

Endoscopic Cyclophotocoagulation

Ablating the ciliary body under direct visualization.

BY JEHN-YU HUANG, MD, MPH, AND SHAN LIN, MD

Cyclodestructive surgery destroys the ciliary body in order to decrease aqueous production and reduce IOP. Because it destroys tissue and can result in significant complications, we have traditionally reserved cyclodestructive surgery as a last choice.

Multiple methods—including surgical excision,¹ diathermy,² ultrasound,^{3,4} cryotherapy,⁵⁻⁷ and laser⁸⁻¹²—have been introduced for cyclodestructive surgery. Many of these methods were developed to reduce the incidence of complications and improve the safety and success rate of cyclodestruction. Complications such as phthisis bulbi, hypotony, hemorrhage in the anterior chamber, or swelling of the eyelids were less frequent in the laser-treated group than in the group undergoing cyclocryotherapy.¹³ Laser cyclophotocoagulation (CPC) has therefore become the principal method for surgically reducing aqueous production in the United States. Transscleral CPC is normally used for refractory glaucoma and in eyes with limited visual potential or for the relief of pain in eyes with no visual potential. Sometimes, ophthalmologists select laser CPC for patients who are not candidates for conventional glaucoma therapy due to poor cooperation during surgery or poor compliance with post-operative care.¹⁴ With the advent of endoscopic cyclophotocoagulation (ECP), there has been a movement toward the utilization of CPC earlier in the glaucoma treatment paradigm and toward its use in eyes with greater visual potential.¹⁵⁻¹⁷

The procedure delivers laser energy to the ciliary processes and produces coagulative necrotic damage to the secretory ciliary epithelium.¹⁸ The routes of laser delivery in CPC include the transscleral,^{8,19,20} transpupillary,²¹

and endoscopic approaches.²² Transpupillary CPC can treat the ciliary epithelium directly, but only a small number of ciliary processes can be visualized and accessed through the pupil.²¹ Transscleral CPC can treat the ciliary processes extensively by means of a “blind” external approach, meaning that the ophthalmologist cannot visualize the ciliary processes directly. Although some surgeons use transillumination to permit some degree of visualization, this method does not ensure the complete identification of the treatment area. Because the surgeon cannot see the target tissue and assess the completeness of treatment, the predictability of the outcome is poor. A high level of energy is needed to increase the possibility of surgical success, and that heightens the risk of complications. If the goal is to minimize the incidence of complications, the surgeon may treat more conservatively, but then the chance of an under-treatment and a need for retreatment rises.

ECP has some potential advantages over the transscleral approach, including better titration of the laser energy and a possible avoidance of excessive treatment and complications. Overall, the higher energy levels used in transscleral CPC result in a more significant lowering of IOP than ECP and a more prolonged effect, perhaps because of our experimental findings that the blood supply is more completely obliterated using transscleral CPC (discussed later in the article).

ECP TECHNOLOGY

The E2 Microprobe Laser and Endoscopy System (Endo Optiks, Little Silver, NJ) incorporates a diode laser that emits pulsed continuous-wave energy at 810 nm, a 175-W xenon light source, a helium-neon laser aiming



Figure 1. The laser and monitor for ECP.

beam, and a video camera (Figure 1). Images are transmitted through a single probe to allow the surgeon to view and ablate the ciliary epithelium.²² This technology is available with a 20-gauge probe (Figure 2), providing a 70° field of view and a depth of focus ranging from 0.5 to 15.0 mm. An 18-gauge endoscope with the same components is also available. The field of view with this version is 110°, with a depth of focus ranging from 1 to 30 mm. Advantages of the larger-diameter endoscope include greater clarity and a more panoramic field of view.²³

INDICATIONS

By ablating the ciliary body to a visible endpoint under direct visualization, ECP may prevent both undertreatment and overtreatment. In a recent study, we used an animal model to look at the histology as well as vascular perfusion after transscleral CPC and ECP. We found that the transscleral approach caused a significant, long-lasting obstruction to the blood flow of the ciliary processes. In contrast, ECP caused an initial reduction in blood flow, but there was a partial return of blood flow after 1 week that became even greater after 1 month. The fact that blood flow is not completely cut off following ECP may explain why there appears to be a significantly lesser risk of hypotony or phthisis with this procedure. In essence, ECP maintains some of the health of the ciliary processes.²⁴

Despite this advantage, we would not recommend using ECP for every patient with refractory glaucoma. Because ECP is an intraocular procedure, it creates risks (eg, endophthalmitis, suprachoroidal hemorrhage) that are not present when a procedure is nonpenetrating. Furthermore, eyes with end-stage glaucoma, a very high IOP, and severely compromised outflow (eg, eyes that have neovascular glaucoma with complete involvement of the angle) are also poor candidates for ECP. In such eyes, transscleral CPC would likelier achieve a more significant and prolonged reduction in IOP than ECP, in part due to the greater vascular damage to the ciliary processes observed in transscleral CPC.²⁴

ECP may also cause other visually significant complications such as cystoid macular edema (CME). In our series of patients, the risk of CME was 10%.²⁵ Thus, in individuals who are at greater risk of macular edema (eg, diabetic and uveitic patients), ECP may not be an appropriate first-line surgical option.

Unfortunately, the peer-reviewed literature has a lack of long-term follow-up study for ECP and its complications. Surgeons may wish to consider ECP when they are opening the eye for another surgery such as cataract extraction, because the risks associated with an intraocular procedure are already present. Berke et al compared the reduction in IOP between phacoemulsification alone and combined

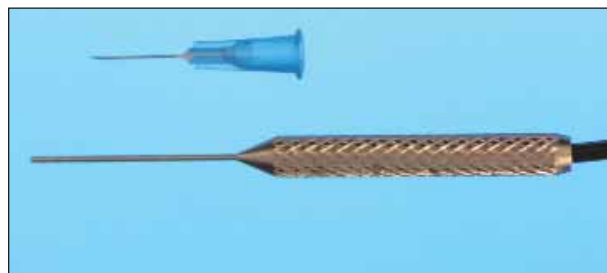


Figure 2. The 20-gauge laser probe for ECP, with a 25-gauge needle presented for a comparison of size.

phacoemulsification/ECP. They found that the combined procedure lowered IOP by 2.1 mm Hg and decreased the use of medications by 1.4. Phacoemulsification alone lowered IOP by 0.5 mm Hg and reduced the use of medications by 0.03.²⁶ Furthermore, patients who have an altered ciliary body anatomy are candidates for ECP as well. In contrast, altered anatomy may result in inadequate treatment with transscleral CPC and damage to adjacent structures such as the pars plana and iris root.

When deciding between performing combined phacoemulsification/ECP versus combined phacoemulsification/trabeculectomy, the surgeon must consider the patient's stage of glaucoma and tolerance of potential complications. Phacoemulsification/trabeculectomy lowers IOP more effectively but is associated with more complications.¹⁵

In addition, ECP has been used effectively to treat pediatric glaucoma, although serious complications (eg, retinal detachment and hypotony) were more common in this group.²⁷ Furthermore, a prospective study compared ECP with Ahmed Glaucoma Valve (New World Medical, Inc., Rancho Cucamonga, CA) surgery and found the former to have equivalent efficacy but fewer complications overall.²⁸

TECHNIQUES AND RESULTS

There are two main approaches to the ciliary processes. Some surgeons may access the ciliary processes from the pars plana, but most choose a limbal approach through a clear corneal incision. The latter is preferable, because it avoids an anterior vitrectomy and the associated risks of choroidal and retinal detachment. Eyes that have extensive posterior synechiae or peripheral anterior synechiae, however, may be better suited to the pars plana approach. We should note that accessing the ciliary process from the pars plana is not safe in phakic eyes.

With the limbal approach, after the pupil's dilation with a mydriatic, the surgeon creates a paracentesis and fills the anterior chamber with a viscoelastic, which is further used to expand the ciliary sulcus. This viscoelastic expansion of the posterior chamber facilitates the approach to the pars

plicata with the ECP probe. After making a clear corneal wound and orienting the probe image outside the eye, the surgeon inserts the 18- or 20-gauge probe through the clear corneal incision and into the posterior sulcus. The probe should be oriented such that the view on the monitor corresponds to the actual orientation of the anatomy. The probe should be far enough away from the ciliary processes that approximately three processes are visible on the screen. This distance will help prevent overtreatment and explosion of the ciliary tissue. The sharpness of the view can be adjusted with the knob at the camera imaging port of the device.

The energy fluence should be set at 0.3 to 0.6 W. Treatment can be continuous, as if the surgeon is painting across ciliary tissue. When performing combined phacoemulsification/ECP, the surgeon implants the IOL first and then removes viscoelastic from behind the lens before inflating the ciliary sulcus with viscoelastic. Typically, only up to 180° of ciliary processes can be treated through one incision, but a curved probe can be used to treat up to 270° of tissue. If additional ablation is desirable, the surgeon can create an incision located approximately 180° from the first incision in order to treat the remaining 90° to 180°. At the end of the procedure, the viscoelastic material should be removed to prevent a postoperative elevation in IOP, and the incisions may be closed with 10–0 nylon sutures.

In a retrospective study that enrolled 68 eyes of 68 subjects with diverse forms of glaucoma at the University of California, San Francisco, ECP alone decreased subjects' IOP

by approximately 10 mm Hg on average.²⁵ It is generally recommended that surgeons treat 270° or more of the ciliary processes in order to lower the IOP significantly. To date, serious complications such as severe hypotony or phthisis have rarely been reported in adult populations.^{25,28} Again, our vascular perfusion study in an animal model demonstrated that ECP does not completely shut down aqueous production in the long term, which may account for the relative avoidance of such complications.²⁴

The surgeon should try to treat both the anterior and posterior extent of the ciliary processes; treating only the tips may miss 50% or more of the tissue that could be producing aqueous. With the correct titration of laser energy for ECP, the surgeon will see shrinkage and whitening of the ciliary processes on the video screen during treatment (Figure 3). The formation of a bubble on the tissue (ie, the tissue has “exploded”) indicates the application of too much energy at the spot, either because the energy level was set too high or a single area received treatment for too long. The probe may also need to be held a little farther away from the processes to avoid concentrating the energy on a small area—again, encompassing approximately three ciliary processes in the surgeon's view.

CONCLUSION

The amount of research and reporting on ECP has increased noticeably in recent years, as ophthalmologists realize that the procedure is a relatively safe and effective alternative for treating glaucoma in select patients. Our indications for using ECP in patients with glaucoma are refractory cases in which the individual has good or fair visual potential and only moderately high IOP. Patients who have greatly elevated IOP with poor outflow facility (such as in neovascular glaucoma) are not appropriate candidates for ECP and would likely be better suited to transscleral CPC. Future studies will provide longer-term follow-up and more information about the risk of CME and other vision-threatening complications associated with ECP. □

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Figure 3. In this endoscopic view, the ciliary processes on the right have been treated and show whitening and shrinkage compared with the untreated processes on the left.

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1. Bietti G. Surgical intervention on the ciliary body; new trends for the relief of glaucoma. *JAMA*. 1950;142:889-897.
2. Dunphy EB, Albaugh CH. Cycloclathrmy: an operation for the treatment of glaucoma. *Trans Am Ophthalmol Soc*. 1941;39:193-213.
3. Coleman DJ, Lizzi FL, Driller J, et al. Therapeutic ultrasound in the treatment of glaucoma. I. Experimental model. *Ophthalmology*. 1985;92:339-346.
4. Coleman DJ, Lizzi FL, Driller J, et al. Therapeutic ultrasound in the treatment of glaucoma. II. Clinical applications. *Ophthalmology*. 1985;92:347-353.
5. Quigley HA. Histological and physiological studies of cyclocryotherapy in primate and human eyes. *Am J Ophthalmol*. 1976;82:722-732.
6. Bellows AR. Cyclocryotherapy for glaucoma. *Int Ophthalmol Clin*. 1981;21:99-111.
7. Caprioli J, Strang SL, Spaeth GL, Poryzees EH. Cyclocryotherapy in the treatment of advanced glaucoma. *Ophthalmology*. 1985;92:947-954.
8. Fankhauser F, van der Zypen E, Kwasniewska S, Rol P, England C. Transscleral cyclophotocoagulation using a neodymium YAG laser. *Ophthalmic Surg*. 1986;17:94-100.
9. Klapper RM, Wandel T, Donnenfeld E, Perry HD. Transscleral neodymium:YAG thermal cyclophotocoagulation in refractory glaucoma. A preliminary report. *Ophthalmology*. 1988;95:719-722.
10. Schuman JS, Jacobson JJ, Puliafito CA, et al. Experimental use of semiconductor diode laser in contact transscleral cyclophotocoagulation in rabbits. *Arch Ophthalmol*. 1990;108:1152-1157.
11. Hennis HL, Stewart WC. Semiconductor diode laser transscleral cyclophotocoagulation in patients with glaucoma. *Am J Ophthalmol*. 1992;113:81-85.
12. Immonen IJ, Puska P, Raitta C. Transscleral contact krypton laser cyclophotocoagulation for treatment of glaucoma. *Ophthalmology*. 1994;101:876-882.
13. Suzuki Y, Araie M, Yumita A, Yamamoto T. Transscleral Nd: YAG laser cyclophotocoagulation versus cyclocryotherapy. *Graefes Arch Clin Exp Ophthalmol*. 1991;29:33-36.
14. Pastor SA, Singh K, Lee DA, et al. Cyclophotocoagulation: a report by the American Academy of Ophthalmology. *Ophthalmology*. 2001;108:2130-2138.
15. Gayton JL, Van Der Karr M, Sanders V. Combined cataract and glaucoma surgery: trabeculectomy versus endoscopic laser cycloablation. *J Cataract Refract Surg*. 1999;25:1214-1219.
16. Egbert PR, Faidoyor S, Budenz DL, et al. Diode laser transscleral cyclophotocoagulation as a primary surgical treatment for primary open-angle glaucoma. *Arch Ophthalmol*. 2001;119:345-350.
17. Lai JS, Tham CC, Chan JC, Lam DS. Diode laser transscleral cyclophotocoagulation as primary surgical treatment for medically uncontrolled chronic angle closure glaucoma: long-term clinical outcomes. *J Glaucoma*. 2005;14:114-119.
18. McKelvie PA, Walland MJ. Pathology of cyclodiode laser: a series of nine enucleated eyes. *Br J Ophthalmol*. 2002;86:381-386.
19. Langseth FG. Transscleral cyclophotocoagulation. A laser treatment for glaucoma. *AORN J*. 1988;48:1122-1125, 1127.
20. Brancato R, Giovanni L, Trabucchi G, Pietroni C. Contact transscleral cyclophotocoagulation with Nd:YAG laser in uncontrolled glaucoma. *Ophthalmic Surg*. 1989;20:547-551.
21. Merritt JC. Transpupillary photocoagulation of the ciliary processes. *Ann Ophthalmol*. 1976;8:325-328.
22. Uram M. Endoscopic cyclophotocoagulation in glaucoma management. *Curr Opin Ophthalmol*. 1995;6:19-29.
23. Jacobi PC, Dietlein TS. Endoscopic surgery in glaucoma management. *Curr Opin Ophthalmol*. 2000;11:127-132.
24. Lin SC, Chen MJ, Lin MS, et al. Vascular effects on ciliary tissue from endoscopic versus trans-scleral cyclophotocoagulation. *Br J Ophthalmol*. 2006;90:496-500.
25. Chen J, Cohn RA, Lin SC, et al. Endoscopic photocoagulation of the ciliary body for treatment of refractory glaucomas. *Am J Ophthalmol*. 1997;124:787-796.
26. Berke SJ, Sturm RT, Caronia RM, et al. Phacoemulsification combined with endoscopic cyclophotocoagulation (ECP) in the management of cataract and medically controlled glaucoma: a large, long term study. Paper presented at: The American Glaucoma Society 16th Annual Meeting; March 4, 2006; Charleston, SC.
27. Neely DE, Plager DA. Endocyclophotocoagulation for management of difficult pediatric glaucomas. *JAPOS*. 2001;5:221-229.
28. Lima FE, Magacho L, Carvalho DM, et al. A prospective, comparative study between endoscopic cyclophotocoagulation and the Ahmed drainage implant in refractory glaucoma. *J Glaucoma*. 2004;13:233-237.