facilitate a deeper understanding of the prevalence and pathogenesis of, diversity of clinical signs associated with, and response to therapy in cats with qualitative and quantitative tear film deficiencies.

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References

1. Stiles J. **Feline Ophthalmology**. In: Gelatt K, Gilger B, Kern T (eds.). Veterinary Ophthalmology. 5 ed. Wiley-Blackwell, 2013, pp 1477-1569.
2. Williams DL. **Immunopathogenesis of keratoconjunctivitis sicca in the dog**. *Vet Clin North Am Small Anim Pract* 2008; 38: 251-268.
3. Craig JP, Nelson JD, Azar DT, et al. **TFOS DEWS II Report Executive Summary**. *Ocul Surf* 2017; 15: 802-812.
4. Lim CC, Reilly CM, Thomasy SM, et al. **Effects of feline herpesvirus type 1 on tear film break-up time, Schirmer tear test results, and conjunctival goblet cell density in experimentally infected cats**. *Am J Vet Res* 2009; 70: 394-403.
5. Cullen CL, Njaa BL and Grahn BH. **Ulcerative keratitis associated with qualitative tear film abnormalities in cats**. *Vet Ophthalmol* 1999; 2: 197-204.
6. Grahn BH, Sisler S and Storey E. **Qualitative tear film and conjunctival goblet cell assessment of cats with corneal sequestra**. *Vet Ophthalmol* 2005; 8: 167-170.
7. Lim CC and Cullen CL. **Schirmer tear test values and tear film break-up times in cats with conjunctivitis**. *Vet Ophthalmol* 2005; 8: 305-310.
8. Sebbag L, Kass PH and Maggs DJ. **Reference values, intertest correlations, and test-retest repeatability of selected tear film tests in healthy cats**. *J Am Vet Med Assoc* 2015; 246: 426-435.
9. Sebbag L, Pesavento PA, Carrasco SE, et al. **Feline dry eye syndrome of presumed neurogenic origin: a case report**. *JFMS Open Rep* 2018; 4(1): 2055116917746786.
10. Berdoulay A, English RV and Nadelstein B. **Effect of topical 0.02% tacrolimus aqueous suspension on tear production in dogs with keratoconjunctivitis sicca**. *Vet Ophthalmol* 2005; 8: 225-232.
11. Hendrix DV, Adkins EA, Ward DA, et al. **An investigation comparing the efficacy of topical ocular application of tacrolimus and cyclosporine in dogs**. *Vet Med Int* 2011; 2011: 487592.
12. Wagner F, Meyer-Lindenberg A, Heider HJ, et al. **A comparison of corneal sensitivity between healthy cats and cats with corneal sequestra**. *Berl Munch Tierarztl Wochenschr* 2003; 116: 427-431.
13. Paepe D, Verjans G, Duchateau L, et al. **Routine health screening: findings in apparently healthy middle-aged and old cats**. *J Feline Med Surg* 2013; 15: 8-19.

14. Stern ME, Gao J, Siemasko KF, et al. **The role of the lacrimal functional unit in the pathophysiology of dry eye**. *Exp Eye Res* 2004; 78: 409-416.
15. Yoon KC, Im SK, Kim HG, et al. **Usefulness of double vital staining with 1% fluorescein and 1% lissamine green in patients with dry eye syndrome**. *Cornea* 2011; 30: 972-976.
16. Sebbag L, Park SA, Kass PH, et al. **Assessment of tear film osmolarity using the TearLab™ osmometer in normal dogs and dogs with keratoconjunctivitis sicca**. *Vet Ophthalmol* 2017; 20: 357-364.
17. Davis K and Townsend W. **Tear-film osmolarity in normal cats and cats with conjunctivitis**. *Vet Ophthalmol* 2011; 14 Suppl 1: 54-59.
18. Whittaker CJ, Wilkie DA, Simpson DJ, et al. **Lip commissure to eyelid transposition for repair of feline eyelid agenesis**. *Vet Ophthalmol* 2010; 13: 173-178.
19. Matheis FL, Walser-Reinhardt L and Spiess BM. **Canine neurogenic Keratoconjunctivitis sicca: 11 cases (2006-2010)**. *Vet Ophthalmol* 2012; 15: 288-290.
20. Dartt DA. **Dysfunctional neural regulation of lacrimal gland secretion and its role in the pathogenesis of dry eye syndromes**. *Ocul Surf* 2004; 2: 76-91.
21. M'Garrech M, Rousseau A, Kaswin G, et al. **Impairment of lacrimal secretion in the unaffected fellow eye of patients with recurrent unilateral herpetic keratitis**. *Ophthalmology* 2013; 120: 1959-1967.

Table 1. Summary information for 10 cats with reduced aqueous tear film (Schirmer tear test 1 < 9 mm/min) and concurrent ocular surface disease seen at the Triangle Animal Eye Clinic (TAEC), University of California-Davis Veterinary Medical Teaching Hospital (UCD VMTH), or Iowa State University's Lloyd Veterinary Medical Center (ISU LVMC). STT-1 = Schirmer tear test 1; mo= month old; yo=year old; DSH= domestic short hair; DLH = domestic long hair; M = male; F = female; I = intact; S = spayed; N = neutered; OD = right eye; OS = left eye; OU = both eyes.

Case #	Signalment	Clinic at which seen	Concurrent ocular disease	All therapies used throughout clinical course	Follow-up (days)	Clinical outcome
1	2 mo MI DSH	TAEC	Symblepharon OU Conjunctivitis OU Nonulcerative keratitis OU	Sodium hyaluronate ophthalmic solution, oral famciclovir	63	Improved corneal transparency OU Improved conjunctivitis OU
2	5 mo FI DSH	TAEC	Symblepharon OU Conjunctivitis OU Nonulcerative keratitis OU	Sodium hyaluronate ophthalmic solution, 0.5% erythromycin; oral famciclovir; symblepharon dissection; warm compresses	135	Improved keratoconjunctivitis OU Static symblepharon OU
3	7 yo FS Abyssinian	TAEC	Corneal sequestrum OS Conjunctivitis OS	Sodium hyaluronate ophthalmic solution, 0.5% erythromycin, 0.3% ofloxacin; oral famciclovir, warm compresses	331	Improved conjunctivitis OS
4	4 yo MN Russian Blue	TAEC	Eosinophilic keratitis OS Conjunctivitis OS	Sodium hyaluronate ophthalmic solution, 1% prednisolone acetate, 0.5% erythromycin; oral famciclovir, doxycycline	309	Resolved keratitis OS
5	16 yo MN DSH	UCD VMTH	Non-healing corneal ulcer OU Anterior uveitis OU Conjunctivitis OD Corneal fibrosis OD Glaucoma OD	Sodium hyaluronate ophthalmic solution, serum, 2% dorzolamide /0.5% timolol, 0.005% latanoprost; oral famciclovir, prednisolone; corneal debridement; thermokeratoplasty	431	Resolved corneal ulceration OU Residual corneal fibrosis and neovascularization OD
6	9 yo FS Maine Coon	UCD VMTH	Corneal sequestrum OU Conjunctivitis OU Meibomitis OU Eosinophilic keratitis OD Ulcerative keratitis OS Corneal fibrosis OS	Sodium hyaluronate ophthalmic solution, 0.5% cidofovir, 0.2% cyclosporine, 0.3% tobramycin, 0.3% ciprofloxacin, 0.3% ofloxacin; oral famciclovir, L-lysine; corneo-conjunctival transposition	994	Resolved ulcerative keratitis OS Recurrence of eosinophilic keratitis OD
7	18 mo MN DSH	UCD VMTH	Descemetocele OU Conjunctivitis OU Corneal fibrosis OS	Sodium hyaluronate ophthalmic solution, serum, neomycin-polymyxin B-dexamethasone, 0.1% idoxuridine, 2% cyclosporine, 0.03% tacrolimus, 0.3% ciprofloxacin; oral prednisolone, azithromycin; warm compresses	922	Nonulcerative keratitis OU
8	14 mo FI Maine Coon	UCD VMTH	Retrobulbar abscess OD Conjunctivitis OD Ulcerative keratitis OD Anterior uveitis OD	Sodium hyaluronate ophthalmic solution, serum, 5.5% cefazolin, 0.3% ciprofloxacin; oral amoxicillin/clavulanic acid, prednisolone	241	Resolved retrobulbar disease OD Resolved conjunctivitis OD Active keratitis OD
9	14 yo FS DSH	ISU LVMC	Ulcerative keratitis OD Conjunctivitis OD	Sodium hyaluronate ophthalmic solution, serum, 0.1% dexamethasone, 0.5% cidofovir, 1% cyclosporine, 0.3% tobramycin, 1% atropine; oral famciclovir; corneal debridement; bandage contact lens	187	Resolved keratoconjunctivitis OD
10	8 yo FS DLH	ISU LVMC	Eosinophilic keratitis OD Conjunctivitis OD Iris hyperpigmentation OD	Sodium hyaluronate ophthalmic solution, 1% prednisolone acetate, 0.5% cidofovir; oral L-lysine; corneal debridement	217	Active keratitis OD Static iris hyperpigmentation OD

Table 2. Results of tear film diagnostic tests and corneal aesthesiometry in 10 cats with aqueous tear deficiency (Schirmer tear test 1 < 9 mm/min) and concurrent ocular surface disease. Results are depicted as "right eye / left eye" and describe findings at the first visit except when mentioned otherwise in the column header. The lower reference limit (LRL) is noted for each test in the column header. STT-1 = Schirmer tear test 1; PRTT = Phenol red thread test; TFBUT = Tear film break up time; CTT = Corneal touch threshold; + = present; OD = right eye; OS = left eye.

Case #	Ocular surface disease present	STT-1 (LRL = 9 mm/min)[8]	STT-1 at last visit (LRL = 9 mm/min)[8]	PRTT (LRL = 15 mm/15sec)[8]	TFBUT (LRL = 9.1 sec)[8]	CTT (LRL = 3.0 cm)[12]	Corneal fluorescein stain retention	Corneal rose bengal stain retention
1	+ / +	2 / 0	7 / 5	26 / 30				
2	+ / +	0 / 0	0 / 5	19 / 11				
3	- / +	10 / 1	14 / 10	31 / 29			+ / +	+ / +
4	- / +	3 / 7	10 / 5	20 / 22			+ / +	- / +
5	+/+	0 / 0	0 / 0		5-7 / 5	0 / 1	+ / -	
6	+/+	0 / 19	13/ 20				- / +	
7	+/+	0 / 0	15 / 0				- / +	
8	+/-	0 / 15	9 /17				+ / -	
9	+/-	5 / 8	9 / 11				+ / -	
10	+/-	7 / 7	8 / 6			0.5 / 3	+ / -	

Table 3. Results of additional diagnostic tests performed in 10 cats with aqueous tear deficiency (Schirmer tear test 1 < 9 mm/min) and concurrent ocular surface disease. FHV-1 = Feline herpesvirus type-1; FCV = Feline calicivirus; FeLV Ag = Feline leukemia virus antigen; FIV Ab = Feline immunodeficiency virus antibodies.

Case #	Eye tested	Corneal cytology	Conjunctival histopathology	Infectious disease testing
4	Left	Eosinophilic, neutrophilic, and lymphocytic inflammation		Nucleic acids of FHV-1, FCV, *Mycoplasma felis, Chlamydia felis*, and *Bordetella bronchiseptica* not detected in corneo-conjunctival swab
5				FeLV Ag and FIV Ab not detected in serum
6	Right	Eosinophilic inflammation	Severe chronic lymphocytic, plasmacytic and neutrophilic conjunctivitis	
8	Right	Neutrophilic inflammation with squamous cell melanosis		
10	Right	Eosinophilic inflammation		

Figures and Figure legends

Figure 1. Clinical photographs of eyes of 10 cats at time of presentation for ocular surface disease and concurrent aqueous tear deficiency (Schirmer tear test 1 < 9 mm/min). Case numbers are shown in the top left and Schirmer tear test-1 values in the bottom right of each image. Abnormalities included symblepharon (Cases 1 and 2), corneal sequestrum (Cases 3 and 6), eosinophilic keratitis (Cases 4 and 10), non-healing corneal ulceration (Case 5), ulcerative keratitis (Case 9), conjunctivitis (Case 7), and retrobulbar abscess (Case 8).

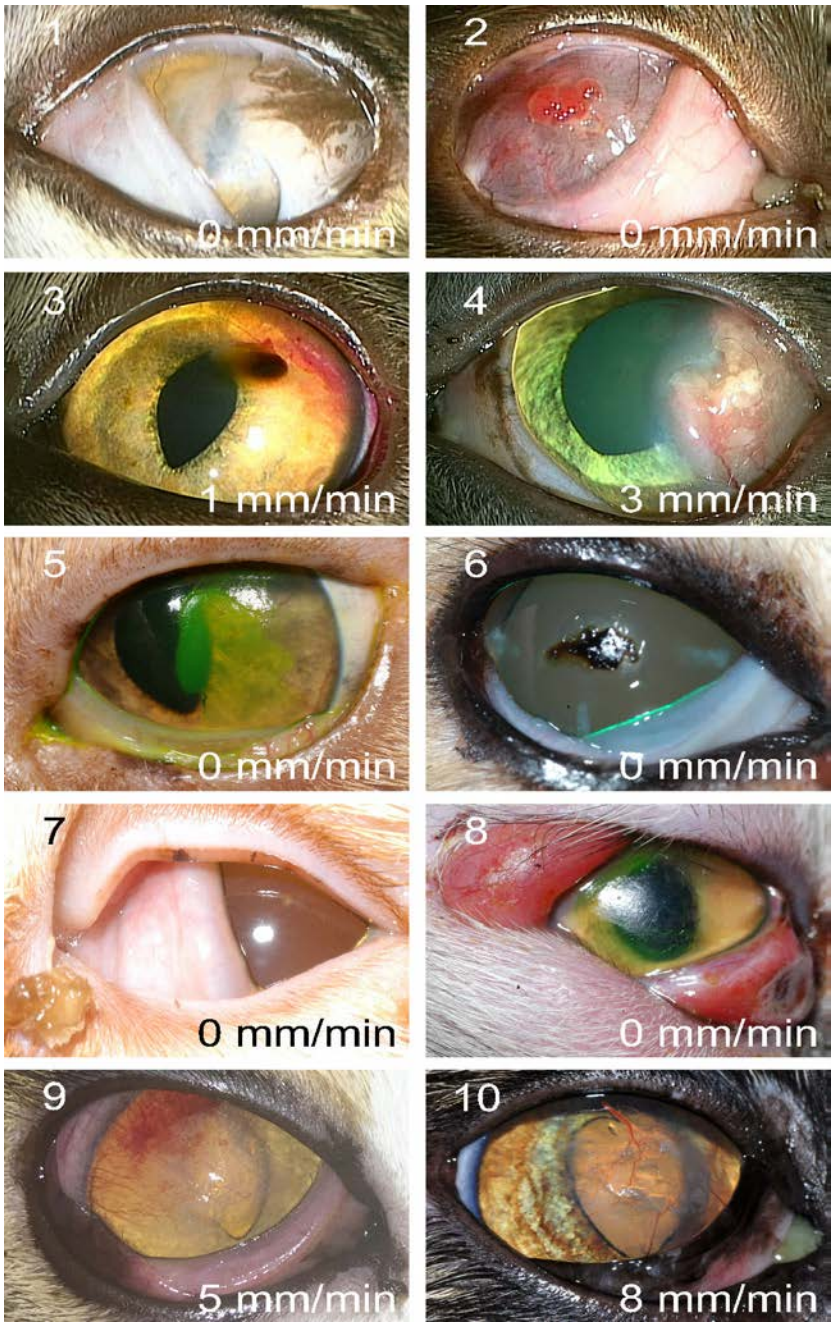

Figure 2. Clinical photographs of eyes of 4 cats at time of follow-up following therapy for ocular surface disease and concurrent aqueous tear deficiency (Schirmer tear test 1 < 9 mm/min). See Figure 1 for appearance at presentation. Case numbers are shown in the top left and Schirmer tear test-1 values in the bottom right of each image. Keratitis in Case 2 improved but symblepharon was static (Day 135). Eosinophilic keratitis resolved in Case 4 (Day 309). Corneal ulceration resolved in Case 5 but there was residual corneal fibrosis and neovascularization (Day 305). Keratoconjunctivitis improved in Case 8 following resolution of the retrobulbar abscess (Day 120).