Excimer Laser Trabeculostomy

A new, minimally invasive surgical procedure for the treatment of open-angle glaucoma.

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Primary open-angle glaucoma (characterized by elevated IOP, cupping of the optic disc, or a diminished visual field) is one of the world's leading causes of blindness.[1-3] The pathology in most open-angle glaucoma is increased outflow resistance at the level of the trabecular meshwork (specifically, the juxtacanalicular meshwork and inner wall of the canal of Schlemm). The affected population is generally over 35 years old, and susceptibility may be inherited. If diagnosed early, glaucomatous damage can be mitigated by lowering an individual's IOP, thus resulting in less visual field loss.

Excimer laser trabeculostomy (ELT) reestablishes physiologic aqueous outflow through endogenous drainage pathways without creating an external filtration bleb. The procedure involves fiber-optically delivering a 308-nm excimer laser light across the anterior chamber through a limbal paracentesis in order to connect the anterior chamber with the canal of Schlemm, thereby reducing outflow resistance and decreasing IOP. This article describes this promising, new, minimally invasive glaucoma surgery and highlights clinical data verifying its efficacy at lowering IOP, especially in combination with cataract surgery.

GLAUCOMA THERAPIES

Today, medications are often the first line of glaucoma therapy, but they are associated with adverse, sometimes severe side effects.[4] In addition, medication regimens may change due to tachyphylaxis and the availability of newer drugs. The costs of medical glaucoma control over a lifetime can also be prohibitive for some patients, a fact that creates a need for safe and effective surgical interventions. After medication use, the most common glaucoma treatments today are argon laser trabeculoplasty (ALT), selective laser trabeculoplasty (SLT), and manual filtering surgical procedures such as trabeculectomy. ALT and SLT increase conventional aqueous outflow through the trabecular meshwork,[5] but these procedures have limited efficacy and duration of effect. Complications of trabeculectomy include hypotony, a shallow or flat anterior chamber with or without choroidal effusion, suprachoroidal hemorrhage, hyphema, and, most commonly, eventual failure as the filtering bleb heals itself.[6] Patients often find the external conjunctival bleb to be uncomfortable, and it can become thin and avascular, thereby increasing the risk of bleb leaks and endophthalmitis.[7] Trabeculectomy tends to be less successful in young eyes and in eyes that produce large amounts of scar tissue. In the case of failed filtration surgery, repeated operations may be necessary, but the chances for success decrease as

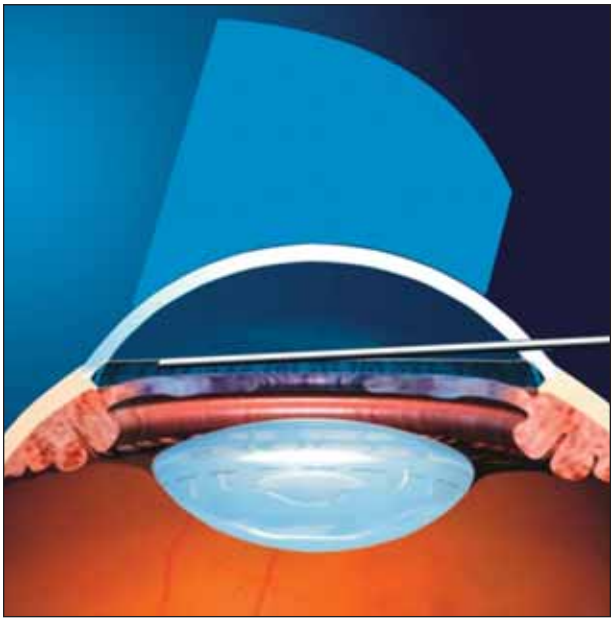


Figure 1. This schematic diagram of ELT shows how the fiber-optic approaches the trabecular meshwork across the anterior chamber.

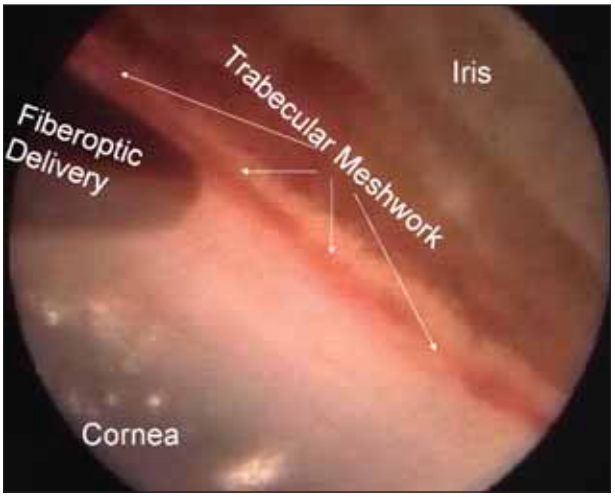


Figure 2. In this endoscopic view, the fiber-optic delivery approaches the trabecular meshwork.

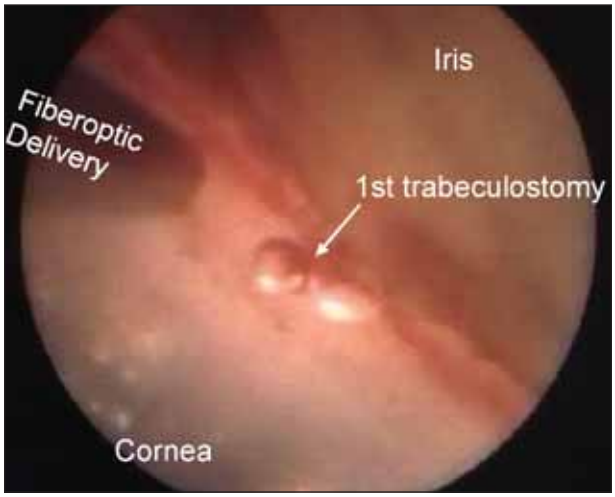


Figure 3. This endoscopic view shows the first trabeculostomy after its creation.

the sclera and conjunctiva are subjected to repeated surgical insults.

Another IOP-lowering procedure involves placing a glaucoma drainage device (tube shunt) such as the Molteno Implant (Molteno Ophthalmic Limited, Dunedin, New Zealand), Baerveldt shunt (Pfizer Inc., New York, NY), Krupin Eye Valve (Hood Laboratories, Pembroke, MA), and Ahmed Glaucoma Valve (New World Medical, Rancho Cucamonga, CA).[8,9] The surgeon places the tube into the anterior chamber and secures a space-maintaining plate in the sub-Tenon's space. Shunts have a relatively high success rate, but the nature of their designs and placement technique puts the patient at a greater risk for complications than do nonimplant surgeries such as trabeculectomy.[10]

ELT TECHNIQUE

The concept of treating the pathology of most open-angle glaucoma via outflow obstruction at the juxtacanalicular trabecular meshwork is well established. To be successful, however, a procedure to bypass this obstruction must be accurate and stealthy, producing little or no healing response. Excimer laser-tissue interactions fulfill both requirements. Because the 308-nm wavelength allows the removal of trabecular meshwork by photoablation without inducing thermal damage, it minimizes the healing response and scar formation. ELT reestablishes physiologic aqueous outflow through endogenous drainage pathways without creating an external filtration bleb. The surgeon excises a defined area of the trabecular meshwork and juxtacanalicular tissue. The laser removes tissue while producing minimal thermal mechanical damage to the surrounding tissue, thereby reducing post-laser healing responses. ELT increases aqueous outflow into the canal of Schlemm and thereby lowers IOP.[11-14]

In ELT, the surgeon makes a paracentesis incision and stabilizes the anterior chamber with a viscoelastic. The laser is passed across the anterior chamber via the paracentesis incision and toward the opposite chamber angle to contact the trabecular meshwork. The surgeon applies laser energy (AIDA Excimer Laser System; TuiLaser AG, Germering, Germany) directly to the trabecular meshwork by means of a fiber-optic delivery system (LAGO 200 or LAGO 200 ENDO; TuiLaser AG), which traverses the anterior chamber via a paracentesis incision (Figure 1).

Currently, ELT involves creating about 10 laser excisions (trabeculostomies) distributed over approximately 90º.

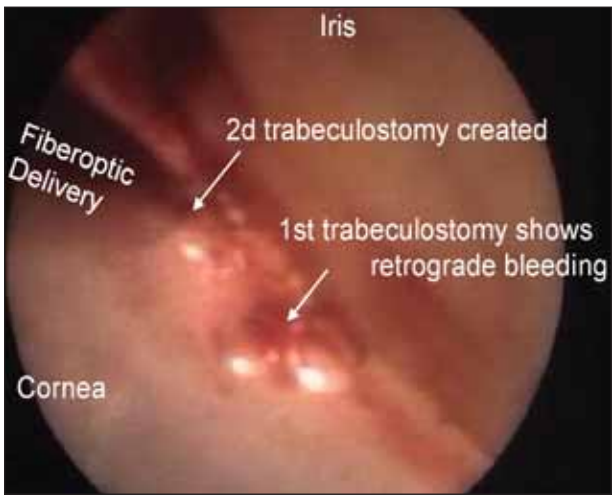


Figure 4. In this endoscopic view, retrograde bleeding occurs at the site of the first trabeculostomy when a second is created.

The surgeon monitors the fiber position either with a goniolens or an endoscope. Figure 2 shows an endoscopic view demonstrating the fiber-optic delivery of laser energy to the trabecular meshwork. Figure 3 shows the first trabeculostomy after creation. In Figure 4, Dr. Funk has created the second trabeculostomy, and retrograde blood is visible at the site of the first trabeculostomy.

COMBINING CATARACT SURGERY WITH ELT

Cataract excision often decreases patients' IOPs. Combining ELT with cataract surgery can further lower IOP and has proven effective clinically for more than 30 months.[15] In contrast, combining clear corneal cataract surgery and filtering glaucoma surgery (ie, trabeculectomy) has been less successful than when the procedures occur at two different time points.[16] When combined with cataract surgery, ELT is performed through the same corneal incisions with only a minimum of additional time.

Clinical studies have consistently demonstrated a significant IOP reduction after ELT[11] to levels in the mid-teens. Reducing IOP to approximately episcleral venous pressure has been shown to effectively stabilize glaucoma.[15,17-20] Figure 5 shows pooled data of combined ELT and cataract surgeries by five surgeons in four German eye clinics. The combined procedures effectively decreased IOP as well as the average number of medications that the patients were taking.

COMPARING ELT, COMBINED SURGERY, AND THE EFFECT OF DIFFERENT POSTOPERATIVE MEDICATIONS

Methodology

Drs. Giers and Kleineberg are collaborating with Lutz Pillunat, MD, of the University of Dresden in Germany on a study in Detmold, Germany. Its purpose is to compare the IOP-lowering effect of ELT as a stand-alone procedure versus a combined procedure with cataract surgery. The investigators also are comparing the effect of different postoperative medications after otherwise identical surgeries. The study is evaluating three groups: ELT alone with postoperative steroids t.i.d. for 10 days (group 1, N=22); ELT alone with postoperative nonsteroidal anti-inflammatory drugs (NSAIDs) t.i.d. for 10 days (group 2, N=15); and combined ELT/cataract surgery with postoperative steroids t.i.d. for 28 days (group 3, N=23).

All subjects are older than 18 years. They had open anterior chamber angles (Shaffer III-IV), an initial IOP of less than 40 mm Hg, and either primary open-angle glaucoma or secondary open-angle glaucoma (such as pseudoexfoliation). The indications for surgery were an increased IOP under maximum tolerated medical therapy, progressive glaucomatous damage under maximum tolerated therapy, allergies to medication, and noncompliance with medical therapy. The exclusion criteria were a narrow anterior chamber angle (Shaffer I-II), neovascularization of the iris, an abnormal iris configuration, and dysplasia of the trabecular meshwork. Postoperative follow-up has occurred 1 day, 8 days, 4 weeks, 3 months, and 6 months after the operation. The investigators are monitoring subjects' IOPs, visual fields, visual acuities, and imaging results with the GDx VCC (Laser Diagnostic Technologies, San Diego, CA).

Results

The average IOP reduction 6 months after surgery in group 1 was 34%. Five of 22 patients have had to remain on antiglaucomatous medication. The visual field results improved in five of 22 patients, deteriorated in one, and remained unchanged in 16. Three patients responded to steroids and underwent treatment with NSAIDs instead. Two suffered allergic reactions to postoperative medication.

Subjects in group 2 also experienced an average IOP reduction of 34% 6 months after surgery. Four out of 15 patients have had to remain on antiglaucomatous med-

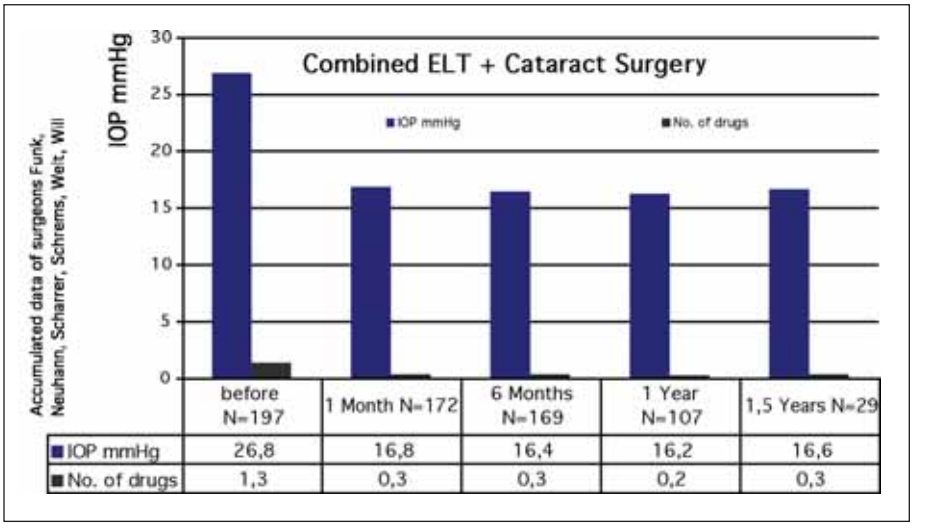
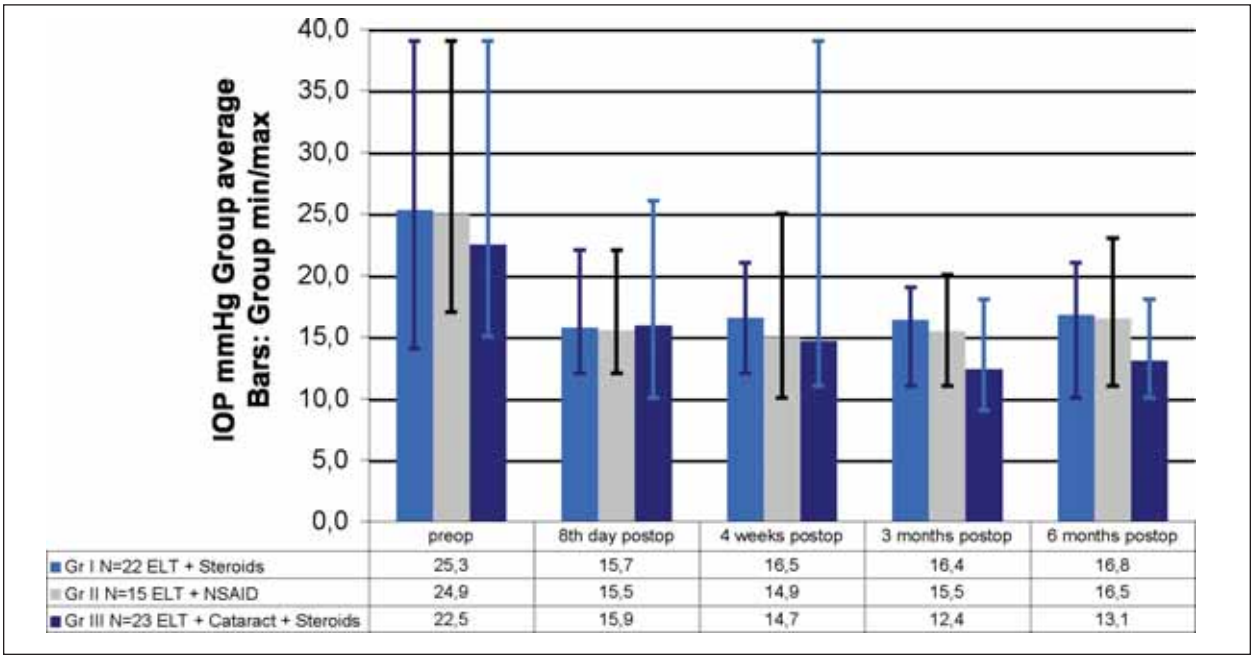


Figure 5. Pooled data from several surgeons show a reduction in IOP versus time after combined ELT and cataract surgery.[18]



	preop	8th day postop	4 weeks postop	3 months postop	6 months postop
Gr I N=22 ELT + Steroids	25,3	15,7	16,5	16,4	16,8
Gr II N=15 ELT + NSAID	24,9	15,5	14,9	15,5	16,5
Gr III N=23 ELT + Cataract + Steroids	22,5	15,9	14,7	12,4	13,1

Figure 6. In this graph of IOP reduction by ELT, the error bars designate maximum and minimum measurements in groups 1 through 3.

ication, although all at lower amounts than before ELT. Visual field results improved in one patient and remained unchanged in 14. One patient developed conjunctivitis and required treatment with an additional topical steroid.

In group 3, subjects experienced an average 42% reduction in IOP 6 months after surgery. Four of 23 patients have had to remain on antiglaucomatous medication, although at lower amounts than before surgery. Visual field measurements improved in five of 23 patients, remained unchanged in 17, and deteriorated in one. Six of 20 patients responded to steroids and were treated with NSAIDs instead. One patient developed conjunctivitis and received treatment with a topical combination steroid-antibiotic q2h.

Figure 6 shows the average IOP for all groups 6 months postoperatively (the study continues to monitor longer periods). These results demonstrate that the IOP reduction is greatest when ELT is combined with cataract surgery.

CONCLUSION

No serious complication of ELT has been reported after hundreds of procedures at multiple centers. ELT creates no filtering bleb or hypotony, and it leaves the conjunctiva intact. Prior surgery does not constitute a contraindication, but we anticipate that procedures that compromise distant outflow channels (such as extensive ALT) may also compromise the efficacy of ELT.

This promising, new, minimally invasive glaucoma surgery is particularly effective in lowering IOP when combined with cataract surgery. Techniques and protocols are evolving, and controlled clinical trials are in progress.[21] Clinical data to date confirm ELT's safety and its efficacy at lowering IOP. ❑

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Occult Cyclodialysis Cleft After Trabeculectomy

BY GEORGE TANAKA, MD

CASE PRESENTATION

A 75-year-old, white, Russian female complaining of decreased vision in her right eye presented for a second opinion. Her past ocular history was significant for open-angle glaucoma and cataracts, for which she had undergone combined cataract and glaucoma surgeries in both eyes. She reported having good vision bilaterally until approximately 5 years after surgery in her right eye, when she developed a painless decrease in vision. Her treating ophthalmologist had diagnosed the patient with a choroidal detachment due to hypotony and referred her to a retinal specialist, who resutured her trabeculectomy flap. In spite of this surgery, the patient's hypotony and choroidal detachment persisted. She then underwent reformation of her anterior chamber with a viscoelastic solution, which increased her IOP and improved her vision temporarily.

The patient's ocular medications on presentation included prednisolone acetate (Falcon Pharmaceuticals, Fort Worth, TX) b.i.d. and atropine q.d. in her right eye. She was taking timolol maleate (Falcon Pharmaceuticals) b.i.d. and latanoprost (Xalatan; Pfizer Inc., New York, NY) q.h.s. for her left eye. Her past medical history was significant for hypertension, non–insulin-dependent diabetes mellitus, atherosclerotic heart disease, and hypercholesterolemia. Her systemic medications included diltiazem, atenolol, glyburide, isosorbide, aspirin, and atorvastatin.

The initial examination in January 2001 revealed a BCVA of 20/200 OD and 20/40 OS. Her IOPs were 6 mm Hg OD and 24 mm Hg OS. Slit-lamp examination revealed corneal folds, a shallow anterior chamber, a PCIOL implant, and no discernable filtration bleb in the patient's right eye (Figure 1). Seidel testing of the superior conjunctiva overlying the scleral flap revealed no leakage, even with gentle pressure on the globe.

Optic nerve examination showed 0.3 C/D OD and 0.8 C/D OS. A low, inferior choroidal detachment was visible with indirect ophthalmoscopy in the patient's right eye. Gonioscopy of her right eye demonstrated a large, patent, internal sclerostomy superiorly, with a poor view of the angle structures through the corneal folds. Gonioscopy of her left eye revealed an open angle with a patent internal sclerostomy.

HOW WOULD YOU PROCEED?

1. What would be your differential diagnosis for the patient's hypotony?
2. What diagnostic tests or procedures would you perform?
3. What therapeutic approaches would you consider?
4. Incidentally, how would you manage her left eye?

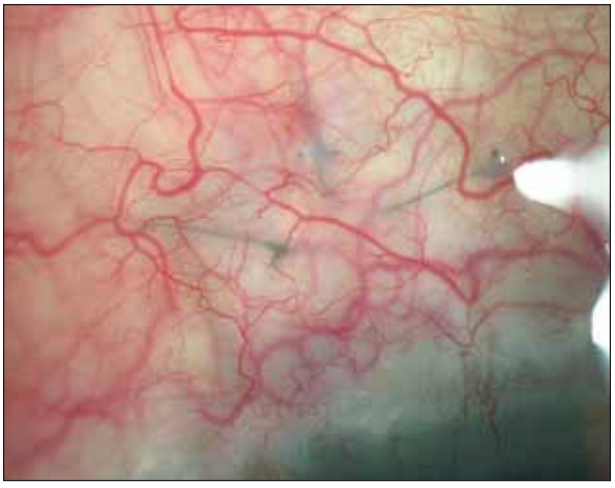

Figure 1. Examination of the superior perilimbal conjunctiva revealed a tightly sutured trabeculectomy flap with no discernable overlying filtration bleb. Seidel testing of this area was negative.

SURGICAL COURSE

I instructed the patient to use her prednisolone acetate q.i.d. and prescribed a 7-day course of oral prednisone (60 mg q.d.). Her systemic beta-blocker was also discontinued after a consultation with her internist.

The patient returned 1 week later. She had a BCVA of 20/400 OD and 20/50 OS, and her IOP was 4 mm Hg OD and 28 mm Hg OS. She had ceased taking all medications except the prednisolone acetate, because she had noted no improvement in her condition. Her right eye's anterior chamber remained shallow, and larger nonkissing bullous choroidal detachments were now observable. At the slit lamp, I injected a viscoelastic solution into the anterior chamber through a temporal paracentesis. Immediately after anterior chamber reformation, the IOP was 26 mm Hg OD with no visible superior filtration bleb. Repeat gonioscopy revealed a probable cyclodialysis cleft posterior to the internal sclerostomy. I performed a needling bleb revision in her left eye a few days later.

In 3 weeks, the patient's visual acuity was 20/25 OD and 20/50 OS. Her IOP was 5 mm Hg OD and 11 mm Hg OS on no glaucoma medications. Both anterior chambers were deep and quiet. A diffuse superior filtration bleb was present in her left eye, whereas no filtration bleb was present in her right. Examination of the fundus showed resolution of the choroidal detachment in her right eye.

Five months thereafter, the patient's visual acuity had dropped to 20/40 OD, with an IOP of 5 mm Hg. I observed marked shallowing of the anterior chamber with peripheral iris-cornea touch as well as a recurrent choroidal detachment. Gonioscopic visualization of the superior angle was hampered by a large irido-corneal adhesion. After performing Nd:YAG laser lysis of this adhesion, I could clearly see a cyclodialysis cleft (Figure 2). The remainder of the right angle was closed. The cyclodialysis cleft was treated with argon laser during two separate sessions that occurred 5 months apart. One month after the second argon laser treatment, the patient's BCVA improved to 20/25 OD, with an IOP of 17 mm Hg. Her anterior chamber was deep, with focal peripheral anterior synechiae. No choroidal detachments could be appreciated.

OUTCOME

The patient remained clinically stable for 2 years, until October 2003, when she presented to the emergency room with severe pain in her right eye and an IOP of 60 mm Hg OD. Emergent paracentesis was performed, and glaucoma medications were restarted. Gonioscopic examination revealed partial closure of the cleft by what appeared to be scar tissue or peripheral capsular fibrosis. Her medications were gradually tapered and discontinued. Upon her last examination in April 2004, her visual acuity was 20/25 OD, with an IOP of 6 mm Hg on atropine q.d.

DISCUSSION

An inadvertent cyclodialysis cleft following intraocular surgery is a rare complication, usually occurring after extracapsular cataract extraction but also reported after phacoemulsification through a scleral tunnel incision,[1] anterior chamber IOL removal,[2] transscleral fixation of a PCIOL,[3] and holmium laser sclerostomy.[4] There are also a few case reports of an inadvertent cyclodialysis following trabeculectomy.[5,6] The case presented herein is unusual with respect to the complication's initial presentation years after surgery and its spontaneous closure years after argon laser treatment. As this case illustrates, the diagnosis of an inadvertent cyclodialysis cleft may not be straightforward but may require a high index of suspicion and careful gonioscopic examination. Anterior chamber reformation with viscoelastic and high-resolution ultrasonic biomicroscopy may be useful diagnostic adjuncts.[7,8]

The management of an inadvertent cyclodialysis cleft is directed toward limiting or eliminating aqueous outflow into the supraciliary space, normalizing IOP, and restoring vision. Less invasive treatments include cycloplegia and observation in cases where good visual acuity is retained.[9] Cyclodialysis clefts unresponsive to conser-

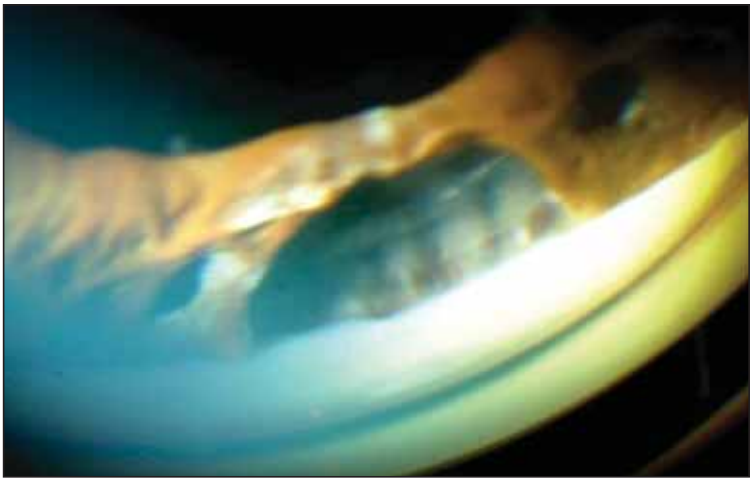

Figure 2. Gonioscopy revealed a cyclodialysis cleft posterior to the internal sclerostomy. The peripheral lens capsule was visible through the iridectomy. The remainder of the anterior chamber angle was closed.

vative measures may respond to treatment with cryotherapy,[6] argon laser,[10,11] transscleral Nd:YAG laser,[12] transscleral diode laser,[13,14] or endoscopic laser.[15] The definitive treatment of persistent or large cyclodialysis clefts involves cyclopexy, in which the ciliary body is reattached to the sclera with sutures.[16] Surgical closure may also be accomplished with vitrectomy, cryotherapy, and intraocular gas tamponade.[17,18] The closure of a cleft usually results in a hypertensive phase, which is transient in eyes with an underperfused yet functional trabecular meshwork. The patient described in this case demonstrates a completely closed angle apart from the area of cyclodialysis. If the cleft closes permanently in the future as a result of additional scarring, a trabeculectomy or other filtering procedure may well be required to maintain a safe and consistent IOP. ❑

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