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Evaluation of one- vs. two-layered closure after wedge excision of 43 eyelid tumors in dogs

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Abstract

Objective The aim was to evaluate how two closure techniques after full-thickness V-shaped excision relate to wound recovery and how these techniques affect eyelid function and stability of the preocular tear film.

Animals studied Thirty-eight dogs with 43 eyelid tumors involving <25% of eyelid margin length were included in a prospective randomized trial.

Procedures The method for wound closure was chosen randomly before the operation. In group A (n = 20), the wound was closed in one layer and in group B (n = 23) in two layers. The wound and eyelid structure were directly evaluated by slit-lamp biomicroscopy several times postoperatively. Eyelid function was indirectly evaluated by interferometry, noninvasive tear film breakup time (nTFBUT), and Schirmer's tear test at the last examination, 5 weeks to 19 months postoperatively.

Results No significant differences were found in group A vs. B although slightly more cases with perfect alignment of the eyelid were seen in group B. In both groups, neither slit-lamp biomicroscopy, interferometry, nTFBUT, nor Schirmer's tear test revealed negative influence on the eyelid function by the previous surgery. Histologically, 29 of 32 tumors were diagnosed as meibomian gland adenomas.

Conclusions These results do not demonstrate a significant difference in wound recovery, eyelid structure, and function after wound closure in 1 vs. 2 layers.

Key Words: eyelid function, eyelid wound closure, interferometry, meibomian gland adenoma, noninvasive tear film breakup time

INTRODUCTION

Eyelid tumors are common findings in elderly dogs. Most of these tumors are benign and originate from the meibomian glands.[1,2] The recommended treatment of choice for small tumors is surgical full-thickness wedge excision.[1,2] According to the current veterinary literature, the wound can be closed without additional blepharoplastic procedures, if the excised lid margin is less than one-quarter to one-third of the total length of the eyelid.[3,4]

To adapt these wounds, three methods are described in the literature:

(1) A single-layer wound closure.[4,5] This method starts by apposing the eyelid margin with a figure-of-eight or horizontal mattress suture with nonabsorbable or absorbable suture material. The remaining muscle-skin layer is apposed with single, interrupted sutures.
(2) A two-layered wound closure.[2,4,6] This method starts by apposing the deeper tarsoconjunctival layer with a simple continuous suture with buried knots of absorbable suture material. The eyelid margin and muscle-skin layer are sutured as described in the first method with nonabsorbable or absorbable suture material.
(3) A modification of the second method.[7,8] This method uses one single absorbable horizontal mattress suture with a buried knot to appose the tarsoconjunctival plate. The eyelid margin and muscle-skin layer are sutured as described in the first method. This third method is the most commonly used method in human medicine.[7]

One of the major functions of the eyelids is to spread the preocular tear film evenly over the ocular surface. Therefore, the surgical outcome of a well-aligned eyelid margin is essential for ocular surface health. An uneven eyelid margin may lead to trichiasis and or to an irregular

distribution of the preocular tear film, causing tear film instability with hyperevaporation of the lacrimal fluid that may finally cause clinical signs of keratitis and keratoconjunctivitis sicca.[9]

It is necessary to apply evidence-based veterinary medicine to the combination of clinical judgment and clinical expertise.[10–12] All ophthalmic surgeons share a basic understanding of eyelid anatomy and function, and over time, each has accumulated a certain amount of clinical expertise. However, it is necessary to mix the use of clinical judgment and expertise with scientific evidence in order to practice evidence-based medicine. To the authors' knowledge, there are no studies that compare the effect of eyelid margin wound closure on the tear film and ocular surface health in dogs. This study theorized that the surgical outcome of a poorly aligned eyelid margin might have a direct effect on the tear film and that suturing technique might influence this outcome. This prospective and randomized study was set out to compare and report the results of full-thickness eyelid wedge, or 'V'-shaped, resection and wound repair between two suturing techniques and their effect on the tear film, with the hope to serve as a source of evidence-based medicine for surgical recommendation.

MATERIALS AND METHODS

Animals

A total of 38 canine patients undergoing full-thickness removal of eyelid neoplasm, smaller than 25% of the entire eye lid length, were included.

Clinical examination

Each dog underwent a preoperative ophthalmic examination performed by the same examiner (GR) that included Schirmer's tear test I (STT; Intervet, Berlin, Germany), fluorescein staining (fluorescein dye paper strips; Haag-Streit, Köniz, Switzerland), and slitlamp biomicroscopy (Kowa SL-15; Kowa, Tokyo, Japan).

Surgery

A standard preventive single dose of amoxicillin-clavulanic acid (12.5 mg/kg, IV, AmoxClav; Hexal, Holzkirchen, Germany) was administered to each dog prior to general anesthesia.[13–15] All tumors were excised by a V-shaped full-thickness incision at least 5 mm beyond the eyelid margin. The method of wound closure for each animal was chosen randomly before the procedure. The wounds of animals in group A ($n = 20$) were closed in a single layer, and those of group B ($n = 23$) were closed in a double layer. Single-layer closure (group A) was achieved through the combination of a figure-of-eight suture to close the eyelid margin and simple interrupted skin sutures to close the remainder of the wound. Double-layer closure (group B) was achieved through a combination of tarsoconjunctival plate horizontal mattress suture with buried knots followed by the same closure as that utilized in animals in group A. Suture material used for the skin included 4-0 monofilament polyamide (Dafilon, Braun Aesculap, Tuttlingen, Germany) and for the tarsoconjunctival plate 6-0 polyglactin 910 (Vicryl, Ethicon; Johnsen & Johnsen, Norderstedt, Germany). The surgeries were performed by one of the two authors (JCE, GR). Both used the same techniques, and the second one was trained and supervised by the first, at all times, ensuring no obvious differences in technique would take place.

Postoperatively, the dogs received oral metamizol (20 mg/kg, PO q 12 h, Novaminsulfon; Ratiopharm, Ulm, Germany) for 3–5 days and a topical treatment with neomycin, gramicidin, and polymyxin B eye drops (q 8 h, Polyspectran; Alcon, Freiburg, Germany) for 1 week.

The nonabsorbable skin sutures were removed after 2 weeks. Thirty-two of the 43 excised tumors were fixed in 10% formalin and submitted for histopathologic examination.

Follow-up wound repair and eyelid structure

The wounds were evaluated by the first author (GR) 2 h ($n_A(t_1) = 20$, $n_B(t_1) = 23$), 2 weeks ($n_A(t_1) = 15$, $n_B(t_1) = 21$), and more than 1 month after the operation ($n_A(t_1) = 12$, $n_B(t_1) = 17$). The follow-up time ranged from 5 weeks to 19 months with a mean time of 10.1 months after the operation.

During these examinations, the wound was evaluated for presence of blood, swelling, depigmentation, and for the recovery of the eyelid structure.

A scoring system was established to grade these features. For the features blood, swelling, and depigmentation, grades 0, 1, and 2 were used for 'not', 'mildly', and 'clearly' present.

To evaluate the eyelid structure, imaginary *x*-, *y*-, and *z*-axes were introduced (Fig. 1). The *x*-axis was drawn as a line parallel to the eyelid margin, the *y*-axis perpendicular to the *x*-axis, and the *z*-axis as a line perpendicular to both the *x*- and *y*-axes. In the scoring system, the misalignment of the axes was graded as follows: grade 0 represented an absence of misalignment; grade 1 represented a

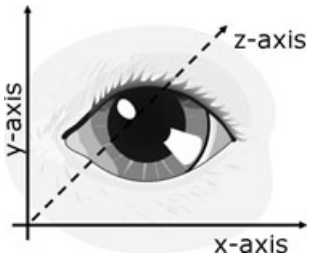

Figure 1. Imaginary set of three axes (*x*, *y*, and *z*) defined to assess eyelid wound alignment. The *x*-axis is drawn parallel to the eyelid margin; the *y*-axis, perpendicular to the *x*-axis; and the *z*-axis, perpendicular to the other two and arising at the cross-point of x and y and extending posteriorly.

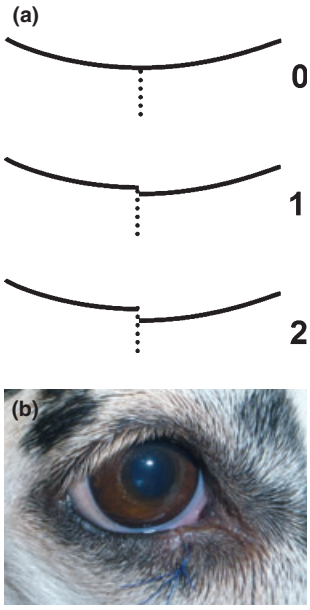

Figure 2. (a) Scoring system used to describe the grade of misalignment with respect to the *y*-axis of the eyelid. Grade 0 shows no misalignment; grade 1, <1-mm misalignment; and grade 2, more than 1-mm misalignment. (b) Clinical picture of a grade 2 misalignment in the *y*-axis of the eyelid, 2 weeks after a full-thickness wedge excision closed in two layers (group B).

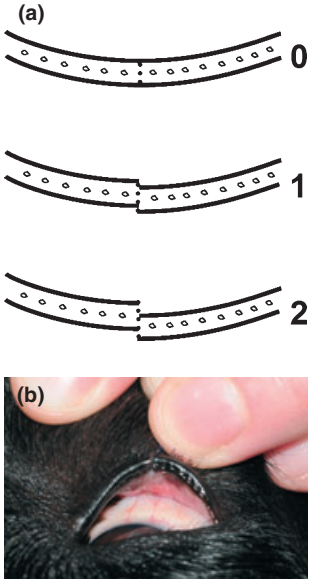

Figure 3. (a) Scoring system used to describe the grade of misalignment with respect to the *z*-axis of the eyelid. Grade 0 shows no misalignment; grade 1, <25% misalignment; and grade 2, more than 25% misalignment. (b) Grade 1 misalignment in the *z*-axis of the eyelid, 2 weeks after a full-thickness wedge excision closed in one layer (group A).

misalignment of <1 mm in the *y*-axis or <25% displacement of the *z*-axis (Figs 2a and 3a,b); and grade 2 represented a misalignment of more than 1 mm in the *y*-axis or more than 25% displacement of the *z*-axis (Figs 2a,b and 3a).

Evaluation of the tear film and eyelid function

To evaluate the effect of wound recovery on the distribution and stability of the preocular tear film, data on interferometry, noninvasive tear film breakup time (nTFBUT), and Schirmer's tear test I (STT-I) were collected in 12 dogs ($n_A = 4$ and $n_B = 8$) at a mean follow-up time of 10.1 months (5 weeks to 19 months) postoperatively. These examinations were always performed by the same examiner (GR).

Interferometry was performed with the Tearscope-plus (Keeler, Windsor, UK) to assess the lipid distribution pattern as described by Craig and Tomlinson.[16] Normal distribution patterns are described as an open or closed meshwork, flow, amorphous, or normal colored fringes (Table 1).

The tear film stability was judged by measuring nTFBUT using the same Tearscope-plus and a grid insert. With the help of this grid insert, a grid pattern was projected onto the tear film, making it easier to see changes in the tear film regularity. The breakup time was defined as the time elapsed between the appearance of a clear grid pattern at time zero and the appearance of irregularities in the pattern as described by Mengher *et al.*[17] and Guillon.[18] The nTFBUT was taken as the mean of three measurements per eye.[19,20] The cut-off value of 5 s was considered as diagnostic for an unstable tear film leading to an evaporative dry eye.[19,21]

As the complete recovery of the tear film after measuring the tear film breakup time (TFBUT) with the use of fluorescein has been reported to occur in 10–20 min,[21] STT-I was not measured until 20 min after nTFBUT testing was performed. For the STT-I, a reference value of 20.4 mm ± 2.89 mm was used.[22]

The results of the assessment of the preocular tear film obtained in operated eyes were compared with those of the nonoperated fellow eye of the same dog at the same day.

Table 1. Different lipid layer patterns that can be seen with the Tearscope-plus. Each pattern corresponds to an estimated lipid layer thickness. An absent and abnormal colored fringes pattern leads to higher tear film evaporation and to signs of keratitis or keratoconjunctivitis sicca[13,15,27,28]

	Lipid layer pattern	Estimated thickness (nm)	Appearance
1	Absent	<10	No visible layer
2	Open meshwork	10–20	Very thin white–blue layer
3	Closed meshwork	20–40	Thin white–blue layer
4	Flow	30–90	White–blue layer with distinct colors
5	Amorphous	80–90	Dens white–blue layer
6	Normal colored fringes	>100	Waves with gradually changing colors
7	Abnormal colored fringes	Variable	Highly variable colored areas

Statistical analysis

Fisher's exact test with a confidence level of 95% was used to compare the parameters of the wound recovery in group A vs. group B. Due to the small amount of data for the parameters of the eyelid function, these results were described rather than statistically tested.

RESULTS

A total of 43 wounds after removal of eyelid tumors in 38 dogs met the inclusion criteria. The mean age of the dogs was 10 years (3–14 years), and there was no sex predilection (21 male, 17 female). Four dogs were presented with one eyelid of each eye affected by a tumor, one dog had one tumor at each eyelid of one eye, and the remaining 33 dogs showed only one eyelid neoplasm. There was no side predilection (22 left eyes, 21 right eyes). Most tumors (31 of 43) were situated in the upper eyelid. The dogs represented purebred and mixed breeds, and none was predominant. Breeds presented more than one time are listed in Table 2. When classified by body weight, seven dogs weighed <10 kg; 21 dogs, between 10 and 20 kg; and 10 dogs, more than 20 kg.

Beside the eyelid tumor, no other ocular abnormalities were found in 34 dogs. Four dogs were previously diagnosed with keratoconjunctivitis sicca (KCS). All were treated with cyclosporine A (q 12–24 h, Optimmune; Intervet, Unterschleißheim, Germany) and artificial tear replacements. In all dogs, the preoperative Schirmer's tear test I readings were above 15 mm/min. Thirty dogs were clinically healthy. Four dogs were previously diagnosed and treated for a cardiac disease. One dog was diagnosed and treated for hypothyroidism together with a cardiac disease. Two dogs were diagnosed and well-regulated for diabetes mellitus, and one was diagnosed and treated for leishmaniasis. All animals, including the ones treated for systemic diseases showed normal blood parameters preoperatively.

Follow-up of wound repair and eyelid structure

Table 3 describes the clinical findings for the wound recovery and eyelid structure 2 h, 2 weeks, and more than 1 month, ranging from 5 weeks to 19 months, after the operation.

Table 2. The dogs in the study represented more different breeds. Breeds represented more than once are listed

Breed	Frequency	Age (years)
Mongrel (10–20 kg)	5	(3) 9–14
Labrador retriever	3	10–12
Labrador mix	1	10
Beagle	3	9–12
West Highland White Terrier	3	10–14
American Cocker Spaniel	2	10–13
Poodle	2	11–14

One wound in group A bled during the recovery, 2 h after the operation. This bleeding stopped and did not need any further surgical intervention. A swelling was seen in almost every wound 2 h after the operation (A: 19 of 20 vs. B: 21 of 23). The swelling reduced after 2 weeks and disappeared in all wounds except one in group A. Depigmentation was seen in half of the cases in both groups 2 weeks after the operation (A: 8 of 15 vs. B: 10 of 21). In a few cases, distinct depigmentation still existed more than 4 weeks after the operation (A: 1 of 12 vs. B: 2 of 17).

Concerning alignment in the *y*-axis, misalignment of <1 mm was seen in a small part of cases in both groups, during the whole follow-up (Table 3). A misalignment of more than 1 mm was only seen in two cases in group B 2 h postoperatively (B: 2 of 23). This misalignment was not visible any more 2 weeks after surgery in the first case and not visible at the last follow-up examination in the second case.

Concerning alignment in the z-axis, a misalignment of <25% was seen in five cases direct postoperatively in group A (5 of 20) and in three cases in group B (3 of 23). At the last examination, this small misalignment had disappeared in group A, but was still visible in two cases in group B (Table 3). A misalignment of more than 25% was seen in one case in group A 2 h after the operation (A: 1 of 20). This misalignment reduced during the follow-up. One case in group B developed a misalignment of more than 25% after more than 4 weeks (B: 1 of 17).

A perfect alignment in both axes at the same time was observed in more cases in group B than in group A, during the whole follow-up period.

Statistically the differences in bleeding, swelling, depigmentation, and alignment between the two methods were not significant ($P > 0.05$).

Evaluation of the tear film and eyelid function

Table 4 shows the results of the interferometry, STT-I, and nTFBUT measured in both eyes during the last examination ($n_A = 4$, $n_B = 8$). Within this group of animals, one dog in group B was diagnosed and well-regulated for Diabetes mellitus (B3, Table 4). Two dogs were known to suffer from and were treated for KCS (A2, A3, Table 4).

Interferometry revealed a normal tear film lipid layer in all operated eyes (Table 4). None of the operated eyes exhibited an unstable tear film. All eyes had a nTFBUT of more than 5s.

An abnormal STT-I of <15 mm/min, but above 10 mm/min, was only found in the operated eyes of two dogs previously diagnosed and already treated KCS (A2, A3, Table 4).

Almost all dogs were free of tumor recurrence during the last examination (37 of 38, 97.4%). Only one dog (group B) showed a small tumor at the excision side 19 months after the operation. At the request of the owner, no histopathology was carried out on the excised first tumor and no excision of the second tumor was performed. It is unknown whether this tumor is a recur-

Table 3. Clinical findings of the eyelid structure after a full-thickness wedge excision closed in one layer (group A) or two layers (group B) in dogs. The findings are graded, grade 0 standing for no alterations, grade 1 for subtle alterations, and grade 2 for obvious alterations. The follow-up was $t = 1$, 2 h; $t = 2$, 2 weeks, and $t = 3$ more than 1 month (mean 10.1 months) after the operation

Time	Group	*n*	Bleeding Grade 0	Bleeding Grade 1	Bleeding Grade 2	Swelling Grade 0	Swelling Grade 1	Swelling Grade 2	Depigmentation Grade 0	Depigmentation Grade 1	Depigmentation Grade 2	Misalignment *y*-axis Grade 0	Misalignment *y*-axis Grade 1	Misalignment *y*-axis Grade 2	Misalignment *z*-axis Grade 0	Misalignment *z*-axis Grade 1	Misalignment *z*-axis Grade 2	Perfect alignment
$t = 1$	A	20	19	0	1	1	17	2	20	0	0	16	4	0	14	5	1	11
	B	23	23	0	0	2	20	1	23	0	0	18	3	2	20	3	0	17
$t = 2$	A	15	15	0	0	10	4	1	7	8	0	11	4	0	10	5	0	7
	B	21	21	0	0	17	3	1	11	7	3	15	5	1	17	4	0	13
$t = 3$	A	12	12	0	0	11	1	0	11	1	0	7	5	0	12	0	0	7
	B	17	17	0	0	17	0	0	15	2	0	13	4	0	14	2	1	13

rence or a new tumor. For the interpretation of the results, this was accepted as a regrowth of the excised tumor, because it developed at the same place as the first tumor and had the same macroscopic appearance.

Histologic examination

Histologically, all 32 submitted tumors had a margin free of neoplastic cells. Most of the submitted tumors (29 of 32, 90.6%) were diagnosed as meibomian gland adenomas. One tumor was diagnosed as a papilloma. This tumor was found in a 3-year-old mixed-breed dog diagnosed for leishmaniasis. One tumor was diagnosed as a diffuse, lymphoplasmacellular, chronic dermatitis (Polish lowland sheepdog, 10 years old). One tumor was diagnosed as a dermal melanocytoma without signs of malignancy (Shih Tzu, 14 years old).

DISCUSSION

Surgery

For small eyelid tumors, treatment by full-thickness wedge excision is preferred.[1,2] Other treatment options described within the literature include cryotherapy,[23] hyperthermic therapy, carbon dioxide laser therapy,[24] radiation therapy, chemotherapy, immunotherapy, and photodynamic therapy.[6] Unfortunately, all these methods need other specialized equipment, and most of them have not been proven to offer a better result than simple resection.[6]

Peterhans and Keller[8] pointed out that the length of the arms of the V-shaped wedge excision should be twice as long as the tumor, otherwise it would lead to wound dehiscence or entropion. As the regular canine palpebral fissure size is described to be 33–35 mm,[25] a tumor of 25% of the eyelid margin would have a length of 7–8 mm. According to Peterhans and Keller,[8] an excision of 16 mm beyond the eyelid margin would be recommended.[8] In the presented study, the excisions beyond the eyelid margin were performed for at least 5 mm but never as long as twice as the tumor. The nonoccurrence of wound dehiscence and entropion in 43 cases stands in contrast to the given recommendations.

For skin closure of the eyelids, nonabsorbable 3-0 to 5-0 nylon, polypropylene, polyester, Dacron, or silk is usually recommended,[4] and more specialized microsurgeons might even use smaller material. The aim of this study was to use basic ophthalmic procedures and to evaluate the effect of an extra suture layer on eyelid wound recovery. Therefore, the same suture was used for the skin suturing in all animals. For the additional closure of the tarsoconjunctival layer, a second suture material, the absorbable polyglactin 910, which is also widely used in veterinary ophthalmic surgery, was used.[4] Whether smaller (e.g., 5 or 6-0) or absorbable suture material (e.g., polyglactin 910) would have had a positive influence on the eyelid wound healing was beyond the focus of this study and would need further clinical research.

Table 4. Clinical findings concerning the interferometry pattern, noninvasive tear film breakup time (nTFBUT), and Schirmer's tear test I (STT-I) reflecting eyelid function more than 1 month (mean 10.1 months) after a full-thickness wedge excision closed in one layer (group A) or two layers (group B) in dogs. The nonoperated fellow eye of the same animal served as the control eye

	Operated eye			Control eye		
Animal	Interferometry	nTFBUT (s)	STT (mm/min)	Interferometry	nTFBUT (s)	STT (mm/min)
A1	Normal fringes	16.0	20	Normal fringes	9.6	23
A2	Normal fringes	9.9	12	Normal fringes	7.5	14
A3	Open meshwork	11.3	10	Open meshwork	8.2	23
A4	Flow pattern	11.6	17	Closed meshwork	6.2	18
B1	Flow pattern	9.5	23	Flow pattern	8.9	22
B2	Normal fringes	12.5	20	Normal fringes	10.1	20
B3	Normal fringes	8.3	18	Normal fringes	12.7	10
B4	Flow pattern	15.1	19	Flow pattern	23.3	20
B5	Normal fringes	13.4	18	Normal fringes	8.1	19
B6	Flow pattern	16.3	21	Flow pattern	10.7	23
B7	Normal fringes	10.6	19	Normal fringes	8.0	20

Case selection

Three dogs well-regulated for Diabetes mellitus or hyperthyroidism were included in this clinical study, because this trial was not scheduled as an experiment in laboratory animals and because it is well-known that elderly dogs may suffer from systemic diseases. In humans, diabetes mellitus is described to cause significant impairment to wound healing, but this has not been documented in dogs.[26] Additionally, data on risk factors for postoperative infection and wound healing in the veterinary literature have produced conflicting results, showing endocrinopathy as a risk factor in one study[27] but not in another.[28] Retrospectively, the authors could not detect a negative influence on the wound healing in these clinically well-controlled dogs.

Unfortunately, there is little specific knowledge on how the tear film tests would be changed by a preexisting condition like KCS being under the regular use of medication like cyclosporine A and/or endocrinopathies like diabetes well-regulated by long-term treatment. In the presented study, this influence was mitigated by testing both eyes of the same dog, using the second nonoperated eye as 'an internal control'. In the long term, more detailed clinical studies on the preocular tear film in dogs treated for ocular and/or systemic diseases are needed.

Follow-up of wound repair and eyelid structure

One dog with a wound closed with a single layer showed bleeding of the wound 2 h postoperatively. This dog had an uneven recovery from anesthesia, and it was assumed that the bleeding was caused by rapid movements during recovery.

Depigmentation was only visible in pigmented eyelids. At the side of the wound, in the first 2 weeks postoperatively, non pigmented tissue covers the wound, and later, pigmentation is produced.

To evaluate the recovery of the eyelid structure, *x*-, *y*-, and *z*-axes were defined (Fig. 1). A misalignment of more than 1 mm in the *y*-axis was seen in two cases in group B, 2 h postoperatively. This obvious misalignment was not visible any more, more than 4 weeks postoperatively. A possible cause for an obvious misalignment only in the two-layered closed wounds could be either the additional suture material at the site of the wound or the additional postoperative tension caused by the continuous tarsoconjunctival suture. The tension and strength of polyglactin 910 decrease with 35% in 2 weeks and will be completely resorbed in 56–70 days.[29] The tension of the suture on the flexible tarsoconjunctival structure is therefore greatest in the first 2 weeks and will disappear after 2 months.

A misalignment of more than 25% in the *z*-axis was identified in one case in group A 2 h postoperatively and in one case in group B after more than 4 weeks postoperatively. In the first case, the misalignment became <25% after more than 4 weeks. In both dogs, the neoplasia was within the lower eyelid situated almost at the lateral canthus. After excision, the very thin temporal eyelid margin had to be appositioned to the other side of the wound with a normal eyelid thickness. In the second case, the eyelid was not pigmented, and due to postoperative wound swelling, the misalignment was not so obvious during the first examinations, but became obvious during the last evaluation. Comparing only these two cases leaves the impression that a misalignment fixed in one layer has more potential to restructure than a wound fixed in two layers.

With respect to a perfect alignment in both axes y and z, it could be seen that this was obtained in more cases in group B than in group A. This would fit to the principle that by a second fixation, rotation around the first fixation point would be inhibited.

The differences found in eyelid structure during and after the recovery in groups A and B could not be proven statistically.

Evaluation of the tear film and eyelid function

To the authors' knowledge, there are no data published for the assessment of eyelid function and ocular surface

health after excisional eyelid surgery in the current human or veterinary literature. Within the group of 12 dogs re-examined at t_3, there were two dogs previously diagnosed and treated for KCS and one dog well-controlled for Diabetes. As little knowledge is available on how the tear film would be influenced by a preexisting condition like KCS and/or Diabetes being under long-term treatment, this condition was mitigated in the presented study by testing both eyes of the same dog, using the second nonoperated eye as 'an internal control'. Therefore, the outcome of the operated eye was compared with the clinical findings of the nonoperated fellow eye of the same animal.

Interferometry is a diagnostic procedure that permits the imaging of the interference pattern of the tear film. This pattern is created by the lipid layer at its interface with the aqueous subphase of the tear film and can be observed in human and canine patients by the use of the Tearscope-Plus.[16,18,30,31] Depending on the thickness of the lipid layer, seven patterns have been described (Table 1).[16,18,30,31] Interferometry did not reveal any abnormal color fringes or absent lipid pattern in this study. Therefore, it was concluded that all the dogs had a sufficient lipid layer to prevent a hyperevaporative dry eye postoperatively.[16] These findings are in agreement with the perception in human ophthalmology that up to 30% of meibomian function can be lost without the clinical consequence of hyperevaporative dry eye.[32,33]

The classic test of tear film stability is the fluorescein tear film breakup time (TFBUT). This is an invasive test that requires the instillation of fluorescein sodium. Unfortunately, fluorescein has been shown to influence the TFBUT in human ophthalmology.[20,34] A decreased TFBUT was measured by Mengher and coworkers,[34] and an increased TFBUT was measured by Johnson and Murphy.[20] As a consequence, the so-called nTFBUT, which does not require an instillation of fluorescein, was introduced in human ophthalmology.[17] To the authors' knowledge, there are no data on the nTFBUT in dogs, only about the invasive TFBUT. The reported mean TFBUT in sedated, young, and healthy beagles (n = 22) is 19–20 s and in nonsedated healthy beagles (n = 24) 22 s.[35,36] In human literature, it is described that nTFBUT becomes lower with age,[37] but no information could be found about the influence of the age or the breed of the dog on the nTFBUT. The clinical impression of the author from a pilot study concerning inter- and intraobserver variation in obtaining TFBUT in dogs is that it is challenging to obtain measurements in conscious dogs (unpublished data). Most of the dogs were trying to squint or retract their eyeballs resulting in (partial) protrusion of the third eyelid minimizing the visible cornea. Based on the author's clinical experience in veterinary medicine and the tendency in human ophthalmology to use the nTFBUT, it was chosen to use the noninvasive method for the presented study. The cut-off value of 5 s for tear film instability was adapted from human literature without further verification in healthy or dogs suffering from evaporative dry eye.[19,21] The mean nTFBUT in this study was 10 s (SD 4.0 s), and there was no measurement <5 s in the operated eyes. The nonoperated fellow eye of the same animal served as the control eye (mean nTFBUT 8.9 s, SD 4.4 s), and there was no difference between both eyes of one dog. It was not clear whether this relatively short breakup time was due to the use of the noninvasive method, due to the relatively high age of dogs, or due to the different kind of presented breeds. Further investigation measuring the noninvasive and invasive TFBUT's in dogs is highly encouraged.

By measuring the STT, a part of the tear film is absorbed by the test strip.[38] This changes the relative composition and stability of the tear film and makes this test more invasive than measuring the nTFBUT.[39] Therefore, the Diagnostic Methodology Subcommittee of the International Dry Eye Workshop recommends to start with the less invasive eye tests, like interferometry and nTFBUT, before the more invasive STT-I.[39] The readings taken in the dogs of this study were in agreement with other clinical studies obtaining STT-I readings in healthy dogs.[22,38]

In the authors' opinion, it would have been better to have a larger number of dogs and data concerning eyelid function and ocular surface health at the last follow-up. In this time-limited prospective study, it was unpredictable how many dogs of which group would be available until the last follow-up. Unfortunately, there was a high loss of cases during follow-up. It can only be hypothesized that this happened due to the age of the animals, long travel distance for some of our clients, and maybe due the good results that did not imply the wish for a recheck for the owner. For further studies, care should be taken to reach better end study numbers.

Histologic examination

90.6% of the lid tumors examined in this study were meibomian gland adenomas. This fits to 70-80% described by Gelatt and Gelatt[4] and Martin,[6] but is much higher than a prevalence of 28.7%[40] or 60%[23] described previously. A confounding factor in this study might be the selection of small lid tumors. Krehbiel and Langham[40] mentioned that malignant tumors were comparatively larger than benign forms. Dubielzig *et al.*[41] described meibomian gland adenomas as relatively small superficial tumors. Another reason for the large number of benign tumors in this study may be the increased awareness of owners toward neoplastic disease and their increased willingness to address even small lesions on their pet and to submit the excised tumor for pathologic examination.

Papillomas typically occur in young dogs.[1] Accordingly, the only papilloma in this study was derived from a relatively young, 3-year-old dog.

Recurrence

The recurrence rate of a meibomian gland adenoma 28 months after surgery is described to be low (15.0% by

Gelatt[1] and 10.5% by Roberts *et al.*[23]). In this study, the recurrence rate of the meibomian gland adenoma was 3.4% one to 19 months after surgery. As the follow-up time was shorter than within the literature and not the same in all cases, it cannot be compared with the rates described in other studies.

CONCLUSION

There were no significant differences found in the recovery of the wound, eyelid structure, and function after wound closure in 1 vs. 2 layers. Wedge excision of eyelid neoplasms smaller than 25% of the eyelid margin did not have an effect on the tear film and ocular surface health.

CONFLICT OF INTEREST

None of the authors of this article has a financial or personal relationship with any person or organization that could inappropriately influence or bias the content of this manuscript.

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