

Eye-related neoplasms in dogs: A retrospective study

Neoplasias relacionadas con los ojos en perros: Estudio retrospectivo

Neoplasias relacionadas aos olhos em cães: Estudo retrospectivo

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Abstract

Background: Eye-related neoplasms in dogs have a significant impact on visual ability, comfort, and longevity. Therapeutic alternatives and prognosis vary according to type of neoplasm and its anatomical location. **Objective:** To describe the frequency and distribution of eye-related neoplasms affecting dogs in the Aburrá valley (Antioquia province, Colombia). **Methods:** A retrospective collection of eye-related neoplasms in dogs, diagnosed at the Animal Pathology Laboratory of Universidad de Antioquia (Colombia), was conducted. Data spanning from years 2005 to 2017 were used. Records included age, sex, breed, neoplasm type and location, and cellular origin of neoplasm. A total of 250 eye-related-neoplasm reports affecting 246 dogs were analyzed -one report per animal, with the exception of four animals with both eyes simultaneously affected by the same type of neoplasm. **Results:** Animals between 8 and 11 years of age were more frequently affected by eye-related neoplasms (43.9%). Labrador retriever (19.1%), mixed-breed dogs (13.4%), and Poodle (12.2%) were the most frequently affected breeds. Neoplasms affected the eyelid in 76.8% of cases. Meibomian gland adenoma was the most frequent neoplasm (22.8%), followed by Meibomian gland epithelioma (20.0%), squamous cell carcinoma (8.8%), and melanocytoma (7.2%). The cellular origin of neoplasms was epithelial in 73.6% of the cases. **Conclusion:** Meibomian gland adenoma was the most common eye-related neoplasm. To our knowledge, this is the first retrospective report aimed to eye-related neoplasms in dogs published in Colombia.

Keywords: adenoma; canine; dog; eyelid; eye globe; eye-related neoplasms; Meibomian gland; ocular neoplasia; tumor.

Resumen

Antecedentes: Las neoplasias relacionadas con los ojos en perros tienen un impacto significativo en la capacidad visual, la comodidad y la longevidad del animal. Las opciones terapéuticas y el pronóstico para el perro y para el tejido afectado varían según el tipo de neoplasia y su ubicación anatómica. **Objetivo:** Describir la frecuencia y distribución de neoplasias relacionadas con los ojos en perros del Valle de Aburrá (Departamento de Antioquia, Colombia). **Métodos:** Se realizó una evaluación retrospectiva de neoplasias relacionadas con los ojos en perros, diagnosticadas en el laboratorio de patología animal de la Universidad de Antioquia (Colombia). Los registros incluyeron información de 13 años (2005-2017). Los datos recolectados incluyeron edad, sexo, raza, tipo de tumor y ubicación, y origen celular de la neoplasia. **Resultados:** Se analizó un total de 250 reportes de neoplasias relacionadas con los ojos, afectando 246 perros (un reporte por animal, excepto cuatro animales en los que ambos ojos fueron afectados simultáneamente por el mismo tipo de neoplasia). Los animales entre 8 y 11 años de edad fueron los más frecuentemente afectados por neoplasias relacionadas con los ojos (43,9%). Las razas Labrador retriever (19,1%), perros mestizos (13,4%) y Poodle (12,2%) fueron las más frecuentemente afectadas. Las neoplasias afectaron el párpado en el 76,8% de los casos. El adenoma de la glándula de Meibomio fue la neoplasia más frecuente (22,8%), seguida por el epiteloma de la glándula de Meibomio (20,0%), el carcinoma de células escamosas (8,8%) y el melanocitoma (7,2%). El origen celular de las neoplasias fue epitelial en el 73,6% de los casos. **Conclusión:** Se encontró que el adenoma de la glándula de Meibomio es la neoplasia ocular más común. Hasta donde sabemos, este es el primer reporte retrospectivo dirigido específicamente a neoplasias relacionadas con ojos en perros publicado en Colombia.

Palabras clave: adenoma; caninos; glándula de Meibomio; globo ocular; neoplasia ocular; párpado; perro; tumor.

Resumo

Antecedentes: As neoplasias relacionadas aos olhos em cães são importantes porque têm um impacto significativo na capacidade visual, conforto e longevidade do animal. As opções terapêuticas e o prognóstico para o cão e para o tecido afetado variam de acordo com o tipo de neoplasia e sua localização anatômica. **Objetivo:** Descrever a frequência e distribuição das neoplasias relacionadas aos olhos em cães do Valle de Aburrá (Estado de Antioquia, Colômbia). **Métodos:** Foi realizada uma coleta retrospectiva de neoplasias relacionadas aos olhos em cães diagnosticados no laboratório de patologia animal da Universidade de Antioquia (Colômbia). Os registros coletaram informações de 13 anos (2005-2017). Os dados coletados incluíram idade, sexo, raça, tipo de tumor e localização e origem celular da neoplasia. **Resultados:** Um total de 250 relatos de neoplasias relacionadas aos olhos foram analisados, afetando 246 cães (um relatório por animal, com exceção de quatro animais, em que ambos os olhos foram afetados simultaneamente para o mesmo tipo de neoplasia relacionada aos olhos). Animais entre 8 e 11 anos foram mais acometidos por neoplasias relacionadas aos olhos (43,9%). As raças Labrador retriever (19,1%), mestiças (13,4%) e Poodle (12,2%) foram as raças mais afetadas. Neoplasias afetaram a pálpebra em 76,8% dos casos. Adenoma da glândula Meibomiana foi a neoplasia mais frequente (22,8%), seguido por epiteloma glândula Meibomiana (20,0%), carcinoma de células escamosas (8,8%) e melanocitoma (7,2%). A origem celular das neoplasias foi epitelial em

73,6% dos casos. **Conclusão:** Este estudo constatou que o adenoma da glândula Meibomiana é a neoplasia ocular mais comum. Para nosso conhecimento, este é o primeiro relato retrospectivo especificamente voltado para as neoplasias relacionadas aos olhos em cães publicados até o momento na Colômbia.

Palavras-chave: adenoma; cão; glândula Meibomiana; globo ocular; neoplasia ocular; pálpebra; tumor.

Introduction

Veterinary ocular pathology is an emerging area, with reports dating from the beginning of the 20th century (Gelatt, 2008). In Colombia, this discipline is still modest when compared to ophthalmology, the specialty from which it derives. The increasing number of veterinary pathology laboratories and institutions offering ophthalmology services will soon depend on the development of this field.

Neoplasms are especially important in clinical practice for being the most frequent cause of death in dogs (47.0%; Withrow *et al.*, 2013). Primary eye neoplasms are relatively uncommon in domestic animals. Frequencies in dogs can be as low as 0.9 (Withrow *et al.*, 2013) to 39.0% (Dubielzig *et al.*, 2010) of all neoplasms.

Eye-related neoplasms are important since they have a significant impact on visual ability, comfort, and longevity, and can lead to tissue destruction and metastasis (Labelle and Labelle, 2013). Therapeutic options and prognosis for life and for the eye will depend on neoplasm type and its anatomical location (Dubielzig, 2017).

It is known that disease prevalence varies largely between countries and between regions within a country. Although reports of ocular diseases in specific animal species and etiological entities are available, there is still the need for data about general frequency and distribution of eye-related neoplasms in our country. Absence of such data does not bias the diagnosis of lesions submitted to pathology labs, but unavailability somehow forces local pathologists and veterinary students

to confront their findings with those reported in the international literature. In addition, understanding the type and frequencies of eye-related neoplasms in dogs would provide information on epidemiological background and potentially help to identify tendencies over time and even risk factors.

The aim of the present report was to describe the frequency and distribution of eye-related neoplasms in dogs using diagnostic records collected during 13 years at the Animal Pathology Laboratory of Universidad de Antioquia (Colombia).

Materials and methods

Ethical considerations

The study involved the analysis of information obtained during regular histopathological diagnosis. Approval from an ethical committee on animal experimentation was not necessary.

Study population, histopathological analysis and data collection

A retrospective search of reports on eye-related neoplasms in dogs was performed. Experienced veterinary pathologists at the Animal Pathology Laboratory of Universidad de Antioquia (Colombia) collected cases between January 2005 and December 2017 from routine histopathological examination. Samples were formalin-fixed, 2-4 μ m-paraffin sectioned, and finally, hematoxylin and eosin-stained. Inclusion criteria considered neoplasms affecting eyelid, ocular globe, and third eyelid in dogs during the period. Data extracted included year of case report, information on the affected dog (i.e.,

age, sex, breed) and neoplasms characteristics (i.e. location, histological type, cellular origin). Nomenclature of the eye-related neoplasms was adopted in conformity with the World Health Organization's Histological Classification of Ocular and Otic Tumors of Domestic Animals (Wilcock *et al.*, 2002).

Data analysis

Data from the records was entered in Excel worksheets (Microsoft Corp., Redmond, WA, USA). Descriptive statistics was presented as percentages and 95% confidence intervals (CI) based on the total number of eye-related neoplasms. Statistical analyses were conducted using Stata14.0 (StataCorp 2015, Texas, USA).

Results

A total of 250 eye-related-neoplasm reports were found in 246 dogs (one report/animal, with the exception of four animals with both eyes simultaneously affected by the same type of neoplasm). Eye samples were submitted from 40 veterinary clinics located in Aburrá valley (Antioquia province, Colombia) and surrounding areas. Reports included dogs from 33 breeds (including mixed-breeds), males and females, aged between 6 months and 18 years. Data regarding distribution of eye-related neoplasms by age, sex, and breed are listed in Table 1.

Data on distribution of eye-related neoplasms by location, neoplasm type, and cellular origin are listed in Table 2. The 250 cases were classified in 30 types, in three locations, both eyes, and three cellular origins.

Table 1. Distribution of eye-related neoplasms by age, sex, and breed of dogs reported at the Animal Pathology Laboratory of Universidad de Antioquia (Colombia) between 2005 and 2017.

Variables	Categories	No. of cases	% of total	95% CI
Age	6 months-3 years	16	6.5	3.4-9.6
	4-7 years	69	28.1	22.4-33.7
	8-11 years	105	42.7	36.5-48.9
	≥ 12 years	49	19.9	14.9-24.9
	Not reported	7	2.8	0.8-4.9
Total	-	246	100	-
Sex	Male	140	56.9	50.3-61.9
	Female	106	43.1	37.0-48.6
Total	-	246	100	-
Breed	Labrador retriever	45	18.3	14.6-24.6
	Mixed-breed	33	13.4	9.2-17.7
	Poodle	28	11.4	7.7-14.3
	Boxer	15	6.1	3.1-9.1
	Schnauzer	13	5.3	2.5-8.1
	Beagle	12	4.9	2.2-7.6
	Golden retriever	11	4.5	1.9-7.1
	Bulldog	9	3.7	1.3-6.0
	Pug	9	3.7	1.3-6.0

Siberian husky	9	3.7	1.3-6.0
Shih-tzu	8	3.3	1.0-5.5
Pitbull	6	2.4	0.5-4.4
Rottweiler	5	2.0	0.3-3.8
Weimaraner	5	2.0	0.3-3.8
Dalmatian	4	1.6	0.0-3.2
Springer Spaniel	4	1.6	0.0-3.2
Australian shepherd	3	1.6	0.0-3.2
Pinscher	3	1.6	0.0-3.2
Yorkshire terrier	3	1.6	0.0-3.2
Bull terrier	2	0.8	0.0-1.9
Chihuahua	2	0.8	0.0-1.9
Cocker Spaniel	2	0.8	0.0-1.9
Fox terrier	2	0.8	0.0-1.9
German shepherd	2	0.8	0.0-1.9
Saint Bernard	2	0.8	0.0-1.9
Shepherd collie	2	0.8	0.0-1.9
Bloodhound	1	0.4	0.0-1.2
Chow-chow	1	0.4	0.0-1.2
Irish setter	1	0.4	0.0-1.2
Jack Russell terrier	1	0.4	0.0-1.2
Pekingese	1	0.4	0.0-1.2
Samoyed	1	0.4	0.0-1.2
Vizsla	1	0.4	0.0-1.2
Total	-	246	100

CI: Confidence interval.

Table 2. Distribution of eye-related neoplasms by anatomical location, type, and cellular origin, at the Animal Pathology Laboratory of Universidad de Antioquia (Colombia) between 2005 and 2017.

Variables	Categories	No. of cases	% of total	95% CI
Anatomical location	Eyelid	192	76.8	71.6-82.0
	Ocular globe	41	16.4	11.8-21.0
	Third eyelid	14	5.6	2.8-8.5
	Ocular globe and eyelid	3	1.2	0.0-2.6
Total		250	100	-
Neoplasm type	Meibomian gland adenoma	57	22.8	17.6-28.0
	Meibomian gland epithelioma	50	20.0	15.0-25.0

Squamous cell carcinoma	22	8.8	5.3-12.3
Melanocytoma	18	7.2	4.0-10.4
Meibomian gland carcinoma	16	6.4	3.4-9.4
Papilloma	16	6.4	3.4-9.4
Hemangiosarcoma	15	6.0	3.1-8.9
Melanoma	11	4.4	1.9-6.9
Cutaneous histiocytoma	7	2.8	0.8-4.8
Iridociliary adenocarcinoma	5	2.0	2.6-3.7
Third eyelid gland adenocarcinoma	4	1.6	0.0-3.2
Apocrine carcinoma	4	1.6	0.0-3.2
Fibrosarcoma	3	1.2	0.0-2.6
Hemangioma	3	1.2	0.0-2.6
Basal cell tumor	2	0.8	0.0-1.9
Mast cell tumor	2	0.8	0.0-1.9
Trichoblastoma	2	0.8	0.0-1.9
Basal cell carcinoma	1	0.4	0.0-1.2
Baso-squamous cell carcinoma	1	0.4	0.0-1.2
Dermoid cystic teratoma	1	0.4	0.0-1.2
Fibroma	1	0.4	0.0-1.2
Iridociliary adenoma	1	0.4	0.0-1.2
Lacrimal gland adenocarcinoma	1	0.4	0.0-1.2
Lipoma	1	0.4	0.0-1.2
Lymphoma	1	0.4	0.0-1.2
Myxosarcoma	1	0.4	0.0-1.2
Trichoepithelioma	1	0.4	0.0-1.2
Transmissible venereal tumor	1	0.4	0.0-1.2
Round cell undifferentiated tumor	1	0.4	0.0-1.2
Undifferentiated carcinoma	1	0.4	0.0-1.2

Total	-	250	100	-
Cellular origin	Epithelial	184	73.6	68.1-79.1
	Melanocytic	29	11.6	7.6-15.6
	Mesenchymal	24	9.6	6.0-13.3
	Round cells	12	4.8	2.2-7.5
	Mixed origin	1	0.4	0.0-1.2
Total	-	250	100	-

CI: Confidence interval.

The following text describes the findings for eye-related neoplasms, grouped according to the international classification system reported by Dubielzig (2017) and mentioned according to frequency as a report group in this study (from most to least frequent). Details for each description refers to significant findings and others to details reported due to interest of the authors.

Meibomian gland neoplasms

Neoplasms of the Meibomian glands were the most frequently found in this study (49.2%; 123/250). These neoplasms, classified as adenoma, epithelioma, and carcinoma, presented an epithelial origin. Meibomian adenoma (Figure 1A) was the most commonly found Meibomian gland neoplasm, as well as the most frequently reported in this study. Labrador retriever (17/57) and Poodle (10/57) were the two most commonly affected breeds. No sex predilection was found. Only one case was classified as ductal adenoma in a 10-year-old female Labrador retriever. Meibomian epithelioma (Figure 1B) was the second most frequently reported neoplasm in this study and it was restricted to the eyelid. A 60.0% (30/50) of the cases occurred in male dogs. Labrador retriever (12/50), Poodle (7/57), mixed-breed (7/57), and Schnauzer (7/57) were the most frequently affected breeds. Three of these cases had ductal differentiation (3/50). After the squamous cell carcinoma, the Meibomian carcinoma (Figure 1C) was the most commonly

found malignant neoplasm. A 62.5% (10/16) of the affected dogs were males. Mixed-breed dogs (5/16) and Labrador retrievers (4/16) were the most frequently affected breeds.

Surface epithelium neoplasms

Papilloma was the most commonly benign epidermal neoplasm found. The eyelid was the location involved in most of the cases (81.3%; 13/16). The bulbar conjunctiva was affected twice (12.5%; 2/16) and only one case was reported affecting the third eyelid. Bulldog (3/16) and mixed-breed dogs (3/16) were the most frequently affected breeds. Squamous cell carcinoma (Figure 1D) was the most commonly malignant neoplasm found in this study and it was reported individually in all anatomical locations (eyelid, third eyelid, and ocular globe). Only one neoplasm case affected two anatomical locations at the same time (third eyelid and ocular globe). The eyelid was involved in most of the cases (59.1%; 13/22), the ocular globe in six cases (27.3%), and the third eyelid, twice (9.1%). The average age for this neoplasm was 8.7 years, and breeds mostly affected were Boxer (7/22) and Rottweiler (3/22). Basal cell neoplasms were present four times in the eyelid, two of them corresponding to benign basal cell neoplasms, found in two females Poodle and Labrador retriever. Basal cell carcinoma was reported in a 10-year-old male Boxer. Likewise, only one case of baso-squamous cell carcinoma was found affecting the eyelid of a 7-year-old male Schnauzer.

Iridociliary neoplasms

Iridociliary neoplasms (6/250) were restricted to the ocular globe. One of them was an adenoma and it was reported in an 8-year-old female Labrador retriever. The remaining were adenocarcinomas affecting three dogs. The age range for iridociliary adenocarcinoma was 5-11 years, with an average of 9.1. No breed tendency was found.

Melanocytic neoplasms

Melanocytoma (Figure 2A) was the most common melanocytic neoplasm (62.1%; 18/29). The age range for this neoplasm was 4-16 years, with an average of 8.7. This neoplasm had higher frequency in males (72.2%; 13/18). The eyelid was the anatomical site most commonly affected by melanocytoma (77.8%; 14/16). The other four cases were intraocular (22.2%). There was no breed predilection in regard to the ocular globe. Melanoma (Figure 2B) was slightly more frequent in males (54.5%; 6/11). The ocular globe and the third eyelid were affected each one, twice. There was not breed predilection, but three of the four dogs were males. Eyelid melanoma (7/11) had an age range of diagnosis between 7-11 years, with Pitbull (2/7) and Labrador retriever (2/7) as the most commonly affected breeds.

Vascular neoplasms

Eighteen vascular neoplasms (7.2%; 18/250) were found. Three cases corresponded to hemangioma (3/18) involving individually the three anatomical locations reported herein. The age range for this neoplasm was 4-14 years, and the breeds affected were Dalmatian, Bull terrier, and mixed-breed dogs. Hemangiosarcoma (15/18) was found in the ocular globe and in the third eyelid (Figure 2C). The ocular globe was affected in 80.0% (12/15) of the cases, and was restricted to the third eyelid in three of the cases. The age range for this neoplasm was 5-13 years, with an average of 8.7. Mixed-breed dogs (6/15) and Dalmatian (2/15) were the most commonly affected breeds. The ocular hemangiosarcoma mostly affected males (66.7%; 8/12).

Fibrous tissue neoplasms

A fibroma was reported in the eyelid of a 13-year-old male Cocker Spaniel. A fibrosarcoma was found in the eyelid of two male Labrador retrievers, and in one case, the neoplasm affected the ocular globe of an 11-years-old female Poodle. A myxosarcoma was reported in the third eyelid of a 4-year-old male Weimaraner.

Round cell neoplasms

Twelve round cell tumors were found (4.8%; 12/250). One of them was an undifferentiated tumor in the eyelid of a 4-year-old male Pug and another one was a transmissible venereal tumor (TVT) in a 2-year-old male mixed-breed dog. Cutaneous histiocytoma was restricted to the eyelid of dogs between 2-8 years of age. Males were most commonly affected (71.4%; 5/7) as well as Labrador retrievers (2/7). A lymphoma was found affecting the eyelid of an 8-year-old male Poodle. Two mast cell tumors (0.8%; 2/250) were reported as, a high-grade mast cell neoplasm affecting the ocular globe of a 12-year-old female Poodle, and a low-grade mast cell neoplasm affecting the ocular globe of a 5-year-old male Golden retriever.

Third eyelid gland adenocarcinoma

This malignant neoplasm, derived from the apocrine third eyelid gland, was found four times in our study, three of them affecting only the third eyelid and one the ocular globe as well. The age range for this neoplasm was 6-15 years. This neoplasm affected a male Beagle, Boxer, and Fox terrier, and a female Weimaraner.

Apocrine neoplasms

Four reports for apocrine carcinoma were found, and two of them had ductal proliferation (ductal apocrine carcinoma). All the animals were males aged 7-10 years. This neoplasm was found twice in Boxers, once in a Poodle and a Golden retriever. The neoplasm affected the eyelid and extended to the ocular globe of an 8-year-old male Boxer. The other three apocrine neoplasms were restricted to the eyelid.

Hair follicle neoplasms

Three benign hair follicle neoplasms were found, corresponding to two trichoblastomas and a trichoepithelioma, all of them located in the eyelid. Trichoblastomas were reported in an 11-year-old male Siberian husky and in a 12-year-old female Poodle. A trichoepithelioma was reported in a 12-year-old male Poodle.

Other eye-related neoplasms

The eyelid of a 14-year-old male Poodle was affected by a lacrimal gland adenocarcinoma (Figure 2D). Additionally, a dermoid cystic teratoma was found in the cornea of a young female Chihuahua.

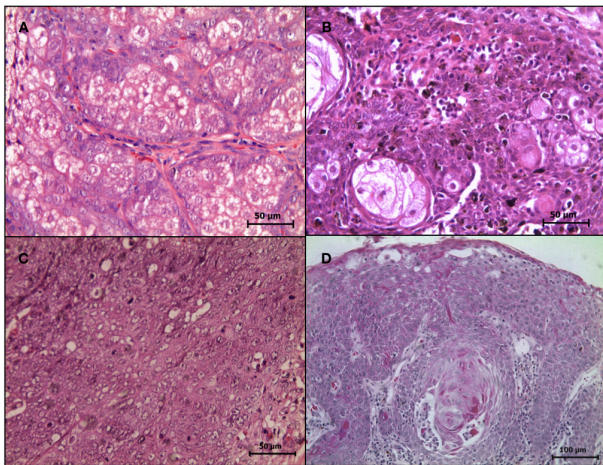


Figure 1. Histopathological features. (A) Meibomian gland adenoma in the upper eyelid of a 7-year-old Labrador retriever (mass size = 0.5 cm). (B) Meibomian gland epithelioma in the upper eyelid of an adult Beagle (note the predominant presence of reserve cells). (C) Meibomian gland carcinoma in the upper eyelid of an 8-year-old Golden retriever. (D) Squamous cell carcinoma affecting the cornea of an 8-year-old male Pug (Hematoxylin & Eosin stain).

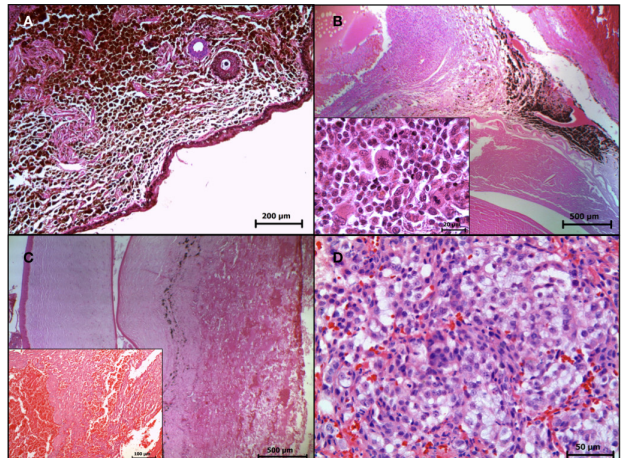


Figure 2. Histopathological features. (A) Melanocytoma in the lower eyelid of a 9-year-old female Yorkshire terrier (note the diffuse presence of melanocytes affecting the dermis). (B) Intraocular infiltrating melanoma in the iris of a 10-year-old male Siberian huskie. The neoplasm extended to both ocular chambers (a magnification of the same lesion after melanin bleaching, presenting pleomorphism and mitotic figures is shown in the inset figure). (C) Hemangiosarcoma in a 5-year-old Dalmatian. Note the presence of dilated structures containing red blood cells affecting the vascular tunic; additionally, this neoplasm extended to the cornea (a greater formation of vascular structures with erythrocytes inside, typical of this neoplasm, is shown in the inset figure). (D) Lacrimal gland adenocarcinoma affecting the palpebral conjunctiva of a 14-year-old male Poodle (Hematoxylin & Eosin stain).

Discussion

Many neoplasm types can affect the eye and adnexal structures in domestic animals. When considering neoplasms, thorough evaluation of the health of the eye and patient is essential to determine the biologic behavior of the condition. Fernandez *et al.* (2013) analyzed a considerable number of ocular neoplasms (n = 173) finding numerous cases in dogs over 10 (43.2%) and 6-10 years (40.6%), and few cases in those under 5 years of age (9.9%). Several studies have evaluated ocular neoplasms, observing an age predilection, mainly in dogs between 8 and 11 years of age (Abarca *et al.*, 2002; Heath *et al.*,

2003; Laus *et al.*, 2008; Conceição *et al.*, 2010; Fernandez, 2013; Werner *et al.*, 2017). These reports are in agreement with our findings, where the age group with the highest incidence (8-11 years of age) presented significant difference when compared to the other age groups. Even though histiocytoma is common in young dogs (with an average age of 3 years; Conceição *et al.*, 2010; Fernandez, 2013) the age range in the present study was 2-8 years.

Fernandez (2013) reported a distribution of ocular neoplasms by sex, with a higher presentation in male dogs (56.2%) compared to females (43.8%). In addition, Silva *et al.* (2016) reported a very similar distribution by sex (55.6 vs. 43.4%), which is consistent with our findings.

Labrador retriever and Poodle dogs were the most commonly affected breeds in our study, similar to Silva *et al.* (2016) who reported that mixed-breed (26.6%), Labrador retriever (16.1%) and Poodle (11.2%) were the breeds most commonly affected by ocular neoplasms. Other researchers reported that Labrador retriever and Poodle breeds are predisposed to ocular neoplasms -mostly adenomas, adenocarcinomas, and melanomas (Conceição *et al.*, 2010; Fernandez, 2013; Dees *et al.*, 2015).

The eyelid was the most frequently affected structure. Consistently with the literature, the most important neoplasms were those affecting the Meibomian glands (Dees *et al.*, 2015). We hypothesize that this could be due to the direct contact of this structure with the environment, increasing the chances of damage and further tissue adaptation to injuries.

The most commonly affected structure in our study was the Meibomian gland, agreeing with the literature (Dubielzig, 2017). Werner *et al.* (2017) reported 9.4 years as the average age for Meibomian neoplasms, which is consistent with our findings (9.9 years). Silva *et al.* (2016) reported the epithelioma (24.3%) and adenoma (15.4%) as the most common neoplasms

affecting the eye and adnexa structures in dogs, similar to our study. The only difference is that adenoma was slightly more frequent compared to epithelioma in our study. Werner *et al.* (2017) reported that Labrador retrievers was the breed most commonly affected by adenoma and epithelioma of the Meibomian glands, which is consistent with what is reported herein.

The literature reports that Meibomian adenocarcinoma is a rare neoplasm of the eyelid, accounting for less than 1.0% of all eyelid neoplasms, with no gender or breed susceptibility (Wilcock *et al.*, 1998; Tavasoli *et al.*, 2012). We found that this neoplasm was one of the lowest occurrence, but it was not as low as reported in the literature.

Eye-related squamous cell carcinoma frequently affected Boxer and Rottweiler in our study. Similar findings about presentation of squamous cell carcinoma in brachycephalic dogs have been reported (Takiyama *et al.*, 2010). This could be due to chronic exposition to excessive sunlight in this kind of dogs (Busse *et al.*, 2008). Nevertheless, Dreyfus *et al.* (2011) reported lower incidence of these neoplasms in brachycephalic breeds. Conceição *et al.* (2010) reported that squamous cell carcinoma was the most common eyelid neoplasm in dogs older than 10 years of age. We found no sex predilection for this neoplasm as it has been reported by the literature (Goldschmidt and Goldschmidt, 2017).

Literature reports that iridociliary neoplasms represent 12.5% of the eye-related neoplasms in dogs, which is consistent with our findings -representing the 14.6% of intraocular neoplasms. Retriever dogs are considered the most commonly affected by these kind of neoplasms (Petterino *et al.*, 2014; Okawauchi *et al.*, 2016). Nevertheless, our study did not find such tendency. We found an average presentation of 8.5 years of age for iridociliary neoplasms, which is consistent with previous reports (Fernandez, 2013).

In a retrospective study by Teixeira *et al.* (2010), melanoma was the most common melanocytic eye-related neoplasm found in dogs, but none of them related to eyelid. We found 14 cases of melanocytoma in the eyelid; similar to what was reported by Wang and Kern (2015) who outlined melanocytic neoplasms as mainly benign, except in the conjunctiva, where the malignant form is more commonly seen. In our study, the malignant form was frequently observed in the ocular globe. The frequency of this neoplasm was higher in males in our study as well as reported by Wang and Kern (2015).

Soft tissue sarcomas are a heterogeneous group of neoplasms of mesenchymal origin, representing 15% of all skin neoplasms in dogs (Campos *et al.*, 2015). The literature reports that canine eyelid sarcomas are infrequent and predisposition to fibrosarcoma in Golden retrievers could exist (Fernandez, 2013; Nordio *et al.*, 2017). In our study, Labrador retriever was the most commonly affected breed, genetically related to the breed reported in the literature. Hendrix *et al.* (2000) reported five cases of fibrosarcoma out of 44 cases of ocular neoplasms, with no predilection by age, sex, or breed.

Histiocytoma is the most common neoplasm seen in young dogs, and the eyelid is a typical site of occurrence (Conceição *et al.*, 2010; Lew *et al.*, 2010). It has been reported that ocular histiocytoma is more frequently found in dogs younger than three years of age (Fernandez, 2013). Nevertheless, we found it in 2 to 8-year-old dogs, averaging five years.

Although there are few reports of TVT in the eye of dogs (a 1-year-old mixed-breed male and a 4-year-old male Labrador retriever), this diagnosis should be taken into account in sexually active young dogs (Milo and Snead, 2017).

According to the literature, adenocarcinoma is more commonly found in the third eyelid gland, compared to adenoma (Fernandez, 2013; Labelle and Labelle, 2013; Dees *et al.*, 2015).

Dees *et al.* (2015) reported an age range of 3-16 years and a male predilection (60.9%), and the breeds most commonly affected by these neoplasms were mixed-breed (20.2%) followed by Labrador retriever (7.5%). The literature also reports a predisposition in geriatric dogs, with an average age of 11 years (Conceição *et al.*, 2010). We found four cases in different breeds, with a male tendency (75%) and the age range was 6-15 years.

Apocrine sweat gland adenocarcinomas account for 0.7 to 2.2% of all skin-associated tumors in dogs (Stern and Eisele, 2011). Simko *et al.* (2003) reported a breed tendency (27.8% in mixed-breeds) with 9 years average age in a study of 44 dogs with apocrine skin neoplasms. The literature reports only two cases of apocrine carcinoma in the eyelid of dogs, corresponding to a 13-year-old male Shetland sheepdog and a 12-year-old female Miniature pinscher (Hirai *et al.*, 1997; Stern and Eisele, 2011). In agreement with Simko *et al.* (2003), we found a tendency in males (100%) and a similar age of presentation (7-10 years), although the breeds affected in our study were different.

As with many retrospective studies, there are difficulties in veterinary medicine reports. This can be due to lack of information in the analysis request form and/or medical records when samples are submitted to the pathology laboratory. Similarly, information is scarce in our country as well as in those sharing similar cultural and ecological conditions. To our knowledge, this is the first retrospective report aimed to eye-related neoplasms in dogs published in Colombia.

In conclusion, the behavior of eye-related neoplasms affecting dogs is similar to that reported in the literature, with variations between countries and regions. Labrador retriever and Poodle dogs were overrepresented in this study, which can be explained by their great presence in Colombia. More complete clinical information at sample submission is required for valuable epidemiological information to make specific and useful

pathological diagnoses. We should increase our understanding of the epidemiological behavior of eye-related neoplasms in dogs during the clinical practice. The present study provides useful epidemiological data for the diagnosis of ocular neoplastic disease by pathologists and clinicians. Further retrospective epidemiological studies are needed to understand the current situation in the country.

Declarations

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

Author contributions

All authors included herein made substantial contributions, as follows:

Julián D Muñoz-Duque: Conception and design of the study, acquisition of data, interpretation of data, drafting and revising the manuscript for important intellectual content, and approval of the submitted version.

María C Ramírez-Rojas: Acquisition of data, drafting of the manuscript for important intellectual content, and final approval of the version to be submitted.

Santiago Duque-Arias: Acquisition of data, drafting of the manuscript for important intellectual content, and final approval of the version to be submitted.

Nathalia M Correa-Valencia: Conception and design of the study, acquisition and interpretation of data, drafting and revising of the manuscript for important intellectual content, and final approval of the version to be submitted.

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