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Lens morphometry determined by B-mode ultrasonography of the normal and cataractous canine lens

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Abstract

Purpose To determine axial lens thickness, anterior chamber depth and axial globe length in canine eyes with normal lenses and in eyes with immature, mature, congenital, posterior polar and diabetic cataract.

Methods B-mode ultrasonography was performed in 50 normal dogs and, as a prephacoemulsification screening procedure, in 100 dogs with cataract. Axial B-mode ultrasonograms were used to determine lens thickness, anterior chamber depth and globe diameter. Statistical comparisons between groups were made by analysis of variance and multivariate analysis, with a significance level of $P < 0.05$.

Results Axial globe lengths were not statistically significantly different between groups apart from the smaller globes in younger dogs with congenital cataract. Axial lens thickness in diabetics (8.4 ± 0.9 mm) was statistically significantly different from the lens thickness in normal eyes (6.7 ± 1.0 mm), eyes with immature cataract (6.4 ± 0.8 mm) and eyes with mature cataract (7.4 ± 0.9 mm) although these groups, while varying in thickness, were not statistically significantly different from each other. Anterior chamber depth was statistically significantly reduced in eyes with diabetic cataract (2.9 ± 0.1 mm) from that in normal eyes (3.8 ± 0.1 mm), eyes with immature cataract (3.5 ± 0.1 mm) and eyes with mature cataract (3.2 ± 0.6 mm) although these groups, while varying in chamber depth, were not statistically significantly different from each other.

Conclusions Lenses with diabetic cataracts were significantly increased in axial thickness compared to lenses in other eyes, although lenses with mature cataracts showed a trend towards increased axial thickness and immature cataracts demonstrated a trend towards reduced thickness. While previous studies on cataract pathobiology have suggested a reduction in lens thickness in immature cataract through lens protein loss and an increase in thickness in mature cataracts through intumescence, this study is the first to document these changes in the canine lens.

Key Words: cataract, dog, intumescence, lens, ultrasound

INTRODUCTION

Previous reports of ultrasonographic evaluation of eyes prior to cataract surgery in the dog have focused on evaluating pathologic events in cataractous eyes such as retinal detachment[1] or on biometry of the eye prior to intraocular lens implantation.[2] Quantitative and qualitative features of lens changes in cataractogenesis have not been assessed in these ultrasonographic studies. This report was initiated on the clinical finding of glaucoma associated with a substantially shallowed anterior chamber in two diabetic dogs with intumescent cataracts (Fig. 1). It is widely accepted that many cataractous lenses are greater in volume than are normal lenses and that diabetic cataracts show a greater degree of intumesence than do nondiabetic cataracts. To date, however, no quantitative data on axial lens thickness in dogs with cataract have been reported but for a clinical abstract documenting spontaneous lens capsule rupture in dogs with diabetic cataract, in which 10 MHz B-mode ultrasonography was employed as discussed further below.[3] In the current study B-mode ocular ultrasonography was used to demonstrate changes in lens thickness and in other axial ocular measurements in dogs with cataract.

MATERIALS AND METHODS

B-mode ultrasonographic examination was performed as a routine procedure prior to cataract extraction in 100 dogs

Table 1. Intraocular measurements in eyes with different lens pathology

Lens type	Globe diameter	Axial lens thickness	Ratio of axial lens thickness to globe diameter	Anterior chamber depth
Normal	20 ± 1.6 mm	6.7 ± 1.0 mm	0.33 ± 0.1	3.8 ± 0.1 mm
Congenital cataract	16.9 ± 0.5 mm	6.2 ± 0.7 mm	0.37 ± 0.1	3.0 ± 0.1 mm
Immature cataract	19 ± 1.2 mm	6.4 ± 0.8 mm	0.32 ± 0.1	3.5 ± 0.1 mm
Mature cataract	20 ± 1.3 mm	7.4 ± 0.9 mm	0.37 ± 0.1	3.2 ± 0.6 mm
Diabetic cataract	19 ± 0.8 mm	8.4 ± 0.9 mm	0.42 ± 0.1	2.9 ± 0.1 mm

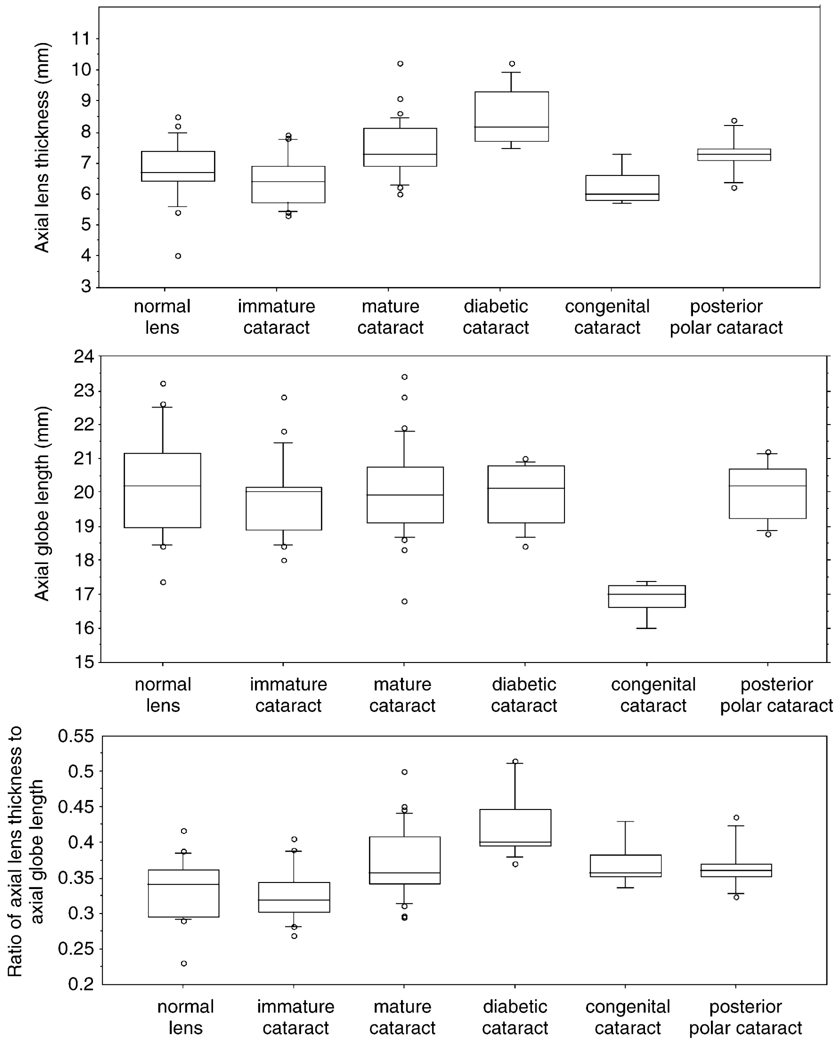

Figure 2. Boxplot of axial lens thickness (top), axial globe length (middle) and ratio of lens thickness to globe length (bottom) for each category of lens.

and in 50 dogs without lens changes using a Biomedica AU530 10 MHz ultrasound scanner (Biomedica, Genoa, Italy) with a 1-cm water bath to distance the probe tip from the ocular surface. A full ophthalmic examination comprising direct and indirect ophthalmoscopy, slit-lamp biomicroscopy and applanation tonometry (Tonopen XL, Menitor, Norwell, MA, USA) was undertaken in each eye prior to ultrasonography. Topical anesthesia was obtained by application of 0.5% amethocaine hydrochloride (Chauvkin, Romford, UK) and adequate contact between the probe and the ocular surface was obtained with sterile ultrasound gel. Measurements of axial globe length were determined in both the horizontal and the vertical meridian using the in-built measurement facility of the scanner as were lens thickness and anterior chamber depth. Data were obtained as the mean of distances from three ultrasonograms for each measurement. Ultrasonograms were rejected when distances measured were more than 5% different from the others from the same eye. Data from eyes with normal lenses and lenses with immature cataract, mature cataract and diabetic cataract were compared by analysis of variance. Influence of age and cataract type on lens thickness was assessed by multivariate analysis.

RESULTS

One hundred and fifty dogs of varying breeds were included in the study, including 50 dogs with normal lenses, 29 with immature cataract, 39 with mature cataract, 20 with diabetic

Figure 1. Sectioned globe from a diabetic dog with phacomorphic glaucoma demonstrating the intumescent lens and narrowed anterior chamber with collapsed iridocorneal angle (photography courtesy of J. Mould).

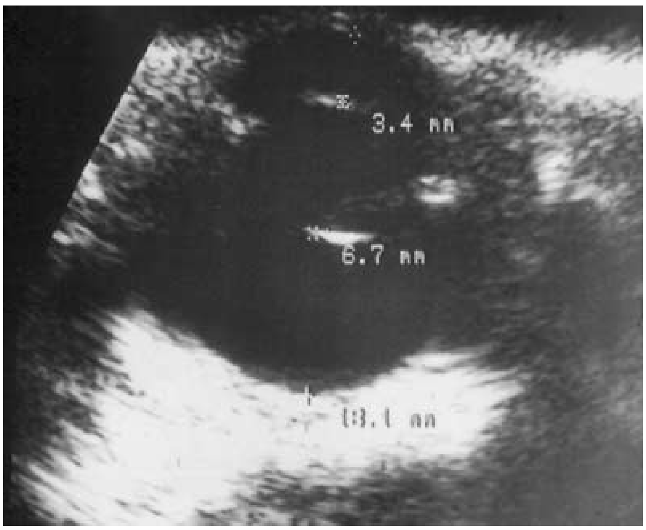

Figure 3. Ultrasonogram of normal eye showing measurements of globe diameter (18.1 mm), anterior chamber depth (3.4 mm) and lens thickness (6.7 mm).

cataract, 6 with congenital predominantly nuclear cataract and 6 with posterior polar subcapsular cataract. Mean measurements and standard deviation of axial globe length, axial lens thickness, ratio of lens thickness to globe length and anterior chamber depth for normal lenses and for lenses with immature, mature and diabetic cataracts are shown in Table 1 and as boxplots in Fig. 2. Distances were corrected for differing ultrasound velocity in the aqueous and lens as determined experimentally previously,[4] although these

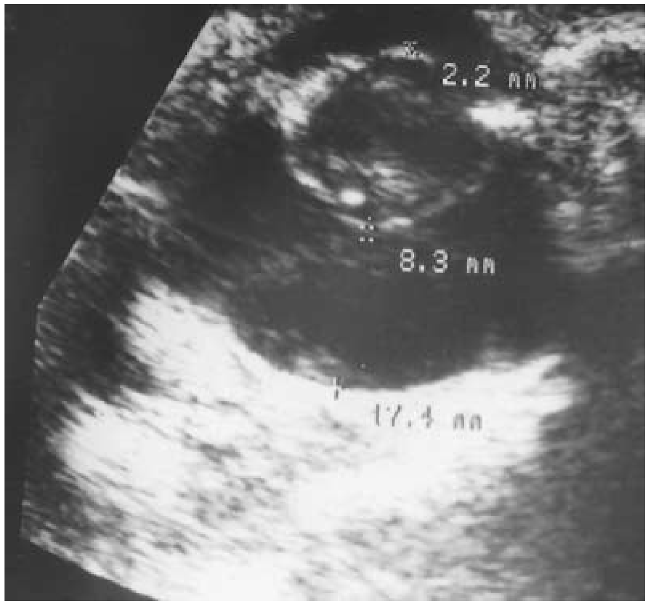

Figure 4. Ultrasonogram of eye with mature cataract showing measurements of globe diameter (17.4 mm), anterior chamber depth (2.2 mm) and lens thickness (8.4 mm).

Figure 5. Ultrasonogram of eye with diabetic cataract showing measurements of globe diameter (19.1 mm), anterior chamber depth (2.7 mm) and lens thickness (9.7 mm).

corrections made no difference to the variations between groups. Representative ultrasonograms for a normal lens and a lens with mature cataract and diabetic cataract are shown in Figs 3, 4 and 5, respectively. Measurements between right and left eyes were not significantly different. Globe diameter was not significantly different between eyes with different lens types apart from younger dogs with congenital cataract where axial globe length was significantly smaller. Lens thickness was significantly different ($P < 0.05$) between normal lenses and lenses with mature cataracts and diabetic cataracts and between diabetic cataracts and all other lenses. Anterior chamber depth was significantly reduced in eyes with diabetic cataracts compared with eyes with noncataractous lenses ($P < 0.05$) but not in other eyes.

Multivariate analysis showed that age was a significant factor in variation of axial lens thickness. Differences between axial thickness of normal lenses, those with congenital cataract and those with immature cataract could be explained by variation in thickness with age (lens thickness = 0.14 age, $P < 0.0001$) but this was not the case with lenses with mature cataract (lens thickness = 0.14 age + 0.8, $P < 0.0001$), diabetic cataract (lens thickness = 0.14 age + 1.7, $P < 0.0001$) or posterior polar cataract (lens thickness = 0.14 age + 0.6, $P = 0.08$).

DISCUSSION

The pathogenesis of many cataracts, especially those in diabetic dogs, involves osmotic effects with increased water content of the lens[5] resulting in greater lens size by intumescence.[6] This study quantifies the difference in lens thickness in various stages of cataract as shown in Table 1 and Fig. 2, demonstrating significant changes between axial thickness of diabetic cataractous and other lenses and between normal lenses and lenses with mature and diabetic cataracts. A recent report of lens capsule rupture in diabetic cataracts demonstrates enlargement of the lens in diabetic cataract with an axial lens thickness of 8–11 mm (mean 9.3 mm), measured with 10 MHz B mode ultrasonography in that report.[3] While mature cataracts and diabetic cataracts increase in size through intumescence, immature cataracts may actually decrease in thickness owing to loss of soluble lens material through the lens capsule.[7,8]

Biometry of the globe is normally undertaken with A-mode ultrasonography when used to determine axial length prior to intraocular lens implantation[2] or for research purposes.[9] In this study, A-mode ultrasonography was not available and B-mode ultrasonography was used. This has the potential disadvantage of inaccuracy if the ultrasound beam is not placed in line with the axis of the eye, but published research has shown A-mode and B-mode ultrasonography to give axial measurements that were not statistically significantly different and thus that B-mode ultrasonography can be as accurate as A-mode biometry.[10,11] Biometry results for the five eyes in which serial measurements were taken in this study suggest that inaccuracy did not appear to be a problem.

Lens thickness increases with age, a feature noted in previous reports in humans[12] and in the dog.[8] This finding was repeated in this study where lens thickness for lenses in each group increased with age. Age as a factor in determination of lens thickness did not confound the variation determined between each group of cataract types.

As well as showing increases in lens size in mature and diabetic cataracts, this study demonstrates a reduced anterior chamber depth in eyes with diabetic cataracts. This significant decrease in anterior chamber depth may be a factor leading to raised intraocular pressure in some dogs, although correlating intraocular pressure with cataract morphometry is difficult because of compounding factors such as lens-induced uveitis. A recent paper correlating intraocular pressure with cataract discussed only the relationship of lens-induced uveitis with changes in intraocular pressure and did not mention the possibility of increased lens size causing a narrowed-angle glaucoma with a corresponding increase in intraocular pressure.[13] The research presented here suggests that, particularly in diabetic cataracts, increases in intraocular pressure should be assessed. Phacomorphic glaucoma, as seen in the two proband cases initiating this study has not previously been reported in the dog but has been documented to be associated with mature cataract in humans.[14,15]

CONCLUSION

This study is the first publication to quantify changes in axial lens thickness in dogs with immature, mature, and diabetic cataracts and to document increases in lens axial thickness characteristic of intumescent mature and diabetic cataractous lenses. The finding of decreased anterior chamber depth in eyes with mature diabetic cataract suggests that narrowing of the iridocorneal angle may result in and predispose to increased intraocular pressure. Therefore, intraocular pressure should be assessed in eyes with mature and diabetic cataracts.

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