Morphologic alterations in the anterior lens capsule of canine eyes with cataracts

Michael E. Bernays, BVSci, and Robert L. Peiffer, DVM, PhD

Objective—To examine the morphologic changes in the anterior lens capsule and lens epithelium of canine eyes with cataracts.

Sample Population—Anterior lens capsules from the eyes of 25 dogs with cataracts and from an additional 10 canine globes with lenses subjectively assessed to be normal.

Procedure—Thickness of each anterior lens capsule was measured by use of a digital microscopic camera and imaging software. All 25 capsules from eyes with cataracts were submitted for light microscopy; 4 were also submitted for electron microscopy.

Results—Thickness of the anterior lens capsule increased with age for the normal lenses and the lenses with cataracts; the change with age was similar for both groups. Light microscopy revealed fibrous metaplasia of lens epithelial cells in 7 of 25 anterior lens capsules with focal thickenings of the posterior aspect of the capsule. Electron microscopy revealed deposition of collagen and basement membrane-like material by fibroblast-like cells.

Conclusions—Results indicate that thickness of the anterior lens capsule in dogs increases with age and that this increase in thickness is not significantly different between normal lenses and lenses with cataracts. In addition, epithelial cells from lenses with cataracts may undergo metaplasia to form plaques composed of fibrous tissue and ectopic basement membrane produced by epithelial cells. (Am J Vet Res 2000;61:1517–1519)

The anterior lens capsule is a basement membrane secreted by the anterior lens epithelial cells. It is composed of type-IV collagen and a mucopolysaccharide matrix. The normal formation and structure of the anterior lens capsule in a variety of species have been described, along with the structure of anterior capsule plaques that develop prior to surgical removal of the lens in people with cataracts. Alterations in the behavior of the lens epithelial cells and lens fiber cells after cataract extraction in humans and dogs with and without implantation of an artificial lens have similarly been studied. However, the microscopic and ultrastructural changes in the anterior lens capsules of dogs with cataracts that have not undergone surgery have been infrequently reported. Therefore, the purpose of the study reported here was to examine the morphologic changes in the anterior lens capsule and lens epithelium of canine eyes with cataracts.

Materials and Methods

Anterior lens capsules—Anterior lens capsules from 25 canine eyes undergoing surgery for cataract removal were submitted by the attending surgeon; all surgeries were performed by 1 of 3 individuals. The capsules were immersion-fixed in 2% paraformaldehyde and 2.5% glutaraldehyde in 0.1M Sorensen's phosphate buffer, pH 7.4. They were then examined by use of a binocular dissecting microscope and bisected.

Capsular thickness—Thickness of 10 cataractous anterior lens capsules for which the age of the patient was known was measured, using a digital microscopic camera and imaging software. Thickness was measured at randomly chosen locations in each quarter-length segment, and mean thickness was calculated.

For comparison, an additional 10 canine globes with lenses subjectively assessed to be normal and of known age were selected from the laboratory collection. These globes were from dogs ranging from 3 months to 14 years old. Mean anterior lens capsular thickness was measured as described for the lenses from dogs with cataracts. Capsular thickness was then plotted as a function of age for the normal lenses and the lenses with cataracts, and the regression line was calculated for each group of lenses, using the method of least squares. Two-way ANOVA was performed to test for differences between the regression coefficients.

Light microscopy—One half of each capsule was submitted for light microscopy. These samples were embedded in paraffin, cut in cross-section, and stained with H & E, periodic acid-Schiff (PAS), Masson trichrome, and Verhoeff elastic stains. Staining characteristics were compared with staining characteristics of positive control samples provided by the processing laboratory. No attempts were made to remove epithelial or fibrous tissue that remained adhered to the capsule, and this associated tissue was examined in situ with the capsule.

Electron microscopy—The remaining halves of 4 capsules that had associated tissue evident during gross or light microscopic examination were submitted for electron microscopy. From each of these halves, a 0.5-mm section was taken by cutting parallel to the straight edge; these pieces were processed routinely for transmission electron microscopy (TEM). The remaining capsule was bisected and processed for scanning electron microscopy (SEM) so that the anterior and posterior surfaces could be examined.

Results

Capsular thickness—Thickness of the anterior lens capsule increased with age for the normal lenses and the lenses with cataracts (Fig 1). Two-way ANOVA confirmed that there was a significant ($P = 0.01$) linear relationship between capsular thickness and age. Regression line analysis indicated cataractous lens capsular thickness was significantly greater than normal lens capsular thickness with age.

 AJVR, Vol 61, No. 12, December 2000

Received Dec 1, 1999
Accepted Jan 31, 2000.
From Animal Eye Services, Kessels Road Veterinary Hospital, McGregor QLD 4109 Brisbane, Australia (Bernays); and the Departments of Ophthalmology and Pathology, University of North Carolina, Chapel Hill, NC 27599 (Peiffer).
Address correspondence to Dr. Peiffer.
The authors thank Dr. Robert Bagnell, Vicki Madden, and Theresa Bone for technical assistance.
sules were thicker than normal lens capsules in dogs < 12 years old (P < 0.01).

Light microscopy—Metaplasia of lens epithelial cells into proliferating spindle-shaped cells was observed in 7 of the 25 anterior lens capsules from eyes with cataracts. Examination of sections stained with Masson stain for collagen and PAS stain for mucopolysaccharide confirmed that these plaques contained mostly basement membrane-like material, with variable cellularity. Proliferating flattened lens epithelial cells formed several parallel layers of duplicated basement membrane fanning out posteriorly from the edge of the plaque. Collagen fibrils were evident between these layers (Fig 2). Some of these lesions were not associated with significant distortion of the mature capsule; others resulted in capsular distortion with marked folding. The extracellular material between the folds did not appear to contain elastin. An additional change that was evident was formation of focal thickenings of the posterior surface of some lens capsules. These excrescences were approximately 13 to 30 µm wide and 3 to 10 µm thick. They stained with

Figure 1—Change in thickness of the anterior lens capsule as a function of age for capsules from 10 canine eyes with cataracts (*) and 10 grossly normal canine eyes (▲). Linear regression lines for the eyes with cataracts (solid line) and the normal eyes (broken line) are indicated, along with the regression equations.

Figure 2—Photomicrograph of the anterior lens capsule (ac) from a dog with a cataract. Notice that proliferating metaplastic lens epithelial cells have formed collagenous tissue (*) fanning out posteriorly from the capsule. Several thin laminations of ectopic basement membrane (arrows) are visible. Periodic acid-Schiff stain; bar = 10 µm.

Figure 3—Photomicrograph of the anterior lens capsule from a dog with a cataract. Focal thickenings on the posterior surface of the capsule (arrows) represent excess basement membrane produced by lens epithelial cells. Periodic acid-Schiff stain; bar = 40 µm.

Figure 4—Scanning electron photomicrograph of the posterior aspect of the anterior lens capsule from a dog with a cataract. Focal guttate excrescences (*) surrounded by irregular epithelial cells (ec) are evident. Bar = 20 µm.

Figure 5—Transmission electron photomicrograph of the anterior lens capsule from a dog with a cataract. Fibrous plaques composed of fibroblast-like cells (f) between bundles of collagen (c) were evident. Bar = 2.42 µm.
PAS stain, and their staining characteristics were homogeneous with staining characteristics of the adjacent capsule (Fig 3).

Electron microscopy—The anterior surface of the lens capsule was generally smooth with slight curvature. However, the ultrastructural appearance of the posterior surface of the anterior lens capsule varied considerably among specimens. On the posterior surface of some capsules, there was an irregular mosaic pattern of lens epithelial cells with round to hexagonal shape. In other capsules, the epithelial cells lost their mosaic appearance and appeared as a continuous irregularly thickened layer of pleomorphic cells. Some capsules were partially or totally denuded of cells. Posterior excrescences appeared occasionally as rounded smooth-surfaced protuberances adjacent to irregular epithelial cells (Fig 4). Deposition of collagen and basement membrane-like material by fibroblast-like cells was observed (Fig 5).

Discussion
Results of the present study indicate that thickness of the anterior lens capsule in dogs increases with age and that this increase in thickness is not significantly different between normal lenses and lenses with cataracts. Results also suggest that in dogs, lens epithelial cells from lenses with cataracts may undergo metabolism to form plaques morphologically similar to the plaques seen in humans with cataracts.1 However, compared with published values for the anterior lens capsule from humans,1 the anterior lens capsule in dogs is thicker and increases in thickness at a faster rate with age. Results of the present study suggest that the capsule in dogs increases in thickness by 5 to 8 µm/yr, whereas in 1 study in people,9 the capsule increased in thickness by only 0.08 µm/yr, and the lens capsule of a 65-year-old human was only 8.65 µm thick, compared with maximum thickness in the present study of 137 µm for a 14-year-old dog.

Waring et al10 have reviewed the structure of the corneal endothelium from healthy eyes and eyes with cataracts. They described guttata excrescences on the posterior surface of the Descemet membrane in people with Fuchs’s endothelial dystrophy. The excrescences observed in the present study, and their association with morphologically altered lens epithelial cells, were similar to the excrescences described by Waring et al. Although lens epithelial cells derive from surface ectoderm and endothelial cells derive from neural crest cells, both of these cells produce basement membrane, and when individual cells or groups of cells become stressed or diseased, localized increases in basement membrane production may occur. In the present study, SEM indicated that wherever guttata excrescences were observed, there was no evidence of the overlying epithelial cells remaining, whereas adjacent areas were characterized by flattened deformed lens epithelial cells. These cells were the same cells that were determined, by means of light microscopy, to be undergoing fibrous metaplasia. Thus, these lens guttata should probably be regarded as markers of long-standing lens epithelial cell dysfunction.

Surgeons performing continuous tear capsulorhexis for cataract removal in dogs have observed a great deal of variability in the ease with which the anterior lens capsule can be torn. Some capsules tear in a smooth and controlled fashion; others are brittle or tough, and tearing is more difficult to control. Further studies are needed to determine whether specific morphologic alterations are correlated with the manner in which individual capsules appear to tear.

References