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A retrospective study of dogs with dacryocystitis: 41 cases.

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1 Introduction

Dacryocystitis is defined as an inflammation of the lacrimal sac (Lavach et al. 1984). With other authors, e.g. (*exempli gratia*, for example) Giuliano (2017), Leiva and Gimènez (2018) or Pickett (2019), the nasolacrimal duct (NLD) is included as well. The tear puncta, the canaliculi and the before mentioned anatomical structures drain the accumulated tears from the eye surface to the external nares. Due to inflammation, the nasolacrimal apparatus (NLA) can occlude and the affected dogs are presented with typical clinical symptoms, like purulent discharge and swelling of the medial canthus region (Grahn and Sandmeyer 2013).

For this retrospective study of the disease, dogs of all animals have been chosen, because they are often affected (Leiva and Gimènez 2018; Pickett 2019). Their dacryocystitis is mainly foreign body induced or a consequence of congenital malformations. Non-existence of the puncta, the canaliculi or NLD are congenital causes. These dogs usually suffer from a life-long history of clinical symptoms. Plant awns, sand or dirt can get into the lacrimal sac and inflame and/or obstruct the natural tear-outflow system (Leiva and Gimènez 2018).

Evaluation of nasolacrimal patency and finding the triggering factors for the obstruction and pain can be a difficult task for veterinary practitioners. The dogs usually do not present with a clear history of foreign body penetration. Therefore diagnosis and proper treatment are often made late on the course of the disease. Rabbits or human neonates are more often affected than dogs, due to their unique anatomical structures (Kanski 2015; Bedard 2019). NLA diseases are rarely described in horses and in some instances in cats (Leiva and Gimènez 2018).

1.1 Aim of the study and hypotheses

The aim of this study is to evaluate the cases diagnosed with dacryocystitis in client-owned dogs at the University of Veterinary Medicine in Vienna from 2001 to the end of 2019, retrospectively. With the acquired data, the following questions should be answered:

1. Is a complete clinical and ophthalmological examination enough for making the diagnosis of dacryocystitis?
2. What is the most common aetiology?
3. Are imaging techniques, like contrast radiography and computer tomography (CT), adding any data of therapeutic value?
4. What is the most effective treatment?

The hypotheses are that dacryocystitis can be diagnosed by an ophthalmological examination, the most common cause is foreign body induced, imaging techniques are not always able to display the foreign body and that an early surgical approach is far more effective than conservative treatment.

2 Literature

2.1 Anatomy and physiology of the nasolacrimal drainage system in dogs

The anatomical structures of the nasolacrimal drainage apparatus in dogs include the superior and inferior puncta at the lid margin that drain the tears into the canaliculi, which consolidate to form the lacrimal sac (Yakely and Alexander 1971). This sac is just a slight dilatation at the beginning of the NLD, not a real sac, like it is in humans or rabbits (Marini et al. 1996; Kanski 2015; Murphy et al. 2013). The NLD passes through the lacrimal canal in the lacrimal and maxillary bones and ends at the nasal punctum, inside the external nares (Murphy et al. 2013). Depending on skull conformation, some dogs may have an additional drainage into the nasopharynx or oropharynx (Grahn and Sandmeyer 2013).

Brachycephalic breeds show a shorter and wider NLD, which makes them less susceptible to obstructions (Crispin 1987). In comparison to normocephalic breeds, their canaliculi have longer dimensions and their NLA follows a different path within the head due to shortening of the midface. Both, brachycephalic cats and dogs show a steeper path of the NLD. This leads to chronic epiphora in affected cats, while affected dogs show no consequences of this kind, since they often drain the tear fluid through an additional opening into the nares or pharynx (Breit et al. 2003; Sahr 2014).

The complete NLA itself is lined with pseudostratified columnar epithelium (Dellmann 1998).

2.2 Diseases of the nasolacrimal drainage system in dogs

2.2.1 Congenital causes

Congenital anomalies of the nasolacrimal system are atresia of the lacrimal puncta, canaliculi or duct, misplacement of the puncta, micropuncta, cysts or ectopic teeth. Missing puncta or micropuncta are regularly observed in some specific Spaniel, Poodle or Terrier breeds, as well as in the Golden retriever and Samoyed. This is usually unilateral and only leads to symptoms, if the lower punctum is affected. Epiphora (tear overflow) may be the only symptom noticeable (Pickett 2019). Not only can the puncta be missing, but also the canaliculi or NLD itself. This is rare in dogs and leads to severe epiphora (Grahn and

Sandmeyer 2013). Brachycephalic breeds and toy breeds are predisposed for misplaced lower lacrimal puncta, due to congenital entropion of the medial lower eyelid (Pickett 2019).

Lacrimal cysts, e.g. dacryops (cysts arising from glandular tissue) or canaliculops (cystic dilatations of the lacrimal canaliculi) have been described in literature and may induce dacryocystitis and occlude the NLA. The exact pathogenesis for those cysts is uncertain, but a congenital anomaly of embryological development is suspected (Grahn and Sandmeyer 2013). Gerding (1991) reports on canaliculops in a young, female Labrador retriever. Symptoms were epiphora, painless swelling under the medial canthus and impatency of the NLD on the affected side (Gerding 1991). Davidson and Blanchard (1991) describe periorbital epidermoid cysts in the medial canthi of three dogs that did not communicate with the NLA, but occluded it through pressure (Davidson and Blanchard 1991). Dacryops is described in case reports about young Labrador retrievers and Basset hounds. With ectopic lacrimal gland tissue, they can occur anywhere near the medial canthus and cause fluctuant swelling with NLD obstruction (Grahn and Mason 1995; Cullen and Grahn 2003; Ota et al. 2009).

Case reports from Ritz et al. (2013) and Voelter-Ratson et al. (2015) describe dacryocystitis as a result of a congenital ectopic/impacted tooth in a seven-month-old female Collie and a five-year-old male Border collie. Both dogs were presented with a history of lifelong epiphora, due to an obstruction on the affected side. Flushing of the NLD was impossible in both cases. The ectopic tooth was already visible on native radiography and therefore contrast induced dacryocystorhinography on x-ray (DCR, the method is described under 2.3.5.) was conducted. It revealed a cystic dilatation of the NLD in front of the tooth. Surgical removal was declined by the owner, so the epiphora persisted (Voelter-Ratson et al. 2015). Ritz et al. (2013) conducted contrast-induced computer tomography-dacryocystography (CT-DCG, the method is described under 2.3.5.), which revealed an impacted caninus as cause for the NLD obstruction. Surgical extirpation was curative (Ritz et al. 2013).

2.2.2 Acquired causes

Acquired inflammation or obstruction of the NLA is mostly caused by foreign bodies. Plant-based foreign bodies (e.g. grass awns) find their way through the puncta and canaliculi to the lacrimal sac where they cause dacryocystitis (Lavach et al. 1984; Laing et al. 1988; Strom et al. 2018; Barsotti et al. 2019). This happens more often in outdoor active dogs in the dry

seasons of the year (Lavach et al. 1984). The foreign body can migrate from the lacrimal sac to the NLD, causing inflammation, obstruction and retrograde dacryocystitis (Pope et al. 2001). End stage inflammatory reaction can result in a constipated NLD by debris, granulating tissue (Giuliano et al. 2006), periostits (Lavach et al. 1984) or osteolysis of the lacrimal bone (Yakely and Alexander 1971). Obstruction of the NLD can lead to cystic dilatation (White et al. 1984; Zimmerman et al. 2019; Wallin-Haakansson and Berggren 2020), and can cause secondary dacryocystitis (van der Woerdt et al. 1997; Lussier and Carrier 2004). Another route of foreign body penetration into the lacrimal sac is described through a dental alveoli of the upper jaw after tooth extraction (Walde et al. 2008).

Other acquired causes of NLA diseases include trauma, neoplasia, cystic malformations or teeth-associated inflammation. Facial bone fractures or eyelid lacerations, due to mechanical trauma, can secondary occlude or separate parts of the NLA (Grahn and Sandmeyer 2013; Pickett 2019). Lysis of tooth roots or periodontal diseases of the upper premolars or molars can result in dacryocystitis and obstruction (Yakely and Alexander 1971; Gelatt et al. 1972; Nykamp et al. 2004). Primary neoplasia of the nasolacrimal sac and duct is uncommon (Pe' er et al. 1996; Grahn and Sandmeyer 2013). Tumors in the nasal cavity or maxillary area are described (Gelatt et al. 1972; Nykamp et al. 2004) and may secondary occlude or invade the NLD and induce inflammation, noticed as massive swelling, mucopurulent ocular or nasal discharge and conjunctival hyperemia. These tumors of different origins may also spread into the orbita and lead to exophthalmos (Grahn and Sandmeyer 2013).
Obstruction of a canaliculus due to dacryoliths (intraluminal calculi) is described in a four-year-old Labrador retriever. The NLA was patent as the dacryoliths were laying in a diverticulum of the lower canaliculus and they were surgically removed (Malho et al. 2013).

2.3 Diagnosis of dacryocystitis in dogs

A complete clinical and ophthalmological examination must be performed. It should focus on vital parameter, the presence, position and size of the lacrimal puncta, conjunctiva, integrity of the cornea, the Schirmer Tear Test (STT) values, the Jones test (fluorescein passage test) and flushing of the nasolacrimal drainage system (Grahn and Sandmeyer 2013).

2.3.1 Symptoms

Symptoms like unilateral clear to mucopurulent ocular discharge, swelling of the medial canthus region and recurring purulent conjunctivitis are typical for dacryocystitis (Leiva and Gimènez 2018). Discharge can sometimes be provoked through mild pressure on the medial canthus and can initiate dermatitis or skin fistulas in this region (Grahn and Sandmeyer 2013; Leiva and Gimènez 2018). Depending on the source of inflammation, the patients are more or less painful (Pickett 2019).

2.3.2 Schirmer tear test (STT)

STT measures the fluid component of the tear film. Therefore a test strip, made out of filter paper with a millimeter scala on it, is placed in the ventral conjunctival fornix and left there to wet for one minute. There are two methods: STT I measures basal and reflex tearing, without topical anaesthesia, while STT II, performed after topical anaesthesia, measures basal tearing only (Grahn and Sandmeyer 2013). Reflex tearing can for instance be observed in dogs with mechanical irritation of the eye or ocular pain (Pickett 2019). In healthy dogs a STT I value of >15mm/min is considered to be physiological. Values <10mm/min are suspicious for keratoconjunctivitis sicca (KCS; meaning a lack of tear production resulting in a “dry eye”), which is the main differential diagnosis to dacryocystitis (Grahn and Sandmeyer 2013). In dogs with dacryocystitis normal to high STT values are typical, due to tear overproduction (Pickett 2019).

2.3.3 Fluorescein dye passage (Jones Test)

The Jones test, or fluorescein dye passage test, is used to check the patency of the NLA (Crispin 1987). Fluorescein-Natrium is available as a solution or as impregnated paper strips and used without local anaesthesia. It is applied to the conjunctiva, not the cornea itself, and commonly used for detecting corneal ulcers. The Jones test is considered to be positive if the fluorescein appears at the nostrils (Grahn and Sandmeyer 2013). The time period between application and appearance is called the nasolacrimal transit time (NLT). It can take up to five minutes in healthy dogs, but depends on factors like skull shape, snout length, age, reproductive status and testing method (solution or paper strip) (Binder and Herring 2010). This test is of minor value in dogs with nasolacrimal drainage into the nasopharynx or

oropharynx. (Binder and Herring 2010; Grahn and Sandmeyer 2013) Brachycephalic breeds usually have a prolonged NLT or false negative test results. (Leiva and Gimènez 2018)

2.3.4 Nasolacrimal flushing

Flushing of the NLD can either be used as a diagnostic tool or for treatment. Local anaesthesia is applied on the eye surface and a 22-24-gauge intravenous catheter without the mandrin or a nasolacrimal cannula (made from plastic or metal) is used to cannulate and flush the puncta with sterile 0.9 % sodium chloride solution. The nose of the patient should be lowered and the fluid is applied through a 5ml-syringe with mild pressure and should pass through the opposite punctum clearly. (Crispin 1987; Grahn and Sandmeyer 2013) In the next step this punctum will be occluded with finger pressure and the solution will again be flushed through the catheter. In a healthy dog it will show up either at the nares or in the pharynx, which can induce swallowing. This procedure requires topical, and in some dogs even general, anaesthesia. If it is not successful, retrograde flushing from the nasal punctum can be tried. (Grahn and Sandmeyer 2013)

2.3.5 Imaging techniques

Plain skull radiographs may not show any abnormalities. To confirm the diagnosis DCR can help to localize the obstruction, or resulting cystic dilatation of the NLD, on a x-ray. (Yakely and Alexander 1971; Gelatt et al. 1972; White et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Wallin-Haakansson and Berggren 2020) It can also divide obstructions into partial or complete. (Gelatt et al. 1972) Therefore approximately 1ml of a viscous, radiopaque contrast material is injected through the cannulated canaliculus, while occluding the opposite punctum. The scans are performed immediately after injection. This method is adequate for identifying blockages, cysts, neoplastic structures and even some foreign bodies, depending on radiological density. (Grahn and Sandmeyer 2013)

Alternatively CT-DCG can be used to identify foreign bodies and assure eventual bone lysis. (Nykamp et al. 2004; Giuliano et al. 2006; Rached et al. 2011; Strom et al. 2018; Zimmerman et al. 2019; Wallin-Haakansson and Berggren 2020) Therefore continual injection of iodinated contrast medium (e.g. Omnipaque, 240mg/ml, Princeton, NJ) into the NLD is

necessary during scans. Magnetic resonance imaging is not an option in these patients, due to signal loss in the bony canal (Nykamp et al. 2004).

Lacrimoscopy (endoscopic visualisation of the lacrimal sac) can be performed through the canaliculi into the lacrimal sac, if there is no stenosis. Samples of the sac can be taken in a less invasive manner than with surgery, but requires, as all of the above mentioned methods, general anaesthesia and the necessary special equipment (Strom et al. 2018).

Rhinoscopy (endoscopic visualisation of the nasal cavity) can be helpful for cyst or foreign body identification and sampling, if they are located in the nasal cavity (White et al. 1984; Grahn and Mason 1995; Singh et al. 2004; Strom et al. 2018).

In a recent paper, Barsotti et al. (2019) identified plant-based foreign bodies in the lacrimal sac trough ultrasonography. In their cases ultrasonography was used to detect linear spear-shaped hyperechoic structures with variable dimensions in the lacrimal sac, later being verified as plant awns. They were removed under general anaesthesia by ultrasound-guided removal with an alligator forceps through the lower punctum. Yet, this method is only applicable for the part of the NLA, which is not surrounded by bony material (Barsotti et al. 2019). Ultrasonography is used in cases of fluid-filled cysts in association with the NLA in the medial canthus region (Davidson and Blanchard 1991; Ota et al. 2009; Malho et al. 2013).

2.3.6 Diagnostic surgery

The surgical approach to the lacrimal sac can be a diagnostic as well as therapeutic step, eventually taking histologic samples and removing foreign bodies, debris, cysts or neoplastic masses. (Grahn and Sandmeyer 2013). The methods are described under 2.4.2.

2.4 Therapy of dacryocystitis in dogs

Treatment goal is the removal of irritating material and restoration of the natural outflow system. Pain and inflammation should be relieved and reduced quickly (Lavach et al. 1984).

2.4.1 Conservative treatment

Out of the ocular discharge a bacteriological examination should be done, followed by sensitivity testing to prevent bacterial resistance. Topical broad-spectrum antibiotics can be used until results are available, and the antibiotic solution is adapted (Lavach et al. 1984). In addition topical corticosteroid or other anti-inflammatory solutions and warm compresses can be used to relieve pain and reduce swelling (Leiva and Gimènez 2018). Medical treatment alone may only result in temporary resolution of the symptoms, but often cannot cope with the underlying cause (van der Woerdt et al. 1997). Flushing of the NLA is commonly used to obtain nasolacrimal patency (Murphy et al. 1977; Lavach et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009). Also cannulation with a polyethylene-tube (Murphy et al. 1977; Lavach et al. 1984) or stent (Giuliano et al. 2006; Strom et al. 2018) is described. Foreign bodies might be removed by flushing if they are small enough (Lavach et al. 1984; Walde et al. 2008; Grahn and Sandmeyer 2013). The method is described under 2.3.4.

2.4.2 Surgical treatment

Congenital cysts can either be surgically removed or endoscopically opened to drain out (White et al. 1984; Gerding 1991). Alternatively, intracystical injection of fibrosing/sclerosing agents, like tetracyclines or polidocanol, can be tried for successful destruction of cysts (Zimmerman et al. 2019).

In case of a foreign body in the lacrimal sac, dacryocystotomy is the only effective treatment, if it cannot be removed by flushing. It is considered to be the gold standard, when it comes to treating unresponsive chronic dacryocystitis (Leiva and Gimènez 2018). Three different approaches to the lacrimal sac in the lacrimal fossa are described. Walde et al. (2008) incise the skin perpendicular and directly adjacent to the medial canthus on the dorsal rim of the lacrimal bone and enter the lacrimal sac via that incision (Walde et al. 2008). Allgoewer et al. (2009) approach the lacrimal sac transconjunctivally at the base of the third eyelid under

microscopic magnification. Outcome was good in all nine dogs, with all ducts regaining patency (Allgoewer and Noeller 2009). Laing et al. (1988) and Leiva and Gimènez (2018) incise the skin parallel to the lower eyelid and remove parts of the lacrimal bone by a burr to get access to the lacrimal sac, which is the most invasive method (Laing et al. 1988; Leiva and Gimènez 2018). If foreign bodies are present, they are removed. The surgical methods of Laing et al. (1988), Allgoewer and Noeller (2009) and Leiva and Gimènez (2018) are followed by flushing of the NLA with the method described above intraoperatively via the opened lacrimal sac. Independent of the approach, the canaliculi and duct are cannulated with a silastic tube at the end of surgery. The lacrimal sac can be left open to heal by second intention, but the subcutaneous/submucosal tissue and skin/mucosa are sutured (Walde et al. 2008; Allgoewer and Noeller 2009; Leiva and Gimènez 2018). The silastic stent is sutured to the hair-covered skin and left in place for three weeks postoperatively under the application of topical broad-spectrum antibiotics and corticosteroid solutions (Murphy et al. 1977; Walde et al. 2008; Grahn and Sandmeyer 2013). The dogs have to wear a protective collar and are controlled on a weekly basis, until the silastic tube is removed (Grahn and Sandmeyer 2013). Irritation from the silastic tube can be a postoperative complication, but resolves completely as soon as it is removed (Laing et al. 1988). In case of a foreign body or obstruction in the NLD a retrograde flush and removal via dacryocystotomy can be tried (Walde et al. 2008).

Giuliano et al. (2006) describes dacryocystomaxillorhinostomy to approach to the lacrimal sac. They incise the skin dorsocaudally from the infraorbital foramen toward the medial canthus. Then the levator nasolabialis muscle is incised and the maxillary bone exposed. It is removed via a burr until the sac can be incised and foreign material can be removed. Next step is cannulation of the NLA with a stent and flushing with sterile 0.9 % sodium chloride solution prior to closure. The levator nasolabialis muscle and subcutaneous tissues are closed in a simple continuous pattern, while the skin is closed in a simple interrupted pattern. The stent is sutured to the hair-covered skin and removed after seven weeks (Giuliano et al. 2006).

NLD obstructions can be relieved by an intraosseous approach as described by Pope et al. (2001), since the duct is surrounded by the maxillary bone in this region. They incise the skin dorsally and rostrally to the infraorbital foramen in caudal direction. Parts of the maxillary bone have to be removed by a drill with a round burr until the NLD is visible. Then foreign bodies can be removed and the NLA is flushed with sterile 0.9 % sodium chloride solution

until the fluid is clear. The NLD can either be sutured or left open, to heal by second intention. The levator nasolabiales muscle and skin above are sutured with a monofilament, absorbable suture in a simple continuous or interrupted pattern. Just like with dacryocystotomy, a silicone stent is placed through the NLA intraoperatively and removed after about two weeks (Pope et al. 2001).

A bypass for the tears from the ocular surface to the nose can be created through canaliculorhinostomy (Wallin-Haakansson and Berggren 2020), conjunctivorhinostomy (Covitz et al. 1977) or maxillorhinostomy (van der Woerdt et al. 1997; Lussier and Carrier 2004).

2.5 Dacryocystitis in other mammals

2.5.1 Horses

Aetiologies for dacryocystitis and NLD obstructions in horses vary from congenital malformations to acquired inflammations, due to foreign bodies, eyelid lacerations, dental diseases or neoplasia (Moore 1992; Giuliano 2017). The symptoms, like epiphora, conjunctivitis and mucopurulent discharge, are the same as in dogs and indicate an underlying nasolacrimal disease. Bacterial, but also mycotic samples should be taken for sensitivity testing and therapeutic evaluation. In case of an obstruction, the Jones test is most likely to be negative on the affected side. Nasolacrimal irrigation should be performed in the sedated horse to assure patency of the duct (Giuliano 2017). Alternatively, imaging techniques can determine abnormalities (Nykamp et al. 2004). Foreign material must be removed, either by flushing or surgically. Medical treatment consist of topical broad-spectrum antibiotic solutions every six hours, preferably after bacterial sensitivity testing and topical corticosteroid solutions to reduce swelling and pain in the affected area, but only if the cornea is intact. These topical medications can be given up to two weeks. If the dacryocystitis is recurrent or not responding to topical treatment, placing a surgical catheter can ease medical application, and can be left in place for up to four weeks postoperatively. Oral anti-inflammatory or antibiotic medication can be added to improve healing (Moore 1992; Giuliano 2017).

2.5.2 Rabbits

Dacryocystitis in rabbits is very common. The anatomical differences compared to many other animals are one lower punctum only, the definite presence of a lacrimal sac and multiple areas of narrowing in the NLD. Due to the anatomical location near the tooth roots, the NLD can easily be affected by dental pathologies, like tooth root abscessation or malformations (Marini et al. 1996; Bedard 2019). According to Florin et al. (2009), 53 % of affected rabbits have underlying dental diseases. The ocular clinical symptoms are equal to the ones in dogs or other species, with mucopurulent discharge being an indication for secondary bacterial infections (Florin et al. 2009). Special attention has to be paid to a complete oral examination, treatment of the underlying cause and frequent flushing procedures (Bedard 2019). The longer the treatment, the poorer the prognosis (Florin et al. 2009).

2.5.3 Cats

Literature on NLA diseases in cats is rare, but it may appear as a consequence of chronic conjunctivitis, after upper respiratory infections or trauma (Lussier and Carrier 2004). In kittens the puncta may occlude due to herpetic keratoconjunctivitis, followed by symblepharon. Local therapy in those kittens consists of conjunctivorhinostomy (Leiva and Gimènez 2018). One case report by Anthony et al. (2010), describes a NLD obstruction in a ten-year-old domestic short-hair cat. The patient presented with chronic, mucopurulent ocular discharge and had a negative Jones test on the left side. DCR revealed a patent NLD, but one place of extraluminal narrowing, later revealed as an upper canine tooth root abscess, was diagnosed. After extraction of the tooth (204), the clinical symptoms resolved (Anthony et al. 2010).

2.5.4 Humans

Human patients with dacryocystitis usually present with unilateral epiphora and swelling of the medial canthus region. These patients often complain about pain, redness and fever episodes, eventually with pus leaking from the puncta (Kanski 2015; Lussier and Carrier 2004). The disease can be divided into an acute onset and a chronic form, and can be regularly observed in human infants, because their NLD is not completely patent at birth. It spontaneously opens up itself within the first weeks (Kanski 2015; Lussier and Carrier 2004).

Acute dacryocystitis in adult patients can be a consequence of chronic infection or irritation (Uddin and Rose 2004). The diagnostic procedure steps in human ophthalmology are an external examination of the eyelids and puncta, followed by the Jones test and contrast dacryocystography to evaluate nasolacrimal patency. The treatment consists of systemic or local broad-spectrum antibiotics for two weeks and removal of pus by flushing procedures. Additional warm compresses can relieve pain (Kanski 2015). If this is not successful, the next steps are systemic antibiotics or endoscopic dacryocystorhinostomy, which is a surgical method that creates a bypass between lacrimal sac and nose cavity, either laser assisted or by surgical instruments (Uddin and Rose 2004; Penttilä et al. 2015). Lacrimal sac neoplasia should be a differential diagnosis, when chronic dacryocystitis occurs in elderly patients. Most lacrimal sac neoplasms are of epithelial origin (75 %), and the remaining of non-epithelial origin (25 %) (Pe' er et al. 1996). Treatment consists of surgical excision, chemotherapy or radiation therapy. Especially lymphomas show good response to chemotherapy, depending on their malignancy (Singh and Ali 2020).

3 Materials and methods

In this retrospective study client-owned dogs, which were presented within 19 years (2001 to 2019) at the university hospital of the Veterinary Medicine University in Vienna, with the final diagnosis of dacryocystitis, were taken into consideration.

The following signalements and patient histories were collected from the in-house animal information system ("TIS") and from handwritten medical records in cases before 2005:

- Breed
- Sex
- Body weight in kilogram
- Age at the time of presentation in years
- Affected eye
- Season (winter from December to February, spring from March to May, summer from June to August, fall from September to November), in which the patient was presented at the university hospital
- Case history and duration of symptoms: Most of the dogs had a history of prescribed medications and data on the previous therapies were collected. From first occurrence of symptoms to introduction at the university hospital (eventually including treatment of other veterinarians) the duration of symptoms was sub-divided into three time-intervals:
    - ≤ 2 weeks
    - 2 weeks to 4 weeks
    - ≥ 4 weeks

All dogs underwent a full ophthalmic examination including vision tests, adspection of the eye and adnexa, periocular palpation, STT I, direct and indirect ophthalmoscopy, fluorescein staining and flushing of the tear drainage system. Irrigation of the lacrimal puncta for flushing was done under local anaesthesia with oxybuprocainhydrochlorid 0.4 % eyedrops (Novain ®, AGEPHA Pharma s.r.o.) or if required, full anaesthesia. Pathologies were noted and statistically evaluated. Results from DCR or CT-DCG scans were collected, if performed. If applicable, the existence and type of a foreign body was noted.

The at the university clinic prescribed treatments were evaluated. Medical treatment consisted of the following drugs:

- Topical antibiotics
- Topical anti-inflammatory drugs
- Systemic antibiotics
- Systemic anti-inflammatory drugs

Additionally either conservative treatment (flushing of the nasolacrimal system with saline) or surgical treatment was performed. Surgery was either dacryocystotomy or, in case of a visible foreign body, direct opening of the lacrimal puncta and canaliculi by an incision. Dacryocystotomy was performed in the following way: To approach the lacrimal sac both lacrimal puncta were cannulated with a probe, if possible. Either the conjunctiva was incised in the medial canthus along the lower eyelid margin in the ventral fornix until the lacrimal sac was incised **(fig. 1, appendix)** or the incision was made through skin immediately adjacent to the nasal canthus perpendicular to it (**fig. 2, appendix**). If existent, foreign body material was removed. The nasolacrimal sac, canaliculi and duct were flushed with saline via the lacrimal sac and tear puncta. Before closure the lacrimal puncta, canaliculi and NLD were cannulated with a silastic tube (outer diameter 1mm) with the aid of a pigtail probe and Monosof ® 4/0 suture material. Closure of the conjunctival tissue or skin was performed with Vicryl ® 5/0-6/0, depending on the dog's size.

Follow-up was done either with recheck at the clinic or feedback of referring veterinarians or owners in written or oral form.

The data were collected in Windows Excel 2010 and statistical analyses were conducted using IBM SPSS Statistics program and Windows Excel 2010. Descriptive statistics and Chi-Quadrat-Tests were done to confirm the hypothesis. A P-value of <0.05 was considered significant in all measurements.

4 Results

The data pool included 41 cases of 38 dogs, listed in **table 1 (appendix).** Cases 3/4 and 7/8 are representing the same dogs with both eyes affected at the same time. Cases 30/31 are representing the same dog, but with two independent incidences of dacryocystitis within an asymptomatic time interval of more than one year in-between.

4.1 History and signalement

The study group consisted of 16 male and 22 female animals, all of different breeds, with Retriever dogs being the most affected ones in this study (11/38; 28.9 %), followed by mixed breeds (4/38; 10.5 %) and West Highland White Terriers (WHWT) and Dachshunds with 3/38 (7.9 %) each. The mean age was 5.4 years (38/38; median 4.2 years), ranging from 0.6 to 14.4 years and with a standard deviation of 3.9 years. The mean weight was 24.6 kilograms (31/38; median 25 kilograms), ranging from 5.7 to 42 kilograms and with a standard deviation of 10.1 kilograms. The season in which the disease was diagnosed at the university hospital was fall in 19/41 cases (46.3 %), summer in 11/41 cases (26.8 %), winter in 6/41 cases (14.6 %) and spring in 5/41 cases (12.2 %). Examination and treatment were initiated by another veterinarian in 31/41 cases (75.6 %), before referral to the university clinic for a second opinion. The time between the first symptoms and presentation at the university clinic was under two weeks in one case (2.4 %), between two and four weeks in 12/41 cases (29.3 %) and over four weeks in 24/41 cases (58.5 %). In the remaining four cases no information about the duration of symptoms was available.

4.2 Symptoms/Ophthalmological findings

In 22/41 cases (53.7 %) the right eye (OD) and in 19/41 cases (46.3 %) the left eye (OS) was affected. Two of the dogs showed signs of dacryocystitis in both eyes (OU) at the same time. All affected dogs had ocular discharge, from serous to mucopurulent to purulent (**fig. 3**, **appendix**). Nine/41 patients (22 %) had pus leaking from the lacrimal puncta and the exudate of 6/41 cases (14.6 %) was described as bloody-mucoid to purulent. Thirty-two/41 of the patients (78 %) showed conjunctivitis or some sort of conjunctival redness and/or oedema at the ophthalmological examination. According to the medical histories, the Jones test was done in nine cases and all of them were negative (9/41, 22 %). Diagnostic flushing under local anaesthesia, as part of the initial examination, was recorded in 39/41 of medical

histories (95.1 %). Two cases (case 15 and 17) were not flushed as the tip of a foreign body was visible in one tear punctum each. In 12/39 (30.8 %) cases the fluid did not appear at the nose, but only at the other punctum, and in 27/39 (69.2 %) cases bloody-mucous to purulent exudate was flushed out of the puncta and the nose. One dog (case 6) had a massive swelling ventral to the medial canthus, but could be flushed easily. Three of the patients (case 13, 29 and 38) could only be flushed under sedation, so this was done in combination with diagnostic imaging. They were taken to surgery immediately afterwards.

4.3 Diagnostic imaging

Diagnostic imaging via DCR with non-ionic iodine was done in 8/41 cases (19.5 %) and except of case 1, all underwent surgery afterwards. Five of those were CT examinations and three x-ray examinations. One CT (case 1) and one x-ray (case 11) examination came back as unsuspicious for a foreign body, which corresponded with the clinical findings. In case 10 a filling defect suspicious for foreign material was seen on radiography and a foreign body could be removed during surgery. Cases 13, 28 and 29 had a stop of contrast agent in the CT examination, but only in cases 13 and 29 a foreign body could be found. Case 16 had a stop of contrast material on X-ray examination and no foreign body was detected. In case 20 the whole NLD was dilated and full of substrate with soft tissue intensity. The contrast agent pooled in the tissue that surrounded the lacrimal sac. No foreign body was visible at dacryocystotomy.

4.4 Treatment

The treatment at the university clinic was grouped into surgical and conservative. In summary 41 cases were treated, out of those, 23 underwent surgery and 18 were treated conservatively only.

4.4.1 Conservative treatment

Conservative treatment consisted of prescribed medication in all 18 cases. In every case diagnostic flushing was performed. Four cases (22.2 %) received medication only but no further treatment. Fourteen/18 cases (77.8 %) received additional flushing's of the lacrimal system with sterile 0.9 % sodium chloride solution (Ecolav ®, B. Braun). Therapeutic flushing was performed in the mean 2.3 times per case. In two cases (14.3 %, case 5 and 31) a plant-

based foreign body was flushed out of the tear puncta. Medical management consisted of various topical or systemic drugs. 13/18 cases (72.2 %) were prescribed topical antibiotic solutions at the affected eye, while 8/18 cases (44.4 %) were administered oral systemic antibiotic drugs. Used substances were amoxicillin or cephalexin systemically and gentamicin or ofloxacin topically. Anti-inflammatory drugs were given in 7/18 cases (38.9 %) as topical solution, while 10/18 cases (55.6 %) were treated systemically. Used substances were carprofen or cimicoxibe systemically and diclofenac/bromfenac or dexamethasone topically.

4.4.2 Surgical treatment

Of the 23 surgically treated cases, 20 received dacryocystotomy. Two (case 15 and 17) had their canaliculi opened with an incision as the tip of a plant-based foreign body was visible. Case 15 had the foreign body in the lower and case 17 in the upper canaliculus. These two cases were not flushed pre-operatively, while the rest (21 cases) was flushed for diagnosis and ten were additionally flushed before or shortly after surgery. The mean number of therapeutic flushing procedures in those cases was 3.4 times. 4/10 were flushed before surgery, 4/10 after surgery and 2/10 received flushing's before and after surgery. 15/21 cases (71.4 %) were taken to dacryocystotomy after diagnostic flushing without further flushing attempts. Case 6, which presented with medial canthus swelling, had an epidermoidal cyst at the proximity of the lower canaliculus that underwent full excision without laceration of the NLA.

Fourteen/23 cases (60.9 %) had a foreign body removed during surgery (**fig. 4, appendix**). In twelve cases it was located in the lacrimal sac and in the two above mentioned cases directly in the canaliculus (**fig. 5, appendix**). All foreign bodies were out of plant material, mostly grass awns and one out of wood (case 41). In 8/20 dacryocystotomy-cases (40 %) no foreign body could be found, but inflammatory debris and/or granulation tissue. The mean time interval between first consult at the university clinic and surgery day was 15 days (median 8 days). 11/23 patients (47.8 %) received medication before surgery. 10/11 cases (90.9 %) were administered topical antibiotic solutions and 3/11 (27.3 %) got topical anti-inflammatory eye drops. Systemic antibiotics were given orally in 2/11 cases (18.2 %) and 6/11 cases (54.5 %) received anti-inflammatory drugs orally as well. Used substances were the same as with the conservative treatment. Since eleven surgically treated cases received

medication before surgery, the number of medically treated cases rises to 29/41 (70.7 %) in total. Furthermore, all cases that underwent dacryocystotomy were treated medically postoperatively as well for various time-intervals with the drugs mentioned above.

4.5 Follow-up

All together 36/41 cases (87.8 %) healed with the prescribed treatment from the university hospital, 3/41 (7.3 %) got lost to follow up and 2/41 (4.9 %) did not recover fully with the first treatment attempt. Mean treatment duration from initial examination to final examination at the university clinic in the 36 healed cases was 39.8 days with surgery (n=17), 52 days without surgery (n=10) and could not be defined in nine cases.

4.5.1 Conservative treatment

Conservative treatment without surgery healed all 18 out of 18 cases (100 %). Four cases were cured with the diagnostic flushing and medical therapy. The rest (14/18, 77.8 %) received additional flushing procedures in various amounts until symptoms resolved completely.

4.5.2 Surgical treatment

Out of the 23 cases, which underwent surgical treatment, 18 showed complete recovery of the symptoms (78.3 %). Three of the remaining dogs were lost to follow up (case 16, 19 and 29) and two (case 20 and 28) still had recurring discharge. Case 28, one of the two dogs that did not recover, showed ocular discharge long after surgery and postoperative flushing procedures according to the owner, but was never again introduced to the clinic. The other dog (case 20) is the only one, which underwent surgeries multiple times. It presented with a history of three months duration and underwent three surgeries on the right lacrimal sac within one year at the university clinic. At first presentation (October 2009) flushing of the right duct was possible but very painful and haemorrhagic fluid exited all openings. No foreign body could be found at dacryocystotomy, so the lacrimal sac was flushed and a silicone tube was placed through the canaliculi and left in place for 23 days. Frequent flushing of the nasolacrimal system and medical therapy did not lead to full recovery. Three months after the first presentation (January 2010) a CT examination was performed and it showed enlargement of the right lacrimal fossa and the whole right NLD was full of material

of soft tissue intensity, indicative for chronic inflammation. The contrast agent ended 2cm after the tear punctum in the adjacent tissue of the lacrimal sac. Another month later (February 2010) the dog was re-operated and a Jackson catheter was put into the NLD from the upper tear punctum (**fig. 6, appendix**) that was removed a month later (March 2010) as there was only slight mucous discharge and the flushing fluid was clear. In June 2010 the dog was presented again as there was a considerable amount of mucous discharge. Medical treatment was not curative so the CT was repeated, a year after first presentation (October 2010). Findings were not different to the previous one, but the lacrimal bone showed osteomyelitis. In surgery, all tissue was removed out of the lacrimal fossa and the visibly altered lacrimal bone was removed by a burr. Dacryorhinostomy was performed, cannulated with a Jackson catheter and flushed multiple times during surgery. The catheter was left in place for six weeks and at the last recheck (May 2011) the right eye showed slight intermittent epiphora. The underlying cause of the disease was never found.

4.6 Decisive factors on healing

The surgically treated (n=23) and the conservatively treated cases (n=18) were compared concerning complete remission and recovery factors. The conservatively treated group had a non-significant healing chance of 100 % ($p>0.05$), because all affected dogs in our study recovered with the prescribed treatment. This is due to the fact that those cases that did not improve were taken to surgery. All of them received medication in various combinations and at least one flushing of the NLA.

The surgical treated group had a non-significant healing chance of 90 % (18/20, $p>0.05$), as three patients got lost to follow up. The combination of flushing before surgery (6/20) had a chance on healing of 83.3 % ($p>0.05$). Fourteen/23 (60.9 %) cases had a foreign body removed via surgery and 2/18 (11.1 %) via flushing. There was no significant correlation between foreign body removal and season of onset ($p>0.05$), but foreign bodies were mostly diagnosed in summer and fall. In total there were 16/41 (39 %) plant-based foreign bodies removed.

5 Discussion

This retrospective study on NLA diseases in dogs describes 41 cases, whereas one similar study by Lavach et al. (1984) reports on 22 cases. Furthermore, there are two more publications with larger case numbers: Strom et al. (2018) describes 16 cases and Wallin-Haakansson and Berggren (2020) eleven cases. All other papers deal with only one to four cases (Yakely and Alexander 1971; Gelatt et al. 1972; Murphy et al. 1977; White et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; Gerding 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Nykamp et al. 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Malho et al. 2013; Ritz et al. 2013; Voelter-Ratson et al. 2015; Barsotti et al. 2019; Zimmerman et al. 2019).

5.1 History and signalement

The duration of case history, the time between first appearance of the symptoms and presentation, varies from only a couple of days to many months or years in literature as well as in this study. Lavach et al. (1984) do not supply information about case histories in each individual case (n=22), but outline three cases, which had durations of three days, five days and eleven months prior to consult (Lavach et al. 1984). With Strom et al. (2018) the median duration of clinical signs before any initiated treatment was 3.2 months (n=16), while Barsotti et al. (2019) examined four dogs with foreign body induced dacryocystitis and these cases had a duration of symptoms before first consult of two weeks, seven months, twelve months and in one case even more than four years (Strom et al. 2018; Barsotti et al. 2019). In other reports, the time interval varies from one month to about four years (Yakely and Alexander 1971; Gelatt et al. 1972; Murphy et al. 1977; White et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; Gerding 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Nykamp et al. 2004; Singh et al. 2004; Ota et al. 2009; Malho et al. 2013; Voelter-Ratson et al. 2015; Zimmerman et al. 2019). The case of Giuliano et al. (2006) even had intermittent symptoms for about seven years (Giuliano et al. 2006). This wide range of durations may be due to owner compliance and partial success with pre-treatment of referring veterinarians. In this study only one dog was presented within two weeks of onset, while it took 58.5 % over four weeks to consult the university clinic.

Pre-treatment was initiated by referring veterinarians in 75.6 % of the dogs, mostly with topical antibiotic or antibiotic-corticoid solutions as described in other publications (Gelatt et al. 1972; Murphy et al. 1977; Laing et al. 1988; Davidson and Blanchard 1991; van der Woerdt et al. 1997; Singh et al. 2004; Giuliano et al. 2006; Voelter-Ratson et al. 2015; Barsotti et al. 2019). Anti-inflammatory pre-medication is described from Strom et al. (2018).

The most affected breed in this study were Labrador retrievers or Golden retrievers, but as these are very popular breeds in Austria, no conclusion concerning breed predisposition can be drawn. Three study dogs were WHWT, known for a predisposition for KCS, the main differential diagnosis to dacryocystitis (Pickett 2019). Two of the WHWT had STT results over 20mm in both eyes and improved with flushing of the NLA. The third WHWT, case 13, could only be examined under sedation and a foreign body was successfully removed from the lacrimal sac during surgery.

The median age at first presentation in this study was 4.2 years, but with a high standard deviation of 3.9 years, so onset at any age is possible. With Lavach et al. (1984) the median age was 3 years (n=22), with Strom et al. (2018) it was 4.3 years (n=16) and with Wallin-Haakansson and Berggren (2020) it was 3 years (n=11) (Lavach et al. 1984; Strom et al. 2018; Wallin-Haakansson and Berggren 2020). In other reports, the age varies from six months to 15 years (Yakely and Alexander 1971; Gelatt et al. 1972; Murphy et al. 1977; White et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; Gerding 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Nykamp et al. 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Malho et al. 2013; Ritz et al. 2013; Voelter-Ratson et al. 2015; Barsotti et al. 2019; Zimmerman et al. 2019). Clinical signs may occur at any age (Lavach et al. 1984; Laing et al. 1988). Also, the median weight of the dogs in this study with 25 kilograms and the high standard deviation of 10.1 kilograms gives no indication for a specific weight group. Yet none of the study dogs had less than 5 kilograms. The median body weight in Strom et al. (2018) was similar with 23.3 kilograms (Strom et al. 2018).

The seasons of presentation were summer and fall in most cases. This corresponds with Lavach et al. (1984), who noticed most foreign body related cases during the dry seasons of a year (Lavach et al. 1984). There was no significant correlation drawn between season and onset of symptoms, as the data available was the season of referral to the university hospital. Duration was over four weeks in most cases, so the exact time of onset could not be determined in retrospect.

5.2 Symptoms/Ophthalmological findings

Symptoms of NLA inflammation and obstruction described in literature were identical to the ones observed in this study. Depending on the cause and chronicity, owners describe unilateral to bilateral mucopurulent to purulent ocular discharge (Yakely and Alexander 1971; Murphy et al. 1977; van der Woerdt et al. 1997; Pope et al. 2001; Lussier and Carrier 2004; Singh et al. 2004; Giuliano et al. 2006; Voelter-Ratson et al. 2015) or just epiphora (Gelatt et al. 1972; Murphy et al. 1977; White et al. 1984; Gerding 1991; Grahn and Mason 1995; Malho et al. 2013; Zimmerman et al. 2019). In some cases, mild conjunctivitis might be the only symptom noticeable, but often it is a response to the discharge (Yakely and Alexander 1971; Barsotti et al. 2019). Some cases appear with dilated tear puncta, others with swelling adjacent to the medial canthus (Gelatt et al. 1972; Lavach et al. 1984; White et al. 1984; Gerding 1991; Giuliano et al. 2006; Ota et al. 2009; Malho et al. 2013; Zimmerman et al. 2019). These classic ophthalmological signs led to the presumptive diagnosis in this study.

Fluorescein staining, as certain part of the ophthalmological examination, was used for conducting the Jones test and evaluating patency in nine cases of this study. It was negative in all nine. This method is commonly used (Gelatt et al. 1972; White et al. 1984; Gerding 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Cullen and Grahn 2003; Lussier and Carrier 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Malho et al. 2013; Ritz et al. 2013; Voelter-Ratson et al. 2015; Zimmerman et al. 2019).

For verification forced irrigation and flushing of the NLA was used under topical anaesthesia, if necessary under full anaesthesia. All of the above authors flushed the NLA for diagnostic purposes in their studies, except Barsotti et al. (2019), who made ultrasonography results a condition for the decision. Some used only local anaesthesia (van der Woerdt et al. 1997; Singh et al. 2004; Giuliano et al. 2006; Malho et al. 2013; Zimmerman et al. 2019), some general anaesthesia (Yakely and Alexander 1971; Gelatt et al. 1972; Laing et al. 1988; Lussier and Carrier 2004) and some did not need anaesthesia or did not give further information (Lavach et al. 1984; White et al. 1984; Davidson and Blanchard 1991; Gerding 1991; Grahn and Mason 1995; Pope et al. 2001; Cullen and Grahn 2003; Ota et al. 2009; Ritz et al. 2013; Voelter-Ratson et al. 2015). In this study, all patients received diagnostic flushings at initial examination, except if a foreign body was already clearly visible. Three/39 (case 13, 29 and 38) had to be anaesthetised and flushing, diagnostic imaging and/or surgery were done in the same anaesthesia. In 30.8 %, the NLA was not patent. Patency

was securely diagnosed in 69.2 % of cases, and in two cases (case 5 and 31) plant material could even be flushed out, just like described in literature (Yakely and Alexander 1971; Pope et al. 2001).

Expression of purulent material from the lacrimal puncta can often be provoked and sampled on bacterial culture and susceptibility testing. Almost no bacterial sensitivity testing for diagnosis was done in this study, although literature recommends it mainly in chronic forms to adjust antibacterial medication and prevent bacterial resistance (Yakely and Alexander 1971; Murphy et al. 1977; Lavach et al. 1984; Laing et al. 1988; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Voelter-Ratson et al. 2015; Strom et al. 2018; Wallin-Haakansson and Berggren 2020). The material should be collected before and after flushing. Bacteria most commonly collected from canine and feline mucous eye-membranes are *Staphylococcus sp., Streptococcus sp.* and *Escherichia coli* (Whitely 2000).

5.3 Diagnostic imaging

Only eight cases underwent native and contrast imaging (three times x-ray, five times CT) under anaesthesia. In six cases a stop was diagnosed and they went to surgery (case 10, 13, 16, 20, 28, 29), and three had a foreign body removed (case 10, 13, 29). DCR on x-ray is often the first approach for NLD patency evaluation (Yakely and Alexander 1971; Gelatt et al. 1972; White et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Wallin-Haakansson and Berggren 2020).

CT-DCG is used to evaluate the bony canal surrounding the NLD, as magnetic resonance imaging is not helpful due to signal loss in the bony canal (Nykamp et al. 2004; Giuliano et al. 2006; Rached et al. 2011; Zimmerman et al. 2019; Wallin-Haakansson and Berggren 2020). Voelter-Ratson et al. (2015) used a combination of DCR on x-ray as well as CT scans for diagnosis in their study, while Strom et al. (2018) approached the nasolacrimal system by a combination of CT-DCG, lacrimoscopy and rhinoscopy (Voelter-Ratson et al. 2015; Strom et al. 2018). Rhinoscopy with a rigid or flexible endoscope is useful for nasal cyst/foreign body identification and destruction, while lacrimoscopy with a miniature telescope can visualize the

mucosa and possible intramural abnormalities of the NLA the best (White et al. 1984; Grahn and Mason 1995; Singh et al. 2004; Strom et al. 2018).
The number of cases which underwent DCR or CT-DCG was minor in relation to the study group (n=41). As patency of the NLD can be diagnosed clinically and foreign bodies could be falsely suspected the benefit of x-ray and CT can be questioned. All other cases went to surgery as soon as flushing did not result in an improvement.

Alternatively, Davidson and Blanchard (1991), Malho et al. (2013) and Barsotti et al. (2019) recommend ultrasonography of the lacrimal sac to detect foreign bodies or fluid-filled cystic structures as a minimal invasive method in dogs (Davidson and Blanchard 1991; Malho et al. 2013; Barsotti et al. 2019). This method has not applied in the examined dogs, but can definitely be an alternative to DCR since it is quick, simple and no anaesthesia is necessary.

No imaging techniques were used by Murphy et al. (1977), Lavach et al. (1984) and Gerding (1991) in their studies.

5.4 Cause

The only congenital cause in this study was the epidermoid cyst of an one-year-old German shepherd dog. Davidson and Blanchard (1991) diagnosed and surgically removed such epidermoid cysts from the medial canthi of three dogs, an one-year-old German shepherd dog, a two-year-old Bouvier de Flandres and a seven-year-old Miniature schnauzer. Symptoms were subcutaneous swelling, an unremarkable DCR and quick recovery after mass removal (Davidson and Blanchard 1991). Gerding (1991) reported on a canaliculops of the inferior canaliculus in an eleven-month-old Labrador retriever, which also underwent full excision (Gerding 1991). Grahn and Mason (1995) as well as Cullen and Grahn (2003) described dacryops directly adjacent to the medial canthus in a six-month-old Basset hound and an one-year-old German shepherd dog (Grahn and Mason 1995; Cullen and Grahn 2003). Case 6, as well as the above-mentioned cases, presented with epiphora, painless swelling right under the medial canthi and healed after surgical removal.

Acquired causes of NLA diseases can affect only the lacrimal sac or the NLD. Inflammatory causes can be foreign body induced, due to cysts/tooth root pathologies or without any detectable cause. Plant-based foreign bodies, penetrating the lacrimal or nasal puncta, are

the most common cause of dacryocystitis (Lavach et al. 1984). Two grass awns were flushed out of the lacrimal sac conservatively; two were removed via incision of the canaliculi and the remaining eleven via dacryocystotomy. One other dog had wooden material removed out of the lacrimal sac. In total 16 foreign bodies were found (16/41, 39 %). Owners often report outdoor activities before appearance of the symptoms (Barsotti et al. 2019). Lavach et al. (1984) described five foreign bodies in their study group (n=22, 22.7 %), while Strom et. al. (2018) found six foreign bodies in 16 cases (37.5 %) (Lavach et al. 1984; Strom et al. 2018). According to Laing et al. (1988), two foreign bodies were identified in one dog in a group of three dogs (Laing et al. 1988). In eight dacryocystotomy-patients in this study no foreign body could be found, just like with Giuliano et al. (2006), who reported on a NLA obstruction in a dog, which later in surgery turned out to be a lacrimal sac granuloma. No foreign body could be found either. As most foreign bodies are out of plant material, they possibly dissolve with inflammation and bacterial overgrowth (Giuliano et al. 2006).

The NLD can be obstructed due to foreign bodies (Pope et al. 2001), but also due to plugs from inflammatory debris or stricture through granulating tissue (Lavach et al. 1984). Consequences are periostitis, osteolysis or closure of the NLD by granulomas (through eventual foreign bodies) or cyst formation (Yakely and Alexander 1971; Lavach et al. 1984; White et al. 1984; Giuliano et al. 2006; Zimmerman et al. 2019; Wallin-Haakansson and Berggren 2020). In case 20 of this study chronic inflammation caused severe bone lysis, as the dog had a history of several months duration. Therefore foreign bodies, even if not found during surgery, are a common cause for dacryocystitis and also were in this study.

5.5 Treatment

Concerning treatment, the study group was split into conservatively and surgically treated patients, and treatment results were compared. Conservative treatment was usually the first choice, unless a foreign body was already visible, and was the only treatment in 18 cases. The focus in these cases was medication and flushing procedures with the aim to spare anaesthesia. A polyethylene tube or stent might ease therapeutic flushing, but was therefore only placed postoperatively in this study (Murphy et al. 1977; Lavach et al. 1984; Giuliano et al. 2006; Strom et al. 2018). Medication alone is not recommended in literature, only in combination with flushing of the NLA (Murphy et al. 1977; Lavach et al. 1984; Laing et al. 1988; Davidson and Blanchard 1991; van der Woerdt et al. 1997; Pope et al. 2001; Cullen

and Grahn 2003; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009). This was mainly possible without full anaesthesia in this study. Only three dogs had to be anaesthetized, the rest received topical anaesthesia only. For comparison, literature describes full anaesthesia for therapeutic flushing procedures (Yakely and Alexander 1971; Murphy et al. 1977; Laing et al. 1988), as well as local anaesthesia only (Singh et al. 2004; Giuliano et al. 2006). However, information on how often and how long flushing is recommended varies. Some do only the diagnostic flush (Gelatt et al. 1972; White et al. 1984; Davidson and Blanchard 1991; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Ota et al. 2009; Voelter-Ratson et al. 2015; Zimmerman et al. 2019) and some the diagnostic flush and one therapeutic/control flush (Yakely and Alexander 1971; Gerding 1991; Grahn and Mason 1995; Singh et al. 2004; Ritz et al. 2013). Other authors flush daily for three weeks (Murphy et al. 1977) to two times daily for seven days (Giuliano et al. 2006) or once every two weeks (Laing et al. 1988). However, in this study, flushing was repeated as long as there was no discharge anymore and was repeated on a weekly basis mostly.

Surgery was performed in 23 cases of this study. Literature usually recommends removal of obstructions of any kind (foreign bodies, granulomas, neoplasms, cysts) via surgery. Cysts are either excised in total (Davidson and Blanchard 1991; Gerding 1991; Cullen and Grahn 2003; Ota et al. 2009; Malho et al. 2013) or perforated to drain out (White et al. 1984; Grahn and Mason 1995; Lussier and Carrier 2004). In this study one epidermoid cyst, which did not communicate with the NLA but obstructed it, was successfully removed in total. Zimmerman et al. 2019 published a case report of a presumable acquired NLD cyst in a middle-aged Golden retriever with an alternative therapeutic method. Conservative therapy failed at first, so intracystical application of 1,5ml polidocanol (1 %) was tried in order to destruct the cyst. The dog fully recovered within ten days, but one adverse effect was mild enophthalmos afterwards (Zimmerman et al. 2019).
If teeth are causal for inflammation, they should be extracted as well (Yakely and Alexander 1971; Gelatt et al. 1972; Ritz et al. 2013; Voelter-Ratson et al. 2015).

Dacryocystotomy is considered to be the gold standard for foreign body removal and surgical treatment of chronic dacryocystitis (Laing et al. 1988; Walde et al. 2008; Allgoewer and Noeller 2009; Leiva and Gimènez 2018), and was performed in 20 cases (48.8 %), ten of those without any before prescribed medication. Depending on location and extent of the obstruction intraosseous approach to the NLD, dacryocystomaxillorhinostomy and

canaliculorhinostomy are described as well (Pope et al. 2001; Giuliano et al. 2006; Wallin-Haakansson and Berggren 2020). Fifthteen cases did not receive further flushing's after the diagnostic flushing, because surgical exploration was recommended. Six cases were flushed before surgery multiple times, but as soon as symptoms did not resolve and owner compliance was sufficient, surgical exploration was conducted as well. In literature with surgical approach, surgery is conducted right after diagnostic flushing (van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Giuliano et al. 2006; Malho et al. 2013).

Recently Barsotti et al. (2019) described ultrasonography guided removal with Hartmann alligator forceps via the upper punctum in four cases, which is less invasive than dacryocystotomy. It should therefore be the first choice of treatment attempt.

5.6 Follow-up

Sixteen plant-based foreign bodies and an epidermoid cyst were successfully removed and overall, 36 cases completely cured. All conservatively treated patients were cured and 19 of 23 surgically treated cases recovered completely. In eight surgical cases the underlying cause could not be determined. Of these eight, four could be cured in the end, two were lost to follow-up and two could not be cured within the first treatment attempt.

Since all conservatively treated dogs healed, the different additional medical treatments seem to be of minor importance. Flushing of the lacrimal system might be the most important factor in the beginning of treatment (Murphy et al. 1977; Lavach et al. 1984; Walde et al. 2008). Four cases in this study received only medication and diagnostic flushing of the NLA. Since all of them recovered, they might have had just very slight inflammation.

All authors of published case reports reported healing (Yakely and Alexander 1971; Murphy et al. 1977; White et al. 1984; Davidson and Blanchard 1991; Gerding 1991; Grahn and Mason 1995; van der Woerdt et al. 1997; Pope et al. 2001; Cullen and Grahn 2003; Lussier and Carrier 2004; Singh et al. 2004; Giuliano et al. 2006; Ota et al. 2009; Malho et al. 2013; Ritz et al. 2013; Voelter-Ratson et al. 2015; Zimmerman et al. 2019; Wallin-Haakansson and Berggren 2020), except of Covitz et al. (1977), who could not cure three out of 21 dogs, Gelatt et al. (1972) and Lavach et al. (1984), who did not give information about the outcome,

Barsotti et al. (2019), who lost one case to follow-up, and Laing et al. (1988), who described persistent epiphora in one of their dacryocystotomy-patients (Gelatt et al. 1972; Covitz et al. 1977; Lavach et al. 1984; Laing et al. 1988; Barsotti et al. 2019). Strom et al. (2018) had median improvement of signs of 95 % (14/16 dogs) with stent placement in the NLA and flushing. Eight dogs in their study showed complete resolution of symptoms (Strom et al. 2018). Wallin-Haakansson and Berggren (2020) reported complete recovery in all of their dogs after canaliculorhinostomy (Wallin-Haakansson and Berggren 2020).

Treatment duration, from first examination to final recheck at the clinic, was in the mean 39.8 days with surgery and 52 days without in this study, which marks a faster recovery through surgical intervention. Strom et al. (2018) placed a stent in the NLA and left it in place for a median duration of 5.6 weeks, followed by postoperative medical treatment. The median treatment duration for topical drugs was 50 days, while for systemic drugs it was 46 days (Strom et al. 2018). Barsotti et al. (2019) gave medication for seven days after foreign body removal in four case reports, while Laing et al. (1988) prescribed medication for 10-14 days post dacryocystotomy (Laing et al. 1988; Barsotti et al. 2019). Lavach et al. (1984) did not give information on treatment duration in detail (Lavach et al. 1984). Wallin-Haakansson and Berggren (2020) recommend topical antibiotic drops until removal of the tube after four to seven months (Wallin-Haakansson and Berggren 2020).

5.7 Conclusion

NLA diseases need a full diagnostic work-up for appropriate treatment. Flushings of the NLA should evaluate patency and if impatency is diagnosed, diagnostic imaging can evaluate, which part is particularly affected. To display plant-based foreign bodies, ultrasonography and lacrimoscopy might be the most effective solutions. If not available or not diagnostic, diagnostic dacryocystotomy is an option. The approach through conjunctiva or skin is very easy and heals without complications. Furthermore it is the treatment option for obstructions that have their cause in the lacrimal sac. Foreign material or even just debris can be removed and patency regained. The approach to the NLD is far more complicated and more invasive and should therefore only be done after diagnostic imaging.

6 Summary

In this retrospective study, 41 cases of inflammation of the lacrimal sac and the nasolacrimal duct in 38 dogs are described over the past 19 years. The information was gathered on signalement, case history, symptoms, diagnostic work up and applied treatment. There was no breed-, sex-, age- or weight-predisposition or laterality of the affected eye. Most of the patients had a long case history and were already treated by other veterinarians, before being presented at the university hospital. The majority was unilaterally affected, but in three dogs both eyes showed symptoms. Cause of presentation was mostly mucopurulent ocular discharge and conjunctivitis. Patency was evaluated through diagnostic flushing in 39 of 41 cases, the remaining two had visible foreign bodies in a lacrimal punctum.

In total, 16 foreign bodies were removed, two via flushing, two out of the canaliculi via incision and twelve via dacryocystotomy. The 18 conservatively treated cases were cured with flushing procedures and medication. Of the 23 surgically treated cases, one had a unilateral epidermoid cyst in the medial canthus, two had a foreign body in the canaliculus and 20 underwent dacryocystotomy. In twelve of the 20 cases foreign material was found and in the remaining eight cases inflammatory debris and granulation tissue only. Imaging techniques (x-ray or computer tomography) were conducted in eight cases and were helpful for localizing the stop of contrast medium within the nasolacrimal system, but not to display plant material. Out of the 41 cases in the data pool, 36 were cured, two did not recover fully and three got lost to follow-up.

7 Zusammenfassung

Diese retrospektive Studie beschreibt 41 Fälle einer Entzündung des Tränensacks und der ableitenden Tränenwege bei 38 Hunden, die über einen Zeitraum von 19 Jahren dokumentiert wurden. Mit Hilfe medizinischer Aufzeichnungen wurden Nationale, Vorgeschichte, Symptome, Diagnostik und Therapie ausgewertet.
Es zeigten sich weder Rasse-, Alters-, Geschlechts- oder Gewichtsprädispositionen, noch eine ungleiche Seitenverteilung der betroffenen Augen. Die Mehrheit der Hunde wurde mit einem unilateralen Geschehen vorstellig. Bei nur drei Patienten waren beide Augen betroffen. Die meisten Hunde hatten eine längere Vorgeschichte und etwaige Vorbehandlungen. Sie zeigten mehrheitlich schleimig-eitrigen Augenausfluss und Konjunktivitis. Die Durchgängigkeit der Tränenwege wurde mittels einer diagnostischen Spülung in 39 von 41 Fällen evaluiert. Die restlichen zwei hatten bereits sichtbare Fremdkörper in einem Tränenpunkt.

Grannen in den Tränenwegen wurden in 16 Fällen entfernt, zwei mittels Spülungen, zwei durch Inzision in die Tränenkanälchen und zwölf mittels Dacryozystotomie. Die 18 konservativ therapierten Hunde profitierten alle von einer Kombination aus Spülungen der Tränenwege mit Kochsalzlösung und Medikation. Von den 23 operierten Fällen hatte einer eine unilaterale Epidermoidzyste im medialen Kanthus, zwei einen pflanzlichen Fremdkörper im Tränenkanälchen und 20 wurden einer Dacryozystotomie unterzogen. In zwölf dieser 20 Fälle wurde Fremdmaterial gefunden und in den restlichen acht nur Entzündungsprodukte und/oder Granulationsgewebe. Acht Fälle erhielten weiterführende Diagnostik durch Kontrast-Dacryozystorhinographie mittels Röntgen oder Computertomographie. Diese war vor allem hilfreich um die Lokalisation einer eventuellen Obstruktion auszumachen, konnte den Fremdkörper selbst aber nicht darstellen. Von den 41 Fällen wurden schlussendlich 36 erfolgreich behandelt, zwei zeigten keine Verbesserung und bei drei Hunden ist das Ergebnis nicht bekannt.

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9 Abbreviations

e.g.	for example
ed.	editor
OS	left eye
OD	right eye
OU	both eyes
NLA	nasolacrimal apparatus
NLD	nasolacrimal duct
NLT	nasolacrimal transit time
STT	Schirmer tear test
KCS	keratoconjunctivits sicca
DCR	dacryocystorhinography (on x-ray)
CT	computer tomography
CT-DCG	computed tomography-dacryocystography
TIS	“Tierspitalsinformationssystem”
WHWT	West Highland White Terriers

10 List of tables

Table 1. – The clinical patients (2001-2019):

Case Nr.	Dog Nr.	Age	Eye	Breed	Patency	Medical Treatment	Therapeutic Flushing	Diagnostic Imaging	Foreign Body	Surgery	Outcome
1	1	5,4	OS	Short-Haired Pointer	Yes	Yes	Yes (3x)	Yes (CT)	No	No	Healed
2	2	12,6	OS	Mixed Breed	Yes	Yes	No	No	No	No	Healed
3	3	6,5	OS	Doberman	Yes	Yes	Yes (6x)	No	No	No	Healed
4	3	6,5	OD	Doberman	Yes	Yes	Yes (6x)	No	No	No	Healed
5	4	4,1	OS	Dachshund	Yes	Yes	Yes (2x)	No	Yes	No	Healed
6	5	1,1	OS	German Shepard	Yes	Yes	Yes (4x)	No	No	Yes	Healed (after cyst removal)
7	6	14,4	OS	West Highland White Terrier	Yes	Yes	Yes (1x)	No	No	No	Healed
8	6	14,4	OD	West Highland White Terrier	Yes	Yes	Yes (1x)	No	No	No	Healed
9	7	2,2	OD	Golden Retriever	Yes	Yes	Yes (4x)	No	Yes	Yes	Healed
10	8	0,9	OS	English Setter	No	No	Yes (2x)	Yes (X-Ray)	Yes	Yes	Healed
11	9	1,0	OD	Cocker Spaniel	Yes	Yes	Yes (4x)	Yes (X-Ray)	No	Yes	Healed
12	10	9,4	OS	Mixed Breed	No	Yes	No	No	No	No	Healed
13	11	10,2	OD	West Highland White Terrier	No	No	No	Yes (CT)	Yes	Yes	Healed
14	12	0,8	OS	Jack Russel Terrier	Yes	Yes	Yes (2x)	No	No	No	Healed
15	13	2,9	OS	Pit Bull Terrier	FB visible	No	No	No	Yes	Yes	Healed
16	14	4,0	OD	Golden Retriever	Yes	No	No	Yes (X-Ray)	No	Yes	Lost to follow-up
17	15	1,3	OD	Munsterlander	FB visible	No	No	No	Yes	Yes	Healed
18	16	3,2	OD	Golden Retriever	Yes	Yes	Yes (1x)	No	No	No	Healed
19	17	1,5	OD	Magyar Viszla	No	Yes	No	No	No	Yes	Lost to follow-up

Case Nr.	Dog Nr.	Age	Eye	Breed	Patency	Medical Treatment	Therapeutic Flushing	Diagnostic Imaging	Foreign Body	Surgery	Outcome
20	18	4,2	OD	Labrador Retriever	Yes	No	Yes (13x)	Yes (CT)	No	Yes	Recurring discharge
21	19	1,2	OD	Golden Retriever	Yes	Yes	No	No	No	No	Healed
22	20	0,6	OS	Golden Retriever	Yes	Yes	No	No	No	No	Healed
23	21	4,1	OS	Golden Retriever	Yes	Yes	Yes (2x)	No	No	No	Healed
24	22	8,8	OD	Scottish Terrier	Yes	Yes	Yes (2x)	No	No	No	Healed
25	23	1,0	OS	Dachshund	Yes	No	Yes (1x)	No	No	Yes	Healed
26	24	2,5	OS	Ratonero Mallorquin	Yes	Yes	Yes (1x)	No	No	No	Healed
27	25	2,8	OD	West Highland White Terrier	Yes	Yes	Yes (1x)	No	No	No	Healed
28	26	5,3	OS	Malinois	No	Yes	Yes (1x)	Yes (CT)	No	Yes	Recurring discharge
29	27	5,0	OS	Wirehaired Pointer	Yes	No	No	Yes (CT)	Yes	Yes	Lost to follow up
30	28	4,6	OS	Munsterlander	Yes	Yes	Yes (4x)	No	Yes	Yes	Healed
31	28	6,5	OD	Munsterlander	Yes	Yes	Yes (2x)	No	Yes	No	Healed
32	29	8,7	OS	Weimaraner	No	Yes	No	No	Yes	Yes	Healed
33	30	3,3	OS	Golden Retriever	No	No	No	No	Yes	Yes	Healed
34	31	9,0	OD	Mixed Breed	Yes	Yes	Yes (1x)	No	Yes	Yes	Healed
35	32	2,7	OD	Labrador Retriever	Yes	Yes	Yes (2x)	No	No	No	Healed
36	33	7,3	OD	Golden Retriever	No	No	No	No	Yes	Yes	Healed
37	34	8,5	OD	Golden Retriever	No	No	Yes (1x)	No	No	Yes	Healed
38	35	2,9	OD	Lagotto Romagnolo	Yes	No	No	No	Yes	Yes	Healed
39	36	5,9	OD	Longhaired Pointer	No	Yes	No	No	No	Yes	Healed
40	37	13,2	OD	Dachshund	No	Yes	No	No	Yes	Yes	Healed
41	38	11,5	OD	Mixed Breed	No	Yes	No	No	Yes	Yes	Healed

In grey: These cases represent the same dogs, but different affected eyes.

“Patency -Yes”= fluid appeared at puncta and nose, “Patency -No”= fluid appeared only at puncta. “Nr.”= Number. “FB”= Foreign body.

11 List of figures

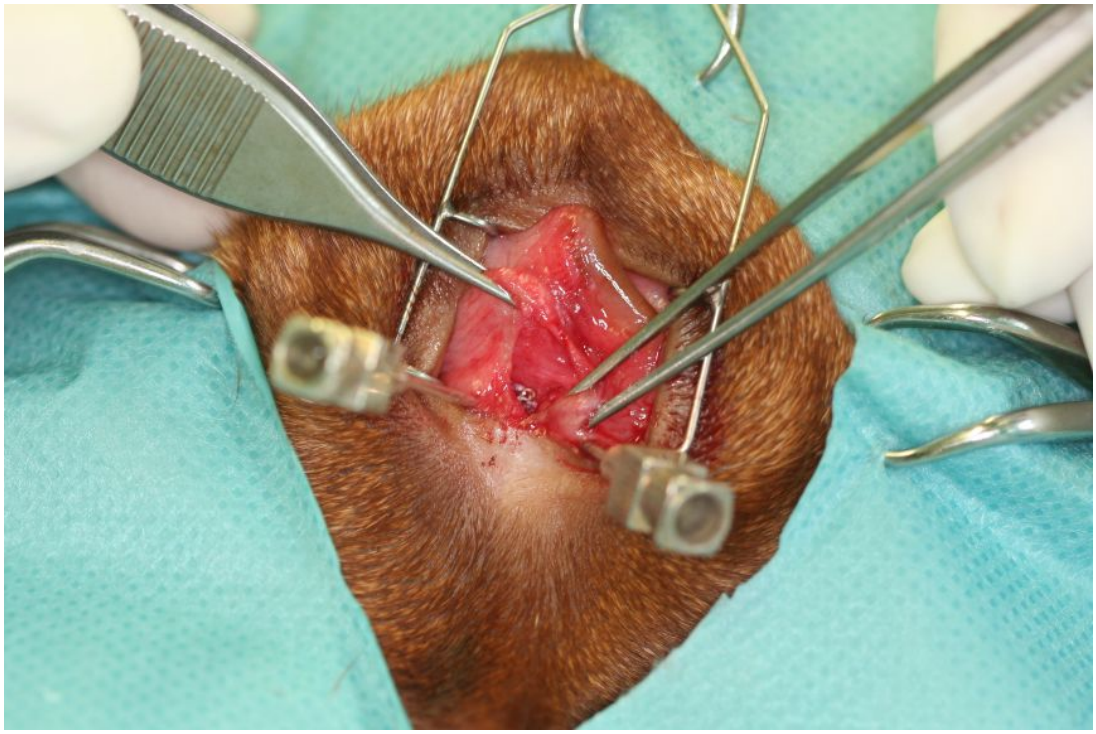

Figure 1. – Intrasurgical approach to the lacrimal sac (transconjunctivally).

Figure 2. – Intrasurgical approach to the lacrimal sac (skin incision).

▲ = lacrimal sac; ☆ = orbital rim

Figure 3. – Dog with chronic dacryocystitis, showing purulent discharge from the right eye.

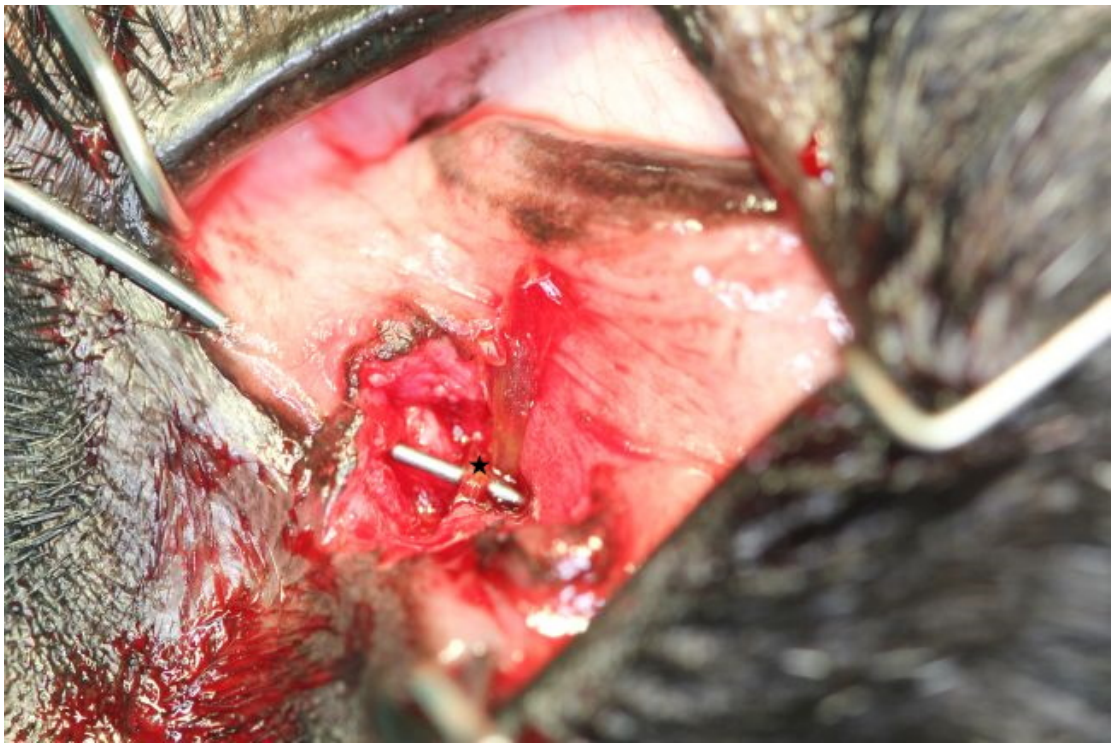

Figure 4. The opened-up lacrimal sac (transconjunctivally) with a grass awn (☆).

Figure 5. – Removal of a grass awn from the lower lacrimal punctum of a pit-bull terrier.

Figure 6. – Dog 18/Case 20 after its second surgery, still showing mucopurulent ocular discharge.