# Diode Laser Cyclophotocoagulation

Technique and results.

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Effective laser treatment of the ciliary processes and ciliary body reduces the inflow of aqueous humor and, thus, decreases IOP—similar to the effect of several types of glaucoma medications. The laser treatment can be applied to an intact eye through the anterior sclera with continuous-wave red and diode near-infrared lasers (transscleral cyclophotocoagulation [CPC]), or it can be accomplished through the invasive direct application of diode near-infrared continuous-wave laser energy to the ciliary processes (endoscopic cyclophotocoagulation [ECP]). The goal is to bring aqueous humor inflow into a better balance with outflow resistance.

## INDICATIONS

### Transscleral CPC

In addition to the successful treatment of severe end-stage glaucoma, transscleral CPC has achieved clinically relevant success rates in cases of refractory glaucoma after penetrating keratoplasty,[1] uveitic glaucoma,[2] glaucoma after intravitreal silicone oil,[3] refractory pediatric glaucoma,[4,5] and failed tube-shunt procedures.[6] The procedure has also been successful as a primary treatment for glaucoma in challenging situations when other interventions are not possible[7] or in patients with a debilitated general medical condition that precludes invasive surgery.

Eyes with serious glaucoma-related challenges and good vision are eligible for treatment, but patients should be warned that, depending upon their preoperative vision and diagnosis, their postoperative vision may be somewhat worse than their pretreatment vision.[8,9] Only rarely does visual acuity improve after surgery. Eligible eyes are often at risk of imminent visual loss from glaucoma.

Treatment is less likely to be helpful for eyes with a total occlusion of outflow, because they would need a nearly total stoppage of aqueous inflow for the postoperative IOP to fall to acceptable levels. Although laser CPC is often performed in an office setting, it requires profound local (usually retrobulbar) anesthesia or general anesthesia in an OR setting; the patient must be cooperative and medically fit for this administration.

### ECP

ECP is for eyes with refractory glaucoma and some eyes with neovascular glaucoma (NVG). Additionally, the procedure has been used for eyes with glaucoma undergoing phacoemulsification as an alternative to combined cataract and glaucoma filtering surgery. It has also been used for eyes with medically controlled glaucoma undergoing phacoemulsification. In the last group, the goal is to reduce the patient's dependence on medical glaucoma treatment.

ECP is an invasive procedure. As with the transscleral approach, it requires profound local (usually peribulbar) anesthesia or general anesthesia in an OR setting, with the usual associated requirements for the patient's cooperation and medical clearance. ECP offers surgeons direct visualization of the ablation's location and effect on target tissue, allows them to adjust the treatment parameters to optimize the tissue's response, and relatively spares underlying pigmented tissue.[10-12] Uram, in the early 1990s, developed a clinical method and commercial system for ECP.[13]

## PATIENT CONSENT

As with all surgery, patients should understand the plan, requirements, benefits, risks, and alternatives and give informed consent for the proposed procedure. For transscleral CPC, surgeons should warn patients about the potential for postoperative pain and some reduction of vision. Patients should also understand that more than one transscleral CPC treatment session may be needed to achieve the desired control of glaucoma.

## DIODE LASER TRANSSCLERAL CPC

### Approaches

There are two approaches to delivering laser energy. The slow coagulation technique is useful for eyes that have a dark or light brown iris with settings of 1.25 W, 4.0- to 4.5-second duration (5.0 to 5.6 J per application), and for eyes with all

other degrees of iris pigmentation with settings of 1.5 W, 3.5- to 4.0-second duration (5.25 to 6.00 J per application). The standard technique uses a starting power of 1.75 W and a 2.0-second duration (3.5 J per application). With this technique, power is adjusted upward or downward in 0.25-W increments according to whether there are excessive (adjust downward) or no (adjust upward) "pops" during applications. Eyes with darker pigmentation require slightly lower energies to obtain equivalent results. Although there are no data comparing the two techniques, their effectiveness appears to be clinically similar, and the reduced disruption of tissue observed during the slow coagulation technique enhances its appeal.

**Steps**

The following steps may be used when performing transscleral CPC with the Oculight SLx system (Iris Medical Instruments Inc., Mountain View, CA) or the Iridex IQ810 laser (Iridex Corporation, Mountain View, CA), each with G-probe delivery:

1. The delivery probe and fiberoptic should be scrupulously cleaned with alcohol wipes before and after treatment
2. Using a slit-lamp biomicroscope or another form of magnified observation, the surgeon treats three quadrants, with about seven applications per quadrant. For the first procedure on an eye, the temporal quadrant is omitted. For a second CPC procedure, at a later date, if more treatment is needed, the surgeon treats three quadrants that omit either the upper temporal or lower temporal quadrant
3. The location of each laser application is guided by the footplate of the G-probe, which is positioned with the curved anterior edge of the footplate on the anterior border of the limbus; each subsequent application is spaced by one-half the width of the footplate. The fiber optic protrudes 0.7 mm from the footplate, causing a slight indentation at the treatment site in the paralimbal conjunctiva. This empties conjunctival vessels at the site and compacts the underlying sclera during treatment, which enhances light transmission. It leaves a temporary dimple that serves as a mark for the next application (during the next application, the trailing edge of the footplate bisects the indentation of the fiber optic at the site of the previous application
4. The surgeon listens for "pops" and watches for surface burns. When they occur, power and technique are adjusted accordingly. The probe's tip must be clean throughout the treatment, because charred debris on the tip may heat and burn into, or through, the sclera.

## ECP

**Setup**

The E2 Microprobe Laser and Endoscopy System (Endo Optiks, Little Silver, NJ) includes a 20-gauge endoscopic probe containing the fiber-optic light source, helium-neon aiming beam, and the 810-nm diode laser treatment source. The power setting ranges from 0.5 to 0.9 W, and the application's duration is controlled by the surgeon. Laser applications to the ciliary processes are typically from 0.5 to 2.0 seconds in duration, depending upon the observed whitening and shrinkage of tissue. The pupil is widely dilated.

**Steps**

1. Injected viscoelastic deepens the anterior chamber, elevates the iris, and expands the ciliary sulcus of the phakic, aphakic, or pseudophakic eye. Inserted through a limbal 2.5-mm paracentesis, the 20-gauge fiber-optic probe provides an endoscopic image for a monitor. In addition to the viewing function, the probe provides the light source, an aiming beam, and the laser beam.
2. Alternatively, in aphakic or pseudophakic eyes, the probe may be introduced through the pars plana after a limited anterior vitrectomy.
3. Direct laser applications (duration of about 0.5 to 2.0 seconds) are aimed at individual ciliary processes to produce visible whitening and shrinkage of the entire anterioposterior extent of the process. Scarred or disrupted tissue should not be treated.
4. Power, duration, or both are adjusted downward if, due to boiling of intracellular water, visible bubbles form or "popping" occurs.
5. From 180° to 360° of the ciliary body circumference are treated, usually requiring two or three paracentesis sites.

### ANESTHESIA FOR LASER CILIARY ABLATION

Transscleral cyclophotocoagulation requires local peribulbar and retrobulbar anesthesia. In the treatment room, using an Atkinson needle and 10-mL syringe, the surgeon administers 2 mL of a 50% mixture of Marcaine 0.5% (Abbott, Abbott Park, IL) and plain lidocaine 2% (without epinephrine) in the peribulbar space in the lateral half of the lower lid followed by 3 to 4 mL in the retrobulbar space. Lesser amounts, fewer sites, or smaller amounts of anesthesia are seldom sufficient.

For endoscopic cyclophotocoagulation, a standard OR preparation is used with peribulbar or retrobulbar anesthesia.

Before starting laser treatment, it is important to allow sufficient time for the local anesthetic agent to spread. The surgeon should use a forceps to test gently for adequate numbing before starting transscleral cyclophotocoagulation.

6. The viscoelastic is removed from the anterior segment of the eye, and if needed, the paracentesis wounds are closed with a single suture.

## POSTOPERATIVE CARE

At the conclusion of either form of CPC, the surgeon should apply a strong, long-lasting cycloplegic (eg, atropine) and a topical steroid and place a soft eye patch to protect the eye until the local anesthesia wears off. After ECP, eyes should receive a topic antibiotic. The cycloplegic b.i.d. and steroid drops q.i.d. are continued for at least 2 weeks and may be required for a longer time. Severe postoperative inflammation may require a more aggressive use of steroids. The antibiotic given t.i.d. to q.i.d. may be discontinued after 1 week. Acetaminophen may be given for pain. Stronger analgesics are seldom needed. Some patients may benefit from the short-term use of an ice pack.

Patients are monitored to ensure safe healing during the several months following the procedure, with initial follow-up at 1 to 7 days, depending upon the level of their pre-treatment IOP and the diagnosis. Thereafter, they are seen with decreasing frequency.

## PROBLEMS AND COMPLICATIONS

### Intraoperative

As previously mentioned, surface burns may occur during transscleral CPC if the fiber-optic tip is contaminated with charred debris.[14] This problem rarely occurs, but the surgeon must be aware of its possibility and watch for it, especially in eyes with dense perilimbal conjunctival or episcleral pigment.

Occasional popping sounds will normally occur during either form of CPC. Repeated pops with every application of laser energy indicate that the power is too high, which brings cellular water to a boil during the application. The surgeon should reduce the power and consider lengthening the duration of applications at the lower power.

The transmission of laser energy to the retina is minimal due to the short focus and large cone angle of the treatment beam during diode transscleral CPC treatment. Retinal irradiation is well within safety guidelines.[15]

### Postoperative

One-third to one-half of eyes undergoing transscleral CPC experience postoperative pain, usually mild but potentially severe. Treatment involves topical cycloplegics, topical nonsteroidal anti-inflammatory medications, ice packs, and systemic analgesics as needed.

Inflammation is to be expected and should be treated appropriately. Severe inflammation with the formation of a protein clot occurs occasionally after transscleral CPC, particularly in eyes with NVG, and it requires more aggressive anti-inflammatory management.

Bleeding is rare and occurs more often in eyes with NVG. It usually is sufficiently mild to resolve spontaneously with the passage of time.

A decrease of two Snellen lines or more has been reported in various studies in anywhere from 12% to 40% (mean of about 25%) of eyes treated with transscleral CPC.[8,9] It appears to be more likely in eyes with preexisting poor vision. The falloff, which sometimes improves with healing, has to be considered in comparison with the expected deterioration that would occur in the absence of intervention.

Although sympathetic ophthalmia has occurred in a small number of eyes after various ciliary destructive procedures,[16-20] no cases have yet appeared in the literature after diode laser transscleral CPC. The author is aware, however, of at least two reliable anecdotal reports of this complication after diode laser transscleral CPC.

Malignant glaucoma was found in an eye after diode laser cyclophotocoagulation.[21] By way of contrast, there are reports of successful treatment for malignant glaucoma with laser cyclotherapy,[22] including treatment for malignant glaucoma with transscleral CPC.[23]

## EXPECTED OUTCOMES

The goal of transscleral CPC is to reduce IOP by decreasing the inflow of aqueous humor. After treatment ablates a sufficient part of the ciliary processes, less aqueous humor is formed. This change is probably permanent, although the amount and duration of decrease has not been quantified. More extensive damage is followed by a greater reduction of aqueous production. Provided there is no new increase of resistance to aqueous outflow through the trabecular meshwork and the uveoscleral route, the IOP will fall.

The reported rates of success (lack of failure) of the transscleral CPC intervention vary from about 50% to greater than 90% after 1 to 2 years.[24,25] The rates of failure are dependent upon the diagnosis of the patient. As noted earlier, eyes with no or minimal outflow before treatment are less likely to have a successful outcome. Patients with NVG often require a second CPC treatment during the first 3 months after the initial procedure; with this supplement, they have an overall long-term success rate of about 50% to 60%.

Often after ciliary ablation, patients are able to reduce topical and systemic medical glaucoma treatment slightly, yet most need continued medical therapy for satisfactory IOP control. A repeat transscleral CPC treatment for eyes with an insufficient or total loss of response to a first CPC procedure is often helpful. This need may occur years after the initial treatment. The rates of success for repeat proce-

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dures are not established quantitatively but are probably lower than after the initial intervention. ❑

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1. Shah P, Lee GA, Kirwan JK, et al. Cyclodiode photocoagulation for refractory glaucoma after penetrating keratoplasty. *Ophthalmology*. 2001;108:1986-1991.
2. Schlote T, Derse M, Zierhut M. Transscleral diode laser cyclophotocoagulation for the treatment of refractory glaucoma secondary to inflammatory eye diseases. *Br J Ophthalmol*. 2000;84:999-1003.
3. Kan SK, Park KH, Kim DM, Chang BL. Effect of diode laser trans-scleral cyclophotocoagulation in the management of glaucoma after intravitreal silicone oil injection for complicated retinal detachments. *Br J Ophthalmol*. 1999;83:713-717.
4. Izgi B, Demirci H, Ysim F, et al. Diode laser cyclophotocoagulation in refractory glaucoma. Comparison between pediatric and adult glaucomas. *Ophthalmic Surg Lasers*. 2001;32:100-107.
5. Kirwan JF, Shah P, Khaw PT. Diode laser cyclophotocoagulation. Role in the management of refractory pediatric glaucomas. *Ophthalmology*. 2002;109:316-323.
6. Semchyshyn TM, Tsai JC, Joos KM. Supplemental transscleral diode laser cyclophotocoagulation after aqueous shunt placement in refractory glaucoma. *Ophthalmology*. 2002;109:1078-1084.
7. Egbert PR, Fiadoyor 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.
8. Wilensky JT, Kammer J. Long-term visual outcome of transscleral laser cyclotherapy in eyes with ambulatory vision. *Ophthalmology*. 2004;111:1389-1392.
9. Pokroy R, Greenwald Y, Pollack A, et al. Visual loss after transscleral diode laser cyclophotocoagulation for primary open-angle and neovascular glaucoma. *Ophthalmic Surg Lasers Imaging*. 2008;39:22-29.
10. Charles S. Endophotocoagulation. *Retina*. 1981;1:117-120.
11. Patel A, Thompson JT, Michels RG, Quigley HA. Endolaser treatment of the ciliary body for uncontrolled glaucoma. *Ophthalmology*. 1986;93:825-830.
12. Zarbin MA, Michels RG, de Bustros S, et al. Endolaser treatment of the ciliary body for severe glaucoma. *Ophthalmology*. 1988;95:1639-1647.
13. Uram M. Endoscopic cyclophotocoagulation in glaucoma management. *Curr Opin Ophthalmol*. 1995;6:19-29.
14. Gaasterland D, Pollack I. Initial experience with a new method of laser transscleral cyclophotocoagulation for ciliary ablation in severe glaucoma. *Trans Am Ophthalmol Soc*. 1992;90:225-246.
15. Myers JS, Trevisani MG, Imami N, et al. Laser energy reaching the posterior pole during transscleral cyclophotocoagulation. *Arch Ophthalmol*. 1998;116:488-491.
16. Bodian M. Sympathetic ophthalmia following cyclodiathermy. *Am J Ophthalmol*. 1953;36:217-225.
17. Harrison TJ. Sympathetic ophthalmia after cyclocryotherapy of neovascular glaucoma without ocular penetration. *Ophthalmic Surg*. 1993;24:44-46.
18. Edward DP, Brown SVL, Higginbotham E, et al. Sympathetic ophthalmic following Neodymium:YAG cyclotherapy. *Ophthalmic Surg*. 1969;20:644-646.
19. Lam S, Tessler HH, Lam BL, Wilensky JT. High incidence of sympathetic ophthalmia after contact and noncontact Neodymium:YAG cyclotherapy. *Ophthalmology*. 1992;99:1818-1822.
20. Bechrakis NE, Müller-Stolzenburg NW, Helbig H, Foerster MH. Sympathetic ophthalmia following laser cyclocoagulation. *Arch Ophthalmol*. 1994;112:80-84.
21. Azuara-Blanco A, Dua HS. Malignant glaucoma after diode laser cyclophotocoagulation. *Am J Ophthalmol*. 1999;127:467-469.
22. Herschler J. Laser shrinkage of the ciliary processes: a treatment for malignant (ciliary block) glaucoma. *Ophthalmology*. 1980;87:1155-1159.
23. Carassa RG, Bettin P, Fiori M, Brancato R. Treatment of malignant glaucoma with contact transscleral cyclophotocoagulation. *Arch Ophthalmol*. 1999;117:688-690.
24. Pastor SA, Singh K, Lee DA, et al. Office technology assessment. Cyclophotocoagulation. A report by the American Academy of Ophthalmology. *Ophthalmology*. 2001;108:2130-2138.
25. Kaushik S, Pandav SS, Jain R, et al. Lower energy levels adequate for effective transscleral diode laser cyclophotocoagulation in Asian eyes with refractory glaucoma. *Eye*. 2008;22:398-405.