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Objective—To evaluate the outcome and describe the complications associated with use of an Ahmed gonioimplant in the treatment of glaucoma in dogs.

Design—Retrospective case series.

Animals—9 client-owned sighted dogs (median age, 9 years) with primary glaucoma.

Procedures—Medical records of dogs with primary glaucoma that underwent unilateral gonioimplant placement (in 2000 through 2008), during which a temporalis muscle fascia graft (n = 8) or porcine intestinal submucosa (1) was used to cover the implant tube as it exited the globe, were reviewed. All dogs were treated with mitomycin C in the conjunctival pocket intraoperatively and with tissue plasminogen activator immediately after surgery; 1% prednisolone acetate was applied to the implanted eye daily until failure of the implant. Medical intervention or additional surgery was performed when intraocular pressures (IOPs) were > 20 mm Hg or progressively increasing values were detected.

Results—After gonioimplant placement, IOP was controlled for a variable period in all dogs. Subsequently, IOP exceeded 20 mm Hg in 7 dogs (median postoperative interval, 326 days). Median interval to vision loss despite interventional surgery was 518 days (range, 152 to 1,220 days). Surgical intervention was necessary in 4 dogs to maintain satisfactory IOP. Implant extrusion attributable to conjunctival dehiscence or necrosis occurred in 4 dogs. At 365 days after surgery, 8 dogs retained vision, and 5 dogs retained vision throughout follow-up.

Conclusions and Clinical Relevance—In dogs with medically refractory primary glaucoma, placement of a gonioimplant appears to be effective in maintaining vision. (J Am Vet Med Assoc 2011;238:610–617)

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laucoma in dogs is a degenerative disease of the retinal ganglion cells and optic nerve, which can progress to blindness. Increased IOP is a major risk factor for the development of glaucoma. Although there are many different classification schemes and proposed mechanisms, primary glaucoma almost always results in vision loss in dogs. The mainstay treatment of primary glaucoma is directed at decreasing excessive IOPs. Medical treatment is often very effective in reducing IOP when initially instituted, but dogs become refractory to the treatment over time. Eventually, IOP increases again, which causes progressive retinal and optic nerve damage and results in vision loss.

Many surgical techniques for IOP reduction have been developed. All of these techniques either decrease the quantity of aqueous humor produced in the eye by destroying portions of the ciliary body or facilitate aqueous humor drainage by augmenting outflow through the ICA or by bypassing the ICA altogether. Cyclodestructive procedures can be effective in long-term control of IOP1,3; however, in dogs, the perioperative inflammation is associated with complete vision loss in 10% to 50% of eyes that are considered to have vision because of paradoxical transient increases in IOP, retinal detachments, or uncontrollable uveitis. Moreover, a considerable percentage of treated dogs develop cataracts, which further impair vision.1,3 Vision is only maintained in 50% to 53% of dogs that undergo cyclodestructive procedures after 1 year.1,3

Gonioimplants provide a route for aqueous humor to bypass a poorly functioning ICA, thereby improving the rate of outflow. These implant procedures are associated with less perioperative inflammation, compared with cyclodestructive procedures, and are reported to be effective in decreasing IOP short term. However, progressive development of fibrosis around implants decreases their ability to drain aqueous humor and is the most common cause for implant failure in both dogs3–5 and humans.6 Ocular administration of antifibrotic agents, such as mitomycin C, decreases the extent of fibrosis around the implant in dogs5,6 and increases the success rate of gonioimplantation in humans.7 The reported success of gonioimplantation surgery in long-term retention of vision varies greatly; depending on the type of implant, the success rate for maintaining vision 12 months after surgery is 3% to 42%.3,10,11

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ICA</td>
<td>Iridocorneal angle</td>
</tr>
<tr>
<td>IOP</td>
<td>Intraocular pressure</td>
</tr>
<tr>
<td>tPA</td>
<td>Tissue plasminogen activator</td>
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Because IOP often increases transiently following cyclodestructive procedures in dogs, some investigators have advocated performing cyclodestruction and gonioimplantation concurrently, but retention of vision is only approximately 50% after 12 months.12,13 The purpose of the study reported here was to evaluate the outcome and describe the complications associated with use of a commercially available Ahmed gonioimplant in the treatment of primary glaucoma in dogs.

Materials and Methods

Case selection—Medical records from the College of Veterinary Medicine, University of Tennessee, were reviewed to identify dogs with primary glaucoma that received a commercially available valved Ahmed gonioimplant in 2000 through 2008. For inclusion in the study, certain criteria had to be met as follows: at the time of initial evaluation, the dog had sight in the affected eye in which the implant was subsequently placed; during placement of the gonioimplant, a temporalis muscle fascia graft or porcine intestinal submucosa was used to cover the implant tube as it exited the globe; and the dog was treated with mitomycin C in the conjunctival pocket intraoperatively.

Medical records review—Medical records of dogs with primary glaucoma that received a gonioimplant in 1 eye and met the other management criteria were reviewed. Information was collected regarding signalment, preoperative ophthalmic examination findings (including IOP measurements), preoperative medication regimen, surgical procedure details, postoperative treatments (medical and surgical interventions) and follow-up ophthalmic examination findings (including IOP measurements), complications, treatment outcome (including results of histologic examination of biopsy samples or enucleated globes, if such procedures were performed), date and cause of death or reason for euthanasia (if applicable). Dogs were assigned an identification number to facilitate data analysis and reporting.

Procedures—For each dog, vision in the eye in which the gonioimplant was to be placed was confirmed prior to surgery on the basis of results of an ophthalmic examination, assessment of the menace response, and maze testing or tracking. After surgery, vision in the implanted eye was assessed qualitatively by evaluation of menace response, dazzle, and maze testing. Medical antiglaucoma treatment after surgery was adjusted on the basis of IOP measurements. Bleb revision procedures to remove scar tissue over the implant or injection of 5-fluorouracil into the bleb was performed when medical treatment failed to reverse progressive increases in IOP or when IOP was > 20 mm Hg.

Harvest of a temporalis muscle fascia graft—Prior to gonioimplantation in the eye of interest, fascia from the ipsilateral temporalis muscle was harvested to cover the gonioimplant tube as it entered the anterior chamber. After a routine surgical preparation and draping with towels, a 5- to 8-cm incision through the skin parallel and approximately 3 cm lateral to the sagittal crest was made. Sharp and blunt dissection was used to expose the temporalis muscle fascia. A piece of fascia (1.5 X 1.5 cm) was excised from the underlying muscle and placed in sterile isotonic saline (0.9% NaCl) solution. The incision was closed routinely.

Gonioimplantation surgery—Each dog was anesthetized routinely and positioned in dorsal recumbency; the globe undergoing gonioimplantation surgery was draped routinely. Cefazolin (22 mg/kg [10 mg/lb], IV, q 90 min) was administered perioperatively in all patients. While viewed through an operating microscope, a perilimbal incision was made through the conjunctiva (5 mm posterior to the limbus and extending a distance equivalent to 3 to 4 clock hours over the dorsolateral quadrant) by use of tenotomy scissors. Via sharp and blunt dissection, the conjunctival incision was extended through the fascia bulbi (Tenon’s capsule) until sclera was reached. A pocket that extended posteriorly from the incision was then created by dissecting Tenon’s capsule from the sclera until the dorsal and lateral rectus tendons were observed. The pocket was extended posteriorly until the gonioimplant could be seated between the dorsal and lateral rectus muscles with the anterior edge placed 8 to 10 mm posterior to the limbus. Hemostasis was maintained with use of topical administration of phenylephrine and application of a handheld cautery unit. A trimmed cellulose sponge impregnated with 0.25 to 0.5 mg of mitomycin C/mL was held within the empty pocket for 5 minutes, with care taken to prevent contact of the sponge with the incised conjunctival edges. The pocket was then rinsed with copious amounts of balanced salt solution for 5 minutes.

One of 2 types of implant16 (the larger of the 2 devices was used when possible) was cannulated with a lacrimal cannula and primed with balanced salt solution containing heparin (2 U of heparin/mL) to confirm valve patency. The implant was then placed into the pocket so that the anterior aspect of the footplate was 8 to 10 mm posterior to the limbus or just posterior to the level of the insertion of the dorsal rectus muscle. The footplate was sutured to the sclera by means of the eyelets with 8-0 or 9-0 nylon suture with a simple interrupted suture in each eyelet. A 21- to 23-gauge hypodermic needle was placed through the limbus parallel and just anterior to the iris. Care was taken to avoid touching the iris, and the needle was immediately withdrawn. The gonioimplant tube was cut to the appropriate length at a 45° bevel such that approximately 2 to 4 mm extended into the anterior chamber, and the tube was inserted into the needle tract. The excised temporalis muscle fascia was then trimmed to cover the terminal portion (3 to 4 mm) of the gonioimplant tube just posterior to its entrance into the globe. The fascia was secured to the sclera by use of 4 cardinal simple interrupted sutures of 8-0 nylon. In 1 dog (dog 4), 4 layers of porcine intestinal submucosal collagen were used to cover the terminal portion of the gonioimplant tube. The conjunctiva and Tenon’s capsule were then closed (single or double layer closure) with 7-0 polygactin 910 suture in a simple continuous pattern. An injection of 25 µg of tPA into the anterior chamber was performed at the end of surgery. In addition, 1 dog (dog 9) underwent a standard 2-port anterior chamber vitrectomy prior to gonioimplantation surgery to remove a small strand of vitreous humor that had the potential to occlude the implant tube.
Postoperative care—Following recovery from anesthesia, prednisolone acetate (1% suspension) and ophthalmic neomycin-bacitracin-gentamicin solution were applied topically to the implanted eye every 6 hours in each dog. Over a period of 3 to 4 weeks, the antimicrobial treatment was discontinued, and the frequency of application of the topical steroid preparation was decreased slowly (rate determined on the basis of clinical signs) until the frequency of administration was decreased to once daily. Treatment with prednisolone suspension was never decreased to less than once-daily administration. With regard to ocular antihypotension medications, the dosages administered after surgery were the same as those administered prior to surgery. For each dog, administration of antiglaucoma medications was then discontinued (1 drug at a time) as long as IOP remained low, but was reinstated as needed if the IOP exceeded 20 mm Hg. Owners were instructed to start ocular massage (gentle digital transpalpebral pressure applied in a small circular pattern for 5 minutes) within 3 weeks after surgery to maintain implant patency.

Bleb revision—When required, a bleb revision was done to remove scar tissue over the implant. While viewed through an operating microscope, a conjunctival incision was made parallel to the limbus directly over the bleb. Sharp and blunt dissection was used to separate the conjunctiva and Tenon’s capsule from the fibrous capsule surrounding the bleb. The fibrous tissue covering the footplate was excised. Immediately, flow of aqueous humor was detected. A cellulose sponge impregnated with 0.25 to 0.5 mg of mitomycin C/mL was placed in the Tenon’s capsule pocket for 5 minutes. Copious amounts of saline solution were used to rinse the pocket for 5 minutes. The conjunctiva was closed routinely.

Results

Dogs—Records of 10 dogs with primary glaucoma that underwent unilateral gonioimplantation surgery in 2000 through 2008 were identified. One dog was excluded from the study because 5-fluorouracil instead of mitomycin C was applied to the conjunctival pocket. There were 3 mixed-breed dogs, 2 Bassett Hounds, 1 Cocker Spaniel, 1 Chow Chow, 1 Dalmatian, and 1 Australian Cattle Dog (Table 1). Dogs were arbitrarily assigned an identification number (1 through 9). Prior to surgery, all dogs had an IOP ≥ 25 mm Hg while receiving maximum medical treatment (ie, concurrent topical administration of a prostaglandin analogue, carbonic anhydrase inhibitor, and β-adrenoceptor blocker), except for dog 5 in which IOP increased from 11 to 21 mm Hg while receiving timolol, dorzolamide, and a prostaglandin analogue (each administered twice daily) in the month preceding surgery. The median age at the time of gonioimplantation surgery was 9 years (age range, 6 to 11).

For all dogs, a diagnosis of primary glaucoma was made on the basis of gonioscopic observation of goniodysgenesis, a narrowed or closed angle, or lack of clinical signs suggestive of a disease process known to cause secondary glaucoma. Dog 2 had lost vision in the right eye as a result of glaucoma prior to the development of diabetes mellitus with secondary cataract formation and phacoemulsification in the left eye; glaucoma developed in the left eye 1 week after uncomplicated phacoemulsification. Medical treatment was used to control IOP for 6 months after surgery, after which IOP increased to 32 mm Hg and a gonioimplant was placed. Dogs 3 and 9 had evidence of zonular breakdown prior to surgery. The IOP in each eye of dog 3 was 70 mm Hg. This dog had bilateral buphthalmia, but had vision in the right eye; both lenses were subluxated, which was deemed to be secondary to the buphthalmia. Dog 9 had a small wisp of vitreous humor within the anterior chamber at the time of gonioimplantation surgery.

Gonioimplantation surgery and postoperative care—Placement of a gonioimplant was achieved successfully in all 9 dogs. All dogs recovered well after surgery. The IOP in each eye of dog 3 was 70 mm Hg. This dog had bilateral buphthalmia, but had vision in the right eye; both lenses were subluxated, which was deemed to be secondary to the buphthalmia. Dog 9 had a small wisp of vitreous humor within the anterior chamber at the time of gonioimplantation surgery.

Table 1—Summary of signalment and time to and reasons for failure of the gonioimplant placed in 1 eye of each of 9 dogs with primary glaucoma.

<table>
<thead>
<tr>
<th>Dog</th>
<th>Breed</th>
<th>Age (y)</th>
<th>Time to failure (d)</th>
<th>Reason for implant failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chow Chow</td>
<td>9</td>
<td>152</td>
<td>Conjunctival necrosis</td>
</tr>
<tr>
<td>2</td>
<td>Dalmatian</td>
<td>10</td>
<td>396</td>
<td>Died</td>
</tr>
<tr>
<td>3</td>
<td>Australian Cattle Dog</td>
<td>9</td>
<td>732</td>
<td>Intraocular pressure spikes</td>
</tr>
<tr>
<td>4</td>
<td>Basset Hound</td>
<td>6</td>
<td>396</td>
<td>Conjunctival dehiscence and implant loosening</td>
</tr>
<tr>
<td>5</td>
<td>Cocker Spaniel</td>
<td>9</td>
<td>720</td>
<td>Implant extrusion</td>
</tr>
<tr>
<td>6</td>
<td>Mixed</td>
<td>8</td>
<td>1,220</td>
<td>Died</td>
</tr>
<tr>
<td>7</td>
<td>Basset Hound</td>
<td>6</td>
<td>365</td>
<td>Conjunctival dehiscence; lost to follow-up</td>
</tr>
<tr>
<td>8</td>
<td>Mixed</td>
<td>6</td>
<td>183</td>
<td>Increased IOP</td>
</tr>
<tr>
<td>9</td>
<td>Mixed</td>
<td>11</td>
<td>518</td>
<td>NA = Not applicable (implant remained functional).</td>
</tr>
</tbody>
</table>

In all dogs except dog 4, a temporalis muscle fascia graft was used to cover the implant tube as it exited the globe; in dog 4, porcine intestinal submucosa was used. Following gonioimplantation surgery, dogs 3 and 7 each underwent 1 bleb revision; dog 9 underwent 2 bleb revisions and received two 5-fluorouracil injections to control IOP in the implanted eye.
bleb revisions at 5 and 17 months. Dog 5 also required 2 injections of 5-fluorouracil (5 mg each administered 2 weeks apart) into the bleb at 9 months after surgery to maintain IOP < 20 mm Hg.

Medical treatment for glaucoma was discontinued at 1 to 4 weeks after surgery in 4 dogs (dogs 4, 6, 7, and 8) and decreased to administration of 1 medication in 2 dogs (dogs 1 and 9). In dogs 3 and 5, medical treatment was initially decreased to administration of 1 medication, but increases in IOP necessitated administration of additional medications at 12 and 19 months after surgery. Dog 2 continued to receive timolol, dorzolamide, and a prostaglandin analogue after surgery at the owner's request, even though the IOP in the implanted eye remained low. As a group, fewer medications were necessary after surgery, compared with the number administered to the dogs before surgery (Figure 1).

IOP measurements—Following gonioimplantation surgery, IOP was successfully maintained at < 20 mm Hg for a variable period in all 9 dogs. Values of IOP eventually exceeded 20 mm Hg in 7 dogs (Figure 2). The median interval between surgery and return of IOP to ≥ 20 mm Hg for the 9 dogs (calculated from the event analysis) was 326 days. Median interval from time of gonioimplantation surgery to measurement of IOP ≥ 20 mm Hg with medical intervention only (ie, until it was necessary to perform another surgical procedure) was 396 days (range, 152 to 1,220 days). In 4 of the 7 dogs in which IOP exceeded 20 mm Hg, an additional surgical intervention (consisting of either bleb revision, intrableb injection of 5-fluorouracil, or placement of a second implant) was undertaken. Regardless of medical treatment or additional surgical interventions, the mean interval from the time of the initial gonioimplant to development of an IOP value ≥ 20 mm Hg (calculated from the event analysis) was 722 days.

Vision in the implanted eyes—At 12 months after surgery, 8 of the 9 dogs had retained vision in the implanted eye. Five of those 8 dogs retained vision throughout their follow-up periods (Figure 3).

Complications and outcome—Among the 9 dogs, complications that developed included a superficial postoperative corneal ulcer (dog 9), conjunctival Candida infection over the surgical site (dog 2), conjunctival dehiscence or necrosis (dogs 1, 4, 5, and 7; successful repair in dog 5), and persistent hypotony with hypotensive retinopathy (dog 4; Figure 4). The Candida infection in dog 2 was treated topically with miconazole and resolved. The lens instability in dog 3 was treated with continued administration of latanoprost in an attempt to prevent lens luxation into the anterior chamber. Conjunctival dehiscence was repaired surgically.
via apposition of conjunctival edges after trimming away of nonviable tissue.

At 152 days following implantation of the gonioimplant, dog 1 developed clinically evident, extensive conjunctival necrosis and increased IOP in the implanted eye. The eye was enucleated, and histologic examination of the conjunctiva overlying the implant revealed severe, acute, locally extensive, suppurative, and necrotizing conjunctivitis. There was also moderate, acute, locally extensive scleritis and choroiditis attributable to the necrotizing conjunctivitis. No infectious organisms were detected. Dog 3 lost vision in the implanted eye 732 days after surgery because of an acute increase in IOP that failed to respond to medical treatment. At 396 days following gonioimplantation surgery in dog 4, the implant was exposed and extruded, such that it was held in place only by the temporalis muscle fascia graft covering the tube as it entered the eye. The implant was removed and the conjunctiva closed routinely. Histologic examination of a biopsy sample of the conjunctiva in the area of the implant revealed mild conjunctivitis. Immediately after removal of the implant, IOP increased and vision was lost; subsequently, the eye was enucleated. Dog 5 was reevaluated because of an extruded implant 214 days after a conjunctival rent was repaired. At that time, the IOP was high, and because vision in the eye was lost 60 days previously as a result of cataract, the globe was enucleated. The cataract was first detected in the posterior cortex 30 days after gonioimplantation surgery. Histologic examination of the enucleated globe revealed diffuse, mild to moderate, acute neutrophilic endophthalmitis (which was presumed to be bacterial in origin, although no organisms were seen and microbial culture was not performed) and multifocal foreign body granulomas within the sclera, as well as goniodysgenesis and cataract. Dog 7 had detectable conjunctival dehiscence over the implant and granulation tissue formation around the base of the implant at 365 days after surgery. The owner declined surgical correction of the dehiscence, and the dog was then lost to follow-up. Interestingly, all of the conjunctival rents occurred over the implant footplate and not over the region of the temporalis muscle fascia graft where the tube entered the globe. In dog 8, IOP in the implanted eye was 41 mm Hg at 183 days after surgery; the implanted eye had a decreased menace response but was able to see falling cotton balls, although tracking was hesitant and inconsistent. At that time, a second implant was placed. The first implant was left in place. Vision in the implanted eye appeared to remain stable after placement of the second gonioimplant for at least 336 days; the owners elected to continue treatment with dorzolamide and timolol after the second surgery even though pressures remained low.

Dog 2 died of unrelated causes 396 days after gonioimplantation surgery. At that time, the implant was still functional and vision was present in the implanted eye. Dog 6 died as a result of abdominal neoplasia 1,220 days after gonioimplantation surgery and still had sight in the implanted eye at that time. At the last follow-up examination performed at 518 days after surgery, dog 9 had a functional implant and retained vision in the implanted eye. Overall, median time to vision loss with interventional surgery was 518 days (range, 152 to 1,220 days).
Discussion

The results of the present study indicated that gonioimplantation surgery, performed by use of the described techniques, is effective in long-term IOP control and vision preservation in dogs. With regard to those goals, the gonioimplantation surgery was as effective as combined cyclodestruction and gonioimplantation, but was associated with fewer immediate postoperative complications.\(^1,2\) Cyclophotocoagulation is reported to cause postoperative intraocular hypertension in most dogs.\(^1,2\) This develops less frequently (10% to 35% of cases) if gonioimplantation is performed concurrently.\(^1,2,12\) Other short-term complications associated with combined gonioimplantation and cyclophotocoagulation in dogs include development of excessive anterior chamber fibrin (which often necessitates intracameral injection of TPA [approx 34% of cases]), corneal ulcers (approx 10% of cases), hyphema (approx 15% of cases), and focal retinal detachments (approx 7% of cases).\(^1,2,12\) In the present study, the only perioperative complications were development of a corneal ulcer and hypertensive retinopathy, each in a different dog.

The most important long-term complication associated with cyclophotocoagulation is cataract formation, which variably interferes with vision and develops in approximately 3% to 25% of treated dogs.\(^1,2,12,13\) One of the dogs in the case series of this report, a 9-year-old Cocker Spaniel, developed a progressive cataract that began in the posterior subcapsular region 30 days after gonioimplantation surgery. Because the dog's other eye had been enucleated, it was not possible to determine whether development of the cataract was an inherited trait. A notable complication in the dogs of this report was the development of conjunctival rents or necrosis that led to implant extrusion. These complications are important in that they require additional anesthetic episodes for correction and predispose affected dogs to the development of vision-threatening complications such as endophthalmitis. Interventional surgical procedures were needed in half of the dogs in the present study because of long-term complications; however, because the owners had been forewarned of this possibility, they were satisfied because the additional intervention prolonged retention of vision.

Although gonioimplant placement and cyclophotocoagulation are commonly performed at the same time to ameliorate the detrimental postoperative effects associated with cyclophotocoagulation, this strategy may lead to an increased likelihood of implant failure. There is evidence that the thickness of the fibrous capsule that forms around the implant is related to the amount of aqueous humor flow through the implant during the postoperative period (ie, the flow of high amounts of aqueous humor results in thicker capsules). Thinner capsules are desired because they are associated with better implant function.\(^1,4\) In dogs, cyclophotocoagulation consistently induces postoperative increases in IOP.\(^1,2\) When a gonioimplant is placed, this increase in IOP is most likely translated into an increase in aqueous humor flow through the implant; the increase in flow, along with the inflammatory mediators that are released during cyclodestruction, may lead to the formation of thicker fibrous capsules, which in turn may result in premature implant failure.

At 365 days, 7 of the 9 dogs in the present study retained sight in the implanted eye, compared with 23 of 48 dogs that underwent cyclodestruction and gonioimplantation surgery in other studies.\(^1,2,12\) Long-term vision preservation was also more successful in the present study, compared with findings following use of the Ahmed implant alone in dogs.\(^1,10\) Only 1 of 7 dogs that received an unmodified Ahmed implant in that report\(^10\) retained sight in the implanted eye after 1 year. The reported success rate (ie, vision present or appropriate IOP in the implanted eye at 12 months after surgery) following use of different types of implants varies. The use of an anterior chamber tube with a large surface area strap was successful in 8 of 12 dogs,\(^1,11\) whereas the use of a Baerveldt filtering device was successful in 3 of 12 dogs; implantation of a T-shaped nonvalved implant or a valved Ahmed implant with a large surface area strap was successful in 1 of 30 dogs and 13 of 31 dogs, respectively.\(^10\) These differences in outcome may be attributable to the complications associated with concurrent cyclodestruction, inherent differences associated with the type of implant used, or differences in the technique used for gonioimplantation.

Placement of gonioimplants that drain into extraorbital regions, such as the frontal sinus, facial vein, and subcutaneous tissue, has also been attempted in dogs. However, such gonioimplantation procedures have not been evaluated for their long-term success, and they are associated with major short-term complications including implant migration, hyphema, tube occlusion, and IOP spikes.\(^15,16\) Endoscopic cyclophotocoagulation is associated with fewer adverse effects and is just as effective as transcleral cyclophotocoagulation and gonioimplantation in humans.\(^17,18\) However, to our knowledge, there are no reports of studies to evaluate the long-term success of endoscopic cyclophotocoagulation alone or in combination with gonioimplantation in dogs.

In the study of this report, a temporalis muscle fascia graft was used to cover the implant tubing as it exited the anterior chamber and to the creation of a scleral flap. The use of a temporalis muscle fascia graft in gonioimplantation has not been previously reported, to our knowledge. Temporalis muscle fascia has been used in several ophthalmologic applications in humans.\(^19-23\) Most commonly, it is used in eyelid reconstruction or in the management of extruding ocular prosthesis. Placement of a temporalis muscle fascia graft over the tube where it enters the anterior chamber decreases the likelihood that the tubing will erode through the conjunctiva as it exits the globe, which predisposes the eye to endophthalmitis. The conjunctival rents that developed in 4 dogs in the present study were located over the footplate of the implant and not over the region where the temporalis muscle fascia was placed, making it unlikely the graft was related to this complication. The results of the present study suggest that the use of a temporalis muscle fascia graft is an effective alternative to the creation of a scleral flap.

Bleb fibrosis is the most common cause for gonioimplant failure in dogs.\(^3,5\) In the present study, mitomy-
cin C was used to decrease development of fibrosis. In a previous study that evaluated the long-term outcomes of placement of Ahmed gonioimplants in dogs, 5-fluorouracil was used as an antifibrotic agent. Mitomycin C has been shown to be 10 times as potent as 5-fluorouracil in decreasing fibroblast growth in vitro and to decrease capsule thickness in dogs. Use of mitomycin C may have been one of the factors that affected the interval during which the implants remained functional in the present study. However, mitomycin C administration may have also contributed to the conjunctival necrosis and accompanying scleritis that developed in dog 1 and the conjunctival rents that were detected in dogs 4, 5, and 7. These ophthalmic adverse effects have not been previously associated with mitomycin C treatment in dogs. However, there are several reports of scleral melting associated with intra- and postoperative mitomycin C treatment in humans that undergo surgery for pterygium. Although only scleral melting or thinning is mentioned in those reports, similar mechanisms of action may have led to conjunctival necrosis in the dogs of the present study. Moreover, increased incidence of tube exposure after gonioimplantation has been associated with intraoperative use of mitomycin C in some humans, whereas others investigators have not documented this association; the gonioimplant tubes were covered by use of scleral tunnels and donor sclera or pericardium in the first and second studies, respectively.

When bleb fibrosis develops despite the use of an antifibrotic and IOP decrease, possible surgical options include bleb revision or placement of a second additional implant. Surgical removal of cicatricial tissue surrounding the implant is successful in reducing IOP and maintaining vision in approximately half of human patients that undergo this procedure. Placement of a second implant has been reported to result in better IOP control than does bleb revision. In dogs, placement of a second implant may be difficult because of the size of the globe and orbit in smaller dogs. In those instances, bleb revision may be the only technically viable alternative.

Another notable difference between the cases in the present study and those previously described is the use of topical 1% prednisolone acetate. In the present study, the frequency of topical prednisolone application was not decreased to less than once daily even if there were no clinically evident signs of inflammation. We believe that continuation of once-daily steroid application has an important role in decreasing the amount of implant fibrosis that develops either by directly acting on fibroblasts surrounding the implant footplate or by decreasing the amounts of inflammatory mediators within the aqueous humor that result from subclinical intraocular inflammation, which may lead to increased fibrosis at the implant footplate. This is supported by findings of a randomized clinical trial in humans, which included improved bleb function, better long-term IOP control, and better visual field outcome with the use of topical 1% prednisolone acetate.

Dog 2 in the present study received a gonioimplant following development of glaucoma after undergoing phacoemulsification for a diabetes-related cataract. The other eye of this dog had been enucleated secondary to primary glaucoma prior to the onset of diabetes. A previous report describes a nearly identical case, in which vision and normal IOP were present at 11 months after the implant was placed. Based solely on these 2 cases, it appears that previous phacoemulsification does not decrease the long-term success of gonioimplantation surgery.

Dog 4 in the present study developed multifocal retinal folds that were attributed to persistent hypotony. Although it is possible that these lesions were present prior to surgery, it seems unlikely because the dog underwent multiple ophthalmic examinations by board-certified ophthalmologists and multifocal retinal dysplasia or retinal folds were not mentioned in the medical record. A similar lesion—hypotony maculopathy—is also described in the human medical literature and develops in approximately 20% of patients after glaucoma filtering surgery. Although there is some controversy as to the mechanism behind the development of the folds, some suggest that they are a result of shrinking of the scleral volume, which results in redundant choroidal and retinal tissues that are thrown into folds. This lesion in dogs has not been described, but may become more common as the use of glaucoma filtering surgery in dogs becomes more prevalent.

A limitation of the present study is the small number of cases evaluated. However, the use of an autologous temporalis muscle fascia graft, long-term topical administration of prednisolone, bleb revision surgeries, and intraoperative administration of mitomycin C and tPA may truly represent techniques that increase the long-term success rate of gonioimplantation surgery in the management of medically uncontrolled glaucoma in dogs.

References


