PAPER

A retrospective survey of ocular abnormalities in pugs: 130 cases

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Objectives: To determine the types and frequency of ophthalmic findings in pugs.

Materials and Methods: Retrospective analysis of case records of pugs presented to an ophthalmology unit between 2001 and 2012. Ophthalmological findings were correlated with age, gender, presenting signs and time of onset of disease.

Results: In total, 130 pugs (258 eyes) with a mean (±sd) age of 2·8 (±2·87) years were examined. Ocular abnormalities identified included keratoconjunctivitis sicca (n=39 eyes), macroblepharon (n=258 eyes), entropion (n=258 eyes), distichiasis (n=56 eyes), ectopic cilia (n=8 eyes), conjunctivitis (n=88 eyes), corneal pigmentation (n=101 eyes), opacity (n=63 eyes), ulceration (n=46 eyes), vascularisation (n=35 eyes), iris-to-iris persistent pupillary membranes (n=21 eyes) and cataract (n=18). Keratoconjunctivitis sicca was significantly associated with the presence of corneal pigmentation (P=0·007 for left eyes; P=0·043 for right eyes). However corneal pigmentation was also identified in pugs (n=61) without keratoconjunctivitis sicca. There was a significant influence of ectopic cilia on corneal ulceration (P<0·001). Younger dogs (mean age, 1·28 (±0·45) years) were significantly more affected by distichiasis.

Clinical Significance: The high number of cases of corneal pigmentation without keratoconjunctivitis sicca suggests that there may be additional yet undetermined factors involved in the development of corneal pigmentation in pugs.

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INTRODUCTION

The pug appears to be increasing in popularity and with its small, stocky and square body shape, round face and large prominent eyes, a high prevalence of disease has been reported. A number of ocular disorders have been described in the pug, some of which are related to the unique anatomical properties of this breed. Common ocular pathologies include entropion, distichiasis, keratoconjunctivitis sicca (KCS), corneal pigmentation (CP), corneal erosion, corneal ulceration, corneal perforation and corneal vascularisation (CV) (Williams 2008; Labelle *et al.* 2013).

In recent years an increase in the number of pugs presented for ophthalmic disorders has been noted. However there are very few large retrospective studies on the most common ophthalmic pathologies in the pug (Labelle *et al.* 2013). Hence the purpose of this study was to report the types and frequencies of ophthalmic findings in the pug and attempt to identify potential influencing factors for the development of these abnormalities.

MATERIALS AND METHODS

Study population and ophthalmologic examination

Case records of all pugs presented to the ophthalmology unit of the Department of Companion Animals and Horses of the Veterinary University in Vienna between 2001 and 2012 were reviewed. All dogs were examined by or under the supervision of an ophthalmology diplomate using slit lamp biomicroscopy (Kowa portable slit-lamp SL-14) and direct and indirect ophthalmoscopy (Heine Omega 2C). Mydriasis was induced using 1% tropicamide

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(Mydriaticum "AGEPHA" Pharmaceuticals) to examine the posterior ocular segments. Schirmer tear test (STT) (Intervet Deutschland GmbH), fluorescein stain (Ophthalmic Strips U.S.P.) and tear film break-up time (TFBUT) were performed. A TFBUT of 20 seconds was considered normal (Saito & Kotani 2001).

Data acquisition

Ocular abnormalities from the case records were categorised according to anatomical region and suspected aetiology and listed on an Excel 2010 spreadsheet (Microsoft Office 2010, Excel 2010) for subsequent statistical evaluation. Additional data, such as gender, age and time of onset of ophthalmic abnormalities according to the history from the owner were also noted.

Statistical analysis

The data were analysed using SPSS v19 (IBM Software). Frequency distribution of gender, age and ocular pathologies were calculated. Influences of age, gender and interrelation between ophthalmic abnormalities were determined using cross tables and tested for significance using Chi squared test. Descriptive predictability models were applied to determine the predicted chance of development of ocular abnormalities based on influencing factors such as age, gender or other predisposing ophthalmic findings. A P value <0.05 was considered significant for all statistical analysis.

RESULTS

Study population

A total of 258 eyes (130 pugs) were examined (Table 1). Sixty-six (50·8%) entire males, 10 (7·7%) neutered males, 39 (30·0%) entire females and 15 (11·5%) neutered females were included. They ranged in age from 0·2 to 12·0 years, with a mean (±sd) of 2·8 (±2·87) years (Fig 1). Presenting signs reported by the owner or referring veterinarian included decreased vision (n=8), blindness (n=4), entropion (n=3), distichiasis (n=6), blepharospasm (n=30), ocular discharge (n=31), conjunctivitis (n=24), corneal opacity including corneal oedema, fibrosis, pigmentation (n=42), corneal injury (n=9) and corneal ulceration (n=6). Less frequent presenting signs included neoplasia of the eyelid (n=2), corneal foreign body (n=1), facial swelling (n=1), reexamination of a repositioned prolapsed eye (n=1), unresponsive pupil (n=1), bulbusprolaps (n=1), hydrophthalmus (n=1), cataract (n=1) and dry eye (n=1). Seven pugs were presented as an emergency, with severe ocular symptoms, which had arisen on the day of presentation. The duration of symptoms otherwise ranged from 0 to 2880 days, with a mean of 90·25 (±346·15) days.

Ophthalmological findings

All pugs included in the study were identified with bilateral macroblepharon and nasal entropion. Further findings associated with the ocular adnexa included distichiasis, ectopic cilia and conjunctivitis.

Distichiasis was found in 28 left (OS) and 28 right eyes (OD) of 35 pugs. Fourteen pugs were affected unilaterally and 21 pugs bilaterally. Nineteen were entire males, 2 neutered males, 11 entire females and 3 neutered females. Of the 56 eyes affected by distichiasis, CP was found OS and OD in 19 and 16, corneal ulcers in 6 and 7, corneal opacities in 7 and 9 and CV in 6 and 5 cases, respectively.

Ectopic cilia were identified OS and OD in six and two cases, respectively (six dogs; four unilaterally and two bilaterally). Five of them were entire males and one was an entire female. CP was found OS and OD in four and one, corneal ulceration in five and two, corneal opacity in two and one case with ectopic cilia, respectively.

Conjunctivitis was found OS and OD in 40 and 48 cases (56 pugs), respectively. Thirty affected animals were male and 26 were female.

STT was documented OS and OD in 116 and 115 cases, respectively (231 eyes; 117 pugs) and ranged from 0 to 27 mm/min. KCS was diagnosed OS and OD in 20 (15·4%) and 19 (14·6%) cases, respectively – in a total of 39 eyes from 29 pugs (STT<15 mm/min). Nineteen were affected unilaterally and 10 pugs bilaterally. Sixteen pugs were entire males, nine entire females, three neutered females and one neutered male. Each of the affected pugs had corneal changes. Thirty-one eyes were diagnosed with CP (17 OS and 14 OD), six eyes had a corneal ulcer (4 OS and 2 OD), eight eyes had corneal opacities not related to pigmentation (4 OS and 4 OD) and nine eyes had CV (5 OS and 4 OD).

One hundred and seven pugs had at least one eye with normal physiological STT (≥15 mm) reference values (192 eyes; 96 OS and 96 OD). Twenty-two pugs had normal STT values unilaterally and 85 pugs bilaterally. One hundred and seventeen of the 192 eyes with normal STT values were affected with CP (61 OS and 56 OD), 50 eyes had corneal opacities (29 OS and 21 OD), 36 eyes were diagnosed with corneal ulceration (18 OS and 18 OD; with 2 eyes having ectopic cilia) and 26 eyes had CV (14 OS and 12 OD).

Regarding qualitative changes of the tear film, four pugs had a TFBUT OU<20 seconds of a total of five pugs, in which TFBUT was determined. One pug had a TFBUT of 19 seconds in one and 21 seconds in the other eye. Three pugs with decreased TFBUT were entire males and two were neutered females. All of them (including the pug with high TFBUT values) had corneal changes, i.e. CP, corneal opacity, corneal ulceration and vascularisation.

The most common corneal findings included CP, corneal opacity and ulcerative keratitis. Twenty-three pugs were affected in one eye whereas 68 pugs had bilateral CP. Forty-six entire male pugs (unilateral=14, bilateral=32) were diagnosed with CP, followed by 25 entire females (unilateral=5, bilateral=20), 13 neutered females (unilateral=2, bilateral=11) and seven neutered pugs (unilateral=2, bilateral=5). Corneal opacity not related to pigmentation was found OS and OD in 36 and 27 cases (53 pugs), respectively. Forty-three pugs were identified with unilateral opacities whereas 10 pugs had bilateral opacities. Thirty entire male, 11 entire female, 7 neutered female and 5 neutered male pugs were affected. Corneal ulceration (Fig 2) was noted OS and OD in 27 and 23 cases (46 pugs), respectively.

Table 1. Pugs (presented between 2001 and 2012) with gender, age, symptom duration, STT values, distichiasis, ectopic cilia, conjunctival and corneal pathologies

Case number	Sex	Age (y)	Duration (d)	STT		Distichiasis		Ectopic cilia		Conjunctivitis		Cornea							
												Pigmentation		Opacity		Ulcer		Vascularisation	
				OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD
1	f	0·7	nk	14	16	–	–	–	–	–	–	+	+	–	–	–	–	–	–
2	m	2·3	nk	nd	nd	–	–	–	–	–	–	–	–	+	+	–	–	–	–
3	nf	5·1	nk	15	15	–	–	–	–	+	–	+	+	+	–	–	–	–	–
4	m	1	240	17	17	–	–	–	–	–	–	+	+	–	–	–	–	–	–
5	nm	0·7	nk	nd	nd	–	–	–	–	–	–	+	+	–	–	–	–	–	–
6	nm	0·7	nk	15	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7	sf	12	nk	7	15	–	–	–	–	–	–	+	+	+	+	–	+	–	+
8	f	0·9	2	15	15	–	–	–	–	–	–	+	+	+	–	–	+	–	–
9	m	0·9	2	nd	nd	–	–	–	–	–	–	+	+	–	–	–	+	–	–
10	m	1	21	15	15	+	+	+	–	–	–	–	–	–	–	+	–	–	–
11	m	3·3	180	20	15	–	–	–	–	–	–	+	–	+	–	–	–	+	–
12	m	1·7	5	15	17	–	+	–	–	–	–	+	+	–	+	–	+	–	–
13	f	1·6	240	15	15	–	+	–	–	–	–	–	–	–	–	–	–	–	–
14	f	1·9	3	15	15	+	+	–	–	–	–	–	–	–	–	–	+	–	+
15	m	3	nk	15	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16	m	1·4	nk	15	15	+	–	–	–	–	–	–	–	–	–	–	–	–	–
17	m	8·9	nk	15	15	–	–	–	–	+	+	–	–	+	–	–	–	+	–
18	m	3·1	180	15	18	–	–	–	–	–	+	–	+	–	–	–	–	–	–
19	m	0·3	3	18	12	–	–	–	–	–	–	+	+	+	–	–	–	–	–
20	m	5·5	2880	15	15	–	–	–	–	–	–	+	+	–	–	-	–	–	–
21	m	11	7	nd	nd	–	–	–	–	–	–	+	+	–	–	–	–	–	–
22	nf	1·3	7	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	–
23	f	1·3	240	18	15	+	–	–	–	+	–	–	+	+	+	+	–	+	–
24	nf	0·3	7	15	15	–	–	–	–	+	+	+	+	+	+	+	+	+	+
25	m	8·7	0	15	e	–	e	–	e	–	e	+	e	+	e	+	e	–	e
26	m	1·9	nk	nd	nd	+	+	+	–	–	–	–	–	–	–	+	–	–	–
27	f	1·3	nk	nd	nd	–	–	–	–	+	+	–	–	–	–	–	–	–	–
28	nm	11·7	1	nd	nd	–	–	–	–	–	+	–	–	–	–	–	–	–	–
29	f	2·5	2	e	18	e	–	e	–	e	–	e	–	e	–	e	–	e	–
30	f	0·5	2	22	21	–	–	–	–	–	+	–	–	–	–	–	+	–	–
31	f	0·2	2	11	14	–	–	–	–	+	+	+	+	–	–	–	–	–	–
32	m	2·6	3	18	17	–	–	–	–	–	+	+	+	–	–	–	+	–	–
33	m	5·5	6	15	15	–	–	–	–	–	–	–	+	–	–	–	–	+	–
34	m	0·9	14	15	20	+	+	–	–	–	–	+	–	+	–	–	–	+	–
35	m	1·2	112	18	15	–	–	–	–	+	+	–	+	–	+	–	–	–	–
36	m	1·3	6	20	13	+	+	+	–	–	–	+	+	+	+	+	–	–	–
37	m	3·5	56	15	15	+	–	–	–	–	–	+	+	+	–	–	–	–	–
38	m	4·2	0	nd	nd	–	–	–	–	–	–	+	–	–	–	–	–	–	–
39	m	4	21	17	10	+	+	–	–	–	–	+	+	–	–	–	–	+	+
40	m	11·7	2	15	9	–	–	–	–	–	–	+	+	+	–	+	+	–	–
41	f	0·3	14	16	15	–	–	–	–	–	–	–	–	+	+	+	+	–	–
42	m	4·9	nk	18	7	–	–	–	–	+	+	+	+	–	–	–	–	–	–
43	f	1·2	nk	15	15	–	–	–	–	+	+	+	+	–	+	–	–	–	–
44	f	0·4	nk	15	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–
45	m	1·7	98	16	16	–	–	–	–	+	+	–	+	+	–	+	–	–	–
46	m	0·3	30	13	13	–	–	–	–	+	+	+	+	–	–	–	–	–	–
47	m	8·2	nk	5	4	–	–	–	–	–	–	+	+	–	–	–	–	–	–
48	m	0·7	nk	13	20	–	–	–	–	–	+	+	+	–	+	–	+	+	+
49	m	0·7	7	15	18	–	–	+	–	–	+	+	–	+	–	+	–	–	–
50	nf	12	nk	10	13	–	–	–	–	+	+	+	+	–	–	–	–	+	+
51	m	0·5	5	20	17	–	–	–	–	+	+	+	–	–	–	–	–	–	–
52	f	2·1	17	15	15	–	–	–	–	+	+	+	+	–	–	–	–	–	–
53	m	1·1	0	15	15	–	–	–	–	+	+	–	–	+	–	–	–	–	–
54	f	0·6	nk	15	15	–	–	–	–	+	+	+	–	–	–	–	–	–	–
55	nm	3·5	nk	15	15	–	–	–	–	+	–	+	+	+	–	–	–	–	–
56	m	0·4	2	14	9	+	–	–	–	+	+	+	+	+	–	+	–	+	–
57	f	0·3	2	0	15	–	+	–	–	–	+	+	–	–	–	–	+	+	–

Table 1. (Continued)

Case number	Sex	Age (y)	Duration (d)	STT		Cornea													
						Distichiasis		Ectopic cilia		Conjunctivitis		Pigmentation		Opacity		Ulcer		Vascularisation	
				OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD
58	nf	2·2	3	20	15	–	–	–	–	+	+	–	–	+	–	+	–	–	–
59	m	0·3	7	12	14	–	–	–	–	–	–	+	+	–	+	–	–	–	+
60	f	1·5	168	18	18	–	–	–	–	–	–	+	+	–	–	–	–	+	–
61	nm	1·8	2	17	15	+	+	–	–	+	+	+	–	–	+	–	+	–	+
62	m	1·8	nk	15	15	+	+	–	–	–	–	+	+	+	+	–	–	–	–
63	f	0·3	0	15	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64	f	0·7	nk	14	18	+	+	–	–	+	+	+	+	–	–	–	–	–	–
65	nf	1·4	nk	12	20	–	+	–	–	+	+	+	+	–	–	–	–	–	–
66	nf	1·3	nk	15	15	+	+	–	–	–	–	–	–	+	+	–	+	–	+
67	nf	7·9	168	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	+
68	f	1·3	1	20	20	–	–	–	–	+	–	–	–	+	–	–	–	–	–
69	nm	4·1	21	15	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–
70	m	5·5	0	6	15	–	–	–	–	–	–	+	–	–	–	–	+	–	–
71	m	0·5	35	10	18	–	–	–	–	–	–	+	+	–	–	–	–	+	–
72	nm	1·5	nk	15	18	–	–	–	–	+	+	+	+	+	–	–	–	+	–
73	m	2	168	15	15	+	–	–	–	–	+	+	–	–	–	–	+	–	–
74	m	0·3	5	16	17	+	+	–	–	–	–	–	–	–	–	+	–	+	–
75	m	3	5	20	12	–	–	–	–	–	–	–	–	+	–	+	–	–	–
76	m	5	7	nd	nd	–	–	–	–	+	–	–	–	–	+	–	+	–	–
77	f	0·6	3	15	15	–	–	–	–	–	+	–	–	–	–	+	–	–	–
78	f	1·8	336	15	16	+	+	–	–	+	+	+	+	–	+	–	–	–	–
79	f	9·2	7	15	10	–	–	–	–	–	+	+	–	–	–	–	–	–	–
80	f	0·4	4	15	nd	–	–	–	–	–	–	–	–	–	+	–	–	–	–
81	m	1·2	3	nd	nd	–	–	–	–	–	+	–	–	–	+	–	–	–	–
82	m	1·4	nk	15	15	–	–	–	–	+	+	+	+	–	–	–	–	–	–
83	m	nk	nk	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	–
84	m	1·6	nk	nd	nd	+	+	–	–	–	–	–	–	–	–	+	–	–	–
85	m	0·8	196	15	15	+	+	–	–	–	–	+	+	–	–	–	–	–	–
86	f	0·4	nk	10	15	–	–	–	–	+	–	–	–	–	–	+	–	–	–
87	nm	1	nk	15	15	–	–	–	–	+	+	+	+	+	–	–	–	–	–
88	nm	2	3	10	12	+	–	–	–	–	–	+	–	–	+	–	+	–	–
89	f	5·2	56	20	20	–	–	–	–	–	–	+	+	–	–	–	–	–	–
90	f	1·2	nk	15	15	+	+	–	–	–	–	+	+	–	–	–	–	–	–
91	f	4·8	1344	20	20	–	–	–	–	–	–	+	+	–	–	–	–	–	–
92	f	0·5	nk	15	15	+	+	–	–	+	+	+	+	–	–	–	–	–	–
93	m	1·1	nk	20	20	–	–	–	–	+	+	+	–	–	–	–	–	–	–
94	m	4·2	21	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	–
95	m	1·2	1	14	13	–	–	–	–	–	–	–	–	–	–	+	–	–	–
96	m	1	2	15	15	–	–	–	–	+	+	+	+	–	–	+	–	–	–
97	m	2·9	10	15	15	–	+	–	–	–	–	+	+	–	+	–	–	–	–
98	m	0·5	1	20	20	–	+	–	–	–	+	–	–	–	+	–	+	–	–
99	m	0·4	3	15	15	–	–	–	–	–	–	–	–	+	+	–	–	–	–
100	nf	2·8	nk	15	15	+	+	–	–	+	+	+	+	–	–	–	–	–	–
101	m	1·7	nk	nd	nd	–	+	–	–	+	+	+	+	–	–	–	–	–	–
102	m	3·2	0	15	15	–	–	–	–	–	–	–	–	–	–	+	–	–	–
103	m	5	nk	15	15	+	+	–	–	+	+	+	+	–	–	–	–	–	–
104	f	410	nk	20	20	+	+	+	+	–	–	+	+	–	+	–	+	–	–
105	f	1·1	nk	15	17	+	–	–	–	–	–	+	+	–	–	–	–	–	–
106	m	7·9	84	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	–
107	f	6·1	nk	10	6	–	–	–	–	–	–	+	+	–	–	–	–	–	–
108	f	1·9	nk	16	20	+	+	–	–	+	+	+	+	–	–	–	–	+	+
109	f	10·4	1	15	11	–	–	–	–	+	–	–	–	+	–	+	–	–	–
110	m	2·5	2	12	15	–	–	–	–	–	+	–	–	+	+	–	+	–	+
111	nf	5	3	15	15	–	–	–	–	–	+	–	+	–	–	+	–	–	–
112	m	1·6	14	15	20	–	–	–	–	–	–	+	+	–	+	–	–	–	–
113	f	5·3	nk	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	–
114	nf	2·4	21	15	15	–	–	–	–	–	–	+	+	+	–	–	–	–	–
115	m	2·4	nk	16	14	–	–	–	–	–	+	+	+	–	+	–	–	–	+

Table 1. (Continued)

Case number	Sex	Age (y)	Duration (d)	STT		Distichiasis		Ectopic cilia		Conjunctivitis		Cornea: Pigmentation		Cornea: Opacity		Cornea: Ulcer		Cornea: Vascularisation	
				OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD
116	f	1·7	7	15	15	–	–	–	–	–	–	–	–	+	+	–	–	–	–
117	nf	3·2	168	15	15	–	–	–	–	–	–	+	+	–	–	–	–	–	–
118	f	2·2	14	nd	nd	–	–	–	–	–	–	+	+	–	–	–	–	–	–
119	f	7·1	336	22	21	–	–	–	–	–	–	+	+	–	–	–	–	+	+
120	f	0·2	1	14	5	–	–	–	–	–	–	+	+	+	–	+	–	–	–
121	nm	2·6	nk	24	23	–	–	–	–	–	–	+	+	–	–	–	–	+	+
122	m	5·9	0	25	18	–	–	–	–	–	–	–	–	–	–	+	–	–	–
123	f	1·1	3	15	15	–	–	–	–	+	–	+	–	–	–	+	–	–	–
124	m	1·6	2	15	15	+	+	+	+	+	+	+	–	–	–	+	+	–	–
125	m	3·2	7	15	27	–	–	–	–	–	–	–	–	–	+	+	–	–	–
126	m	0·5	nk	15	15	–	–	–	–	+	+	–	–	+	+	–	–	–	–
127	m	6	2	20	20	–	–	–	–	–	–	+	+	+	–	–	–	+	–
128	nf	8·2	7	15	19	–	–	–	–	–	–	+	+	–	–	–	–	–	–
129	nf	1·8	nk	15	15	–	–	–	–	–	+	–	+	+	–	–	+	–	+
130	m	2·9	nk	25	22	–	–	–	–	–	–	+	+	–	–	–	–	–	–

f Entire female, nf Neutered female, m Entire male, nm Neutered male, nd Not done, nk Not known, e Enucleated.

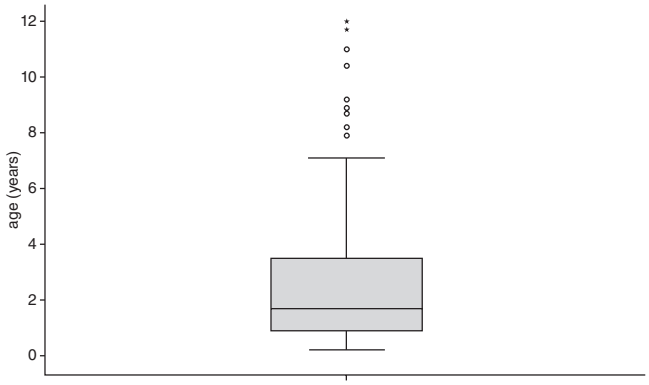

FIG 1. Age distribution of pugs presented

Forty pugs had a unilateral ulcer and in three pugs both eyes were affected. Twenty-six were entire male, followed by 12 entire female, 6 neutered female and 2 neutered male pugs. Corneal ulceration in the absence of KCS and ectopic cilia were found OS and OD in 17 cases each (32 pugs; 2 bilateral, 30 unilateral). Concurrent corneal opacity was identified OS and OD in 11 cases each. Ulcerative keratitis was associated with CV OS and OD in four and eight cases, respectively. The remaining corneal disorders included CV (19 OS and 16 OD; 21 unilateral and 7 bilateral of 28 pugs; of which 4 had corneal ulceration OS and 8 OD), corneal perforation (4 eyes of 4 pugs), descemetocoele (3 eyes of 3 pugs), microcornea (2 eyes of 1 pug), corneal abscess (1 eye), corneal degeneration (uncertain if lipid or calcium; one eye) and adherent leukoma (1 eye).

Further ocular abnormalities of the anterior segment included bilateral iris–iris persistent pupillary membranes (PPMs) in 10 pugs. One pug had iris–iris PPMs, however no information regarding laterality could be determined from the case records. In one case the lens was affected by PPMs unilaterally. The remaining abnormalities of the iris included iris coloboma in one eye and bilateral iris atrophy in one pug.

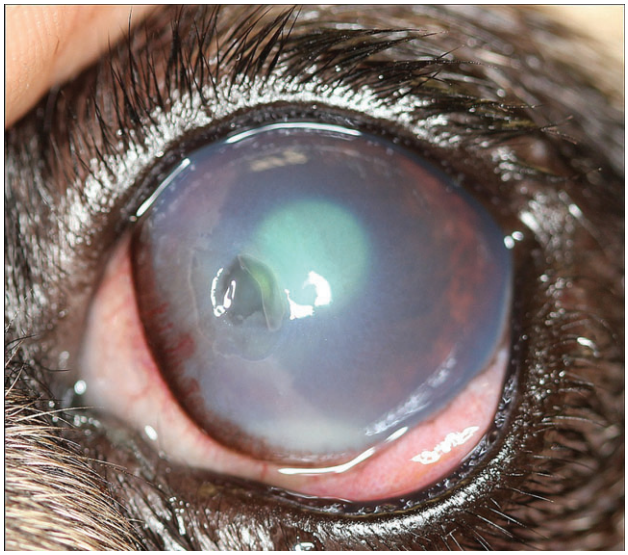

FIG 2. One-year-old pug with a corneal ulcer

Abnormalities of the lens included cataract formation in 18 eyes of 11 pugs. In 14 eyes (8 pugs) the cataract was located in the nucleus, four eyes (3 pugs) had cortical cataract and one eye complete cataract. One pug was referred because of a laceration of the anterior lens capsule due to a perforating corneal foreign body, requiring phacoemulsification.

One pug was identified with a persistent hyperplastic tunica vasculosa lentis. Vitreous degeneration was found in three pugs.

Fundus abnormalities were identified in two pugs, one of which had bilateral atrophy of the non-tapetal fundus and the other retinal folds suggestive of retinal dysplasia. Further statistical analysis of posterior segment changes were not performed because of the small number of diseases.

Association with influencing factors

A statistically significant influence of young age on distichiasis was determined. A marked association of ectopic cilia at an early age was noted, however this difference was not significant. There was no statistically significant influence of age or gender on the development of any other ocular abnormality.

There was a significant association of KCS and CP (P=0·007 for left eyes; P=0·043 for right eyes), although a considerable number of pugs with CP in the absence of KCS were also identified. Furthermore a significant influence of ectopic cilia on the development of corneal ulceration (P<0·001) was revealed.

DISCUSSION

This study clearly demonstrates a high prevalence of pugs with ocular abnormalities at an early age (mean 2·8 years). This finding is in clear contrast to a recent study with a population of 295 pugs, which were presented at a median age of 4·1 years (Labelle *et al.* 2013). A recent retrospective analysis of ocular abnormalities in other brachycephalic breeds determined an onset of ocular disorders in a later stage of life (between 3 and 10 years of age) (Sinitsina 2011). The exact reasons for this age difference at the time of presentation remain speculative, however a bias of the results due to the currently increasing popularity of this breed is possible.

Regarding disease of the ocular adnexa, all pugs were identified with bilateral macroblepharon and nasal entropion. Both findings represent a congenital entity of the pug (Stades & van der Woerdt 2013). However, a statistically significant influence of nasal entropion on the development of ensuing corneal disorders in pugs has not been established to date (Labelle *et al.* 2013).

Distichiasis and ectopic cilia are inherited developmental eyelid conditions which are common in dogs (Grahn & Peiffer 2013). This study corroborates the results of the recent study by Labelle *et al.* (2013), in which no significant association between distichiasis or ectopic cilia and CP was established.

The fact that neither the chronic irritation of nasal entropion, distichiasis or ectopic cilia had any statistical influence on the development of CP is surprising. This result suggests additional yet undetermined factors, in the development of CP. Labelle *et al.* (2013) confirmed that CP in pugs is not associated with diseases such as tear film deficiencies or ocular abnormalities. In that study a genetic basis for CP in pugs was suggested (Labelle *et al.* 2013).

The lack of the aqueous component of the tear film (quantitative KCS) may lead to various ocular disorders: corneal ulceration, CV, corneal scarring and corneal perforation. The most frequently affected breeds are the Cavalier King Charles spaniel, English bulldog, Lhasa apso, Shi tzu, West Highland white terrier and the pug (Williams 2008). Giuliano (2013) lists the pug as the sixth most frequently affected dog breed to develop KCS. In the study by Westermeyer *et al.* (2009), the pug was ranked as the 25th most likely breed to develop KCS with 1491 pugs less than 1 year of age identified as having KCS. The results of this study clearly show a high prevalence of young pugs diagnosed with KCS, however the influence of age on the presence of disease was not statistically significant.

KCS may also manifest as a lack of adequate tear film quality because of an imbalance in the tear film composition (mucin or lipid components), resulting in ocular surface diseases (Giuliano 2013). Qualitative KCS may be diagnosed by determining the TFBUT (Barabino *et al.* 2004) and measuring the level of lipids on the eyelid margin with a Meibometer (Courage-Khazaka) (Ofri *et al.* 2007; Benz *et al.* 2008; Ewert 2011). Normal TFBUT ranges from 19·7 ±5 to 21·53 ±7·42 seconds (Featherstone & Heinrich 2013). Unfortunately the TFBUT was only recorded in five pugs. Four of these five pugs had a deficiency in tear film quality. The high prevalence of low TFBUT values in pugs is corroborated by several other studies (Arnold *et al.* 2013; Labelle *et al.* 2013). There are only a few studies on canine meibometry with mean meibomium lipid concentrations of 179 ±60 MU (meibometer units) measured with the older version of the Meibometer MB550 (Ofri *et al.* 2007). In contrast 211 ±48 MU and 205 ±41 MU were measured, respectively, in OD and OS using the Meibometer MB550 (Benz *et al.* 2008). Ewert (2011) used the Meibometer MB550 to examine the concentration of lipids on the eyelid margin of 98 dogs, including four pugs. In that study a mean of 299·47 ±170·4 MU was reported. To the authors' knowledge no further studies on meibometry in pugs exist. Hence an explanation for the poor tear film quality related to this breed is still lacking.

All pugs with KCS also had concurrent corneal disorders. This result is corroborated by several studies, reporting corneal pathologies (i.e. vascularisation, pigmentation, ulceration) as a consequence of underlying KCS (William 2008; Westermeyer *et al.* 2009). However, it was interesting that a marked number of pugs showed CP and corneal ulceration in the absence of KCS. This result suggests an influence of yet undetermined factors in the development of CP and corneal ulceration.

In this study, less than half of the population was diagnosed with conjunctivitis, most likely as a consequence of chronic irritation of nasal entropion, distichiasis or ectopic cilia (Stades & van der Woerdt 2013).

CP is a melanin deposition in the corneal epithelium and stroma as a result of chronic irritation or inflammation of the cornea (McCracken & Klintworth 1976). Potential causes include distichiasis, ectopic cilia, trichiasis or insufficient tear production (Azoulay 2013). The prevalence of CP is well described with several brachycephalic breeds (i.e. pug, Shi tzu, Lhasa apso, Pekingese) being overrepresented (Ledbetter & Gilger 2013). The breed related palpebral fissure of these breeds has been associated with the development of CP (van der Woerdt 2004).

In one case report, a 12-year-old pug was presented with KCS, pigmentary keratitis OU and a corneal mass, caused by *Toxoplasma gondii* (Swinger *et al.* 2009). A recently published study reported on the presence of CP in pugs (Labelle *et al.* 2013).

Similar to that study, CP was the most frequently detected corneal disorder in this study (101 eyes, 90 pugs). In the previous study, CP could be found in at least 1 eye of 243 of the 295 pugs (Labelle *et al.* 2013). However, CP was clearly the most frequently identified corneal disorder in this study population, hence further investigations are warranted in order to determine additional influencing factors on the development of this disease.

On the basis of the results of this study, the pug is also at high risk for the development of corneal ulceration (Stades & van der Woerdt 2013). Corneal ulcers are a common problem in dogs in general due to various reasons: malposition of the eyelids, eyelash disorders, quantitative and qualitative KCS, foreign bodies and trauma (Lackner 2001; van der Woerdt 2004; Williams 2008). A superficial ulcer may rapidly progress to a deep or melting ulcer. Furthermore, one study determined the pug as having the highest percentages of positive bacterial cultures in cases of corneal ulceration (Wang *et al.* 2008). In the present study, 43 pugs were presented with corneal ulcers and three with unilateral descemetoceles. Results of bacterial cultures and treatment modalities were not evaluated as a part of this study. However, the results clearly show that the pug is at high risk of developing corneal ulcers.

The presence of iris-to-iris PPMs was observed in the study by Labelle *et al.* (2013), among which 228 pugs had iris-to-iris PPMs in the left and 232 in the right eye. In contrast to that study, iris-to-iris PPMs were only found in 11/130 pugs in this study, however in some cases presence of PPMs may not have been recorded.

In Austria, pugs are not required to have an ophthalmic examination performed prior to breeding. Therefore there is little information about hereditary ocular disorders such as cataracts. In this study, cataracts were diagnosed in 18 eyes (11 pugs). In USA, pugs are suspected to have hereditary cataracts (Davidson & Nelms 2013). There are no studies regarding the incidence of cataracts in pugs in Austria to date.

The present results suggest that fundus abnormalities are rare in pugs with only 2 of 130 pugs having such changes. A possible explanation may be that some fundus disorders go unnoticed because of underlying corneal changes, such as CP. As with cataracts, data of fundus abnormalities in pugs are lacking.

As in most retrospective studies, there were some limitations, which may have negatively influenced the results. The greatest limitation was an inconsistency in the management of medical records throughout the period in review. Some values, for instance TFBUT were not recorded in most cases, which made the statistical analysis challenging. Furthermore as in any other referral hospital, the results may have been biased because of the study population under investigation. Several dogs are referred at a later stage of the disease, thereby shifting the age distribution of the population. Furthermore the number of pugs in Austria with qualitative or quantitative KCS and CP, which remains undetected because of a lack of ocular discomfort may be higher than anticipated.

However based on the results of this study, it can be concluded that pugs are over-represented with quantitative and qualitative tear film abnormalities. Furthermore an influence of KCS on the development of corneal pathologies was clearly identified. Due to the marked number of pugs with corneal pathologies without underlying KCS an influence of additional contributing factors (e.g. abnormal tear film composition) is assumed. Further studies are warranted to investigate the aetiology of early onset ocular abnormalities in pugs.

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

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