Endoscopic cyclophotocoagulation combined with phacoemulsification versus phacoemulsification alone in medically controlled glaucoma

Brian A. Francis, MD, MS, Stanley J. Berke, MD, Laurie Dustin, MS, Robert Noecker, MD

PURPOSE: To compare the outcomes of combined endoscopic cyclophotocoagulation (ECP) and phacoemulsification cataract extraction versus cataract extraction alone in eyes with medically controlled open-angle glaucoma (OAG) and visually significant cataract.

SETTING: Clinical practices of glaucoma specialists and comprehensive ophthalmologists.

DESIGN: Prospective nonrandomized matched-control study.

METHODS: Consecutive patients with medically controlled OAG and visually significant cataracts were treated with ECP and cataract extraction (study group) or cataract extraction alone (control group). The groups were matched in age and baseline intraocular pressure (IOP). The main outcome measures were the change in IOP and number of glaucoma medications. Secondary measures included visual acuity and postoperative complications.

RESULTS: In the study group (n = 80) the mean IOP decreased (baseline: 18.1 mm Hg ± 3.0 [SD]; 1 year: 16.0 ± 2.8 mm Hg; 2 years: 16.0 ± 3.3 mm Hg). The number of glaucoma medications decreased from 1.5 ± 0.8 to 0.4 ± 0.7 (1 year and 2 years). In the control group (n = 80), the mean IOP was 18.1 ± 3.0 mm Hg (baseline), 17.5 ± 3.6 mm Hg (1 year), and 17.3 ± 3.2 mm Hg (2 years). The mean number of glaucoma medications was 2.4 ± 1.0, 1.8 ± 1.2, and 2.0 ± 1.0, respectively. The difference in IOP and medication reduction between the 2 groups was statistically significant at all timepoints. Visual acuity outcomes and complication rates were similar between the 2 groups.

CONCLUSION: Combined ECP and cataract extraction resulted in lower IOP and a greater reduction in glaucoma medications than cataract extraction alone in medically controlled OAG patients with visually significant cataract.

Financial Disclosures: Proprietary or commercial disclosures are listed after the references.

J Cataract Refract Surg 2014; 40:1313–1321 © 2014 ASCRS and ESCRS

Cataract and glaucoma are 2 of the most common conditions that cause visual impairment, and each becomes more prevalent with advancing age. Because the natural history of cataract and glaucoma is often parallel, it is tempting to manage both conditions with a single operation. Traditionally, a significant percentage of combined glaucoma and cataract procedures have included trabeculectomy. However, such surgery can be associated with significant postoperative complications.[1–13] Perhaps more concerning is that late complications can occur years or even decades later in an otherwise well-functioning bleb.[14–17] Aqueous drainage devices are a reasonable alternative to trabeculectomy and may have a lower risk for infection or conjunctiva-related complications; however, tube shunts also carry significant risks, including diplopia, hypotony, corneal decompensation, and tube exposure.[18]

When first introduced, cyclophotocoagulation was used as a last-resort method to lower intraocular pressure (IOP) when all other medical and surgical efforts had failed. The procedure has evolved through much iteration, including both contact and noncontact transscleral delivery systems. Because the risk for chronic

http://dx.doi.org/10.1016/j.jcrs.2014.06.021

inflammation and phthisis is too high, the transscleral approach to cyclophotocoagulation, while effective at lowering IOP, is not used routinely early in the disease process. More recently, a more target-specific endoscopic-guided technique has gained popularity. Endoscopic cyclophotocoagulation allows delivery of the laser energy in a precise and efficient manner so that for many surgeons, the indications for cyclophotocoagulation have expanded to include eyes with better visual potential. Moreover, given that the procedure can be performed through the same incision used for phacoemulsification, many surgeons have used ECP as an adjunct to cataract surgery. In addition, ECP spares the sclera and conjunctiva; thus, trabeculectomy or an aqueous drainage procedure can be performed if needed in the future.

Endoscopic cyclophotocoagulation uses a diode laser that emits pulsed continuous-wave light at 810 nm, a 175-watt xenon light source, a helium–neon aiming beam, and video imaging integrated into a fiberoptic system delivered through a 19-gauge probe. The laser delivery system allows the treatment of the ciliary processes to be performed under direct visualization, which makes it possible for the surgeon to titrate the effects on the ciliary epithelium far better than when using the transscleral approach. Furthermore, ECP is a more efficient delivery method than the transscleral approach and thus minimizes collateral tissue injury. The clinical use of ECP has shown effective IOP lowering with a good safety profile in the treatment of uncontrolled and refractory forms of glaucoma.[19–26]

The purpose of this study was to determine whether combining ECP with phacoemulsification in the setting of cataract and medically controlled glaucoma results in a long-term decrease in IOP and/or in the number of glaucoma medications required compared with phacoemulsification alone. In an effort to answer this question, a prospective nonrandomized matched-control study with a large patient cohort and extended postsurgical follow-up was performed.

Submitted: January 23, 2014.
Final revision submitted: June 8, 2014.
Accepted: June 8, 2014.

From Doheny Eye Institute (Francis), Department of Ophthalmology, David Geffen School of Medicine of the University of California Los Angeles, and the Department of Preventative Medicine and Biostatistics (Dustin), Keck School of Medicine of the University of Southern California, Los Angeles, California; Albert Einstein College of Medicine, Bronx and Nassau University Medical Center (Berke), and East Meadow, the Ophthalmic Consultants of Long Island (Berke), Lynbrook, New York; Ophthalmic Consultants of Connecticut (Noecker), Fairfield, Connecticut, USA.

Corresponding author: Brian A. Francis, MD, MS, 1450 San Pablo Street, 3000, Los Angeles, California 90033, USA. E-mail: francis@jsei.ucla.edu.

PATIENTS AND METHODS

The study population included consecutive patients with open-angle glaucoma (OAG) and visually significant cataract from the practices of 5 ophthalmic surgeons with experience in the ECP procedure. The study population, including the control group and study group, were roughly equally divided among the 5 surgeons. All patients provided informed consent for the surgical procedure and inclusion in the study. The study met the tenets set by the Helsinki Declaration for research on human subjects and was approved by an institutional review board.

Inclusion criteria were medically controlled primary OAG with mild to moderate optic nerve damage with or without visual field damage assessed using the 24-2 Swedish Interactive Threshold Algorithm[27] and standard- or full-threshold Humphrey Visual Field Analyzer (Carl Zeiss Meditec AG) (mean deviation 0 to −12 dB, without reduction in a paracentral point to below 10 dB). Patients were required to have optic nerve damage characteristic of glaucoma, such as focal notching or an increase in generalized cupping from baseline, as well as an IOP of 21 mm Hg or greater at presentation. Those without evidence of optic nerve damage (even with an abnormal visual field) were not included. Individual surgeons defined adequate IOP control (target IOP) for each patient based on the extent of optic nerve cupping and visual field loss. Eyes with advanced uncontrolled glaucoma characterized by advanced optic nerve cupping and visual field damage were not included in this study. Other exclusion criteria included a mechanism of glaucoma other than open angle, previous filtration, tube, or cyclodestructive surgery. Previous laser trabeculoplasty was not an exclusion. Patients with fewer than 6 months of follow-up due to dropout or insufficient time since surgery were excluded. The control group and study group were enrolled during the same time period and in the same geographic area. All surgeons contributed roughly equal percentages of patients to each group.

Surgical Technique

The technique of ECP has been described.[24] Briefly, the surgeon performs phacoemulsification with intraocular lens implantation via a temporal clear corneal incision in the usual manner. A sodium hyaluronate ophthalmic viscosurgical device (OVD) is then injected posterior to the iris but anterior to the lens capsule. Inflating the sulcus in this manner is deemed sufficient when the majority of the length of each ciliary process can be visualized. The laser endoscope (Endo Optiks) is inserted through the corneal incision and through the pupillary space to access the ciliary processes (Figure 1). The entire available epithelium of each process is whitened under direct endoscopic visualization using the infrared 810 nm wavelength diode laser (Figure 2). Laser power levels range between 200 mw and 500 mw with continuous wave duration. The ciliary ring is treated for 270 to 360 degrees. Overtreatment, characterized by tissue explosion ("popping"), is avoided. Once the treatment is completed, the OVD is completely removed from the eye using irrigation/aspiration.

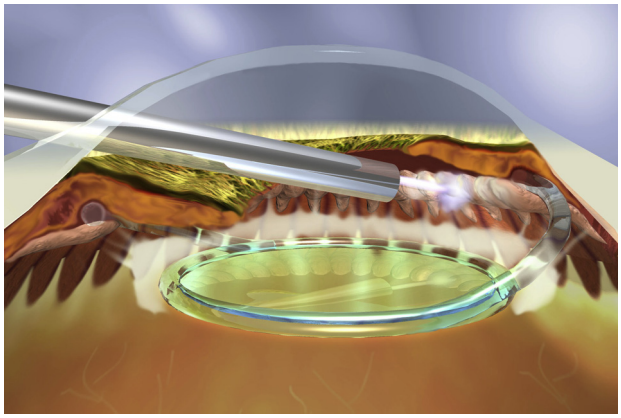

Figure 1. The laser endoscope enters the anterior chamber through a clear corneal incision, through the pupil, and anterior to the capsule and IOL into the ciliary sulcus space. Note that the sulcus has been expanded by OVD, permitting visualization and laser delivery to the ciliary processes.

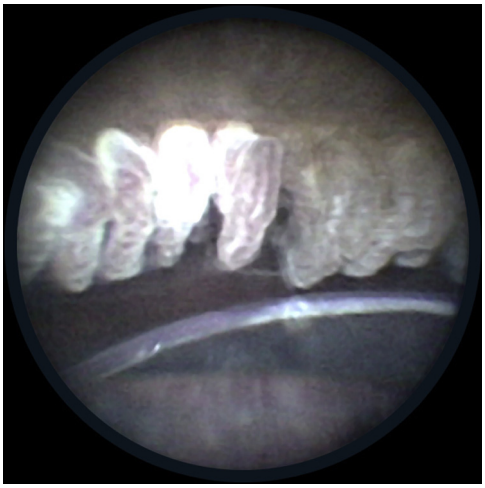

Figure 2. Endoscopic view of ciliary processes during ECP. Shrinkage and whitening of the tissue are the treatment endpoints.

Postoperative Care and Medication

Postoperative care was similar in both groups. All eyes were treated with a fluoroquinolone antibiotic 4 times a day, ketorolac 0.5% 3 times a day, and prednisolone acetate 1.0% 4 times a day for 1 week, tapering afterward based on tolerance and observed inflammation. All patients were initially kept on all glaucoma medications until the 1-month follow-up, after which medications were decreased at each subsequent visit if the IOP was maintained at the target level. Medications were added if the IOP was above the target on 2 consecutive visits for each individual patient. The treating physician established the target IOP before surgery, and the decision to change medications was made by that physician on a case-by-case basis. All patients were followed by the same physician before and after surgery, and the observers and the patients were therefore unmasked to treatment.

The algorithm for a reduction in medications was uniform for all patients. Aqueous suppressants were discontinued first, followed by prostaglandin analogs. The first aqueous suppressant discontinued was a topical carbonic anhydrase inhibitor or an α-agonist, which was decided by patient preference if there was relative intolerance or side effects of 1 medication over the other. This was followed by discontinuation of the β-blocker.

Outcome Measures

Preoperative and postoperative measures of visual acuity and IOP as well as the number of glaucoma medications being used were recorded. The main outcome measures were IOP and number of glaucoma medications being used 1 year and 2 years after surgery compared with baseline values and compared between groups. Secondary outcome measures were visual acuity and postoperative complications. Serious complications were defined as retinal detachment, intraocular hemorrhage requiring surgical intervention, choroidal hemorrhage, chronic uveitis, IOL dislocation, endophthalmitis, and hypotony (IOP $\leq$5 mm Hg). The development of clinically significant cystoid macular edema (CME) was assessed in patients with unexplained diminished postoperative visual acuity (worse than 20/25) by fluorescein angiography.

This study applied success criteria similar to those set forth in the Tube Versus Trabeculectoy Study[18]; that is, IOP less than 21 mm Hg and greater than 5 mm Hg and 20% reduction from baseline with no additional glaucoma medications or glaucoma surgery or loss of light perception. The main analysis used these criteria but also included a reduction in glaucoma medications without a rise in IOP. This definition was used because it was believed it would best fit the present study's patient group in which IOP was medically controlled and the surgery was performed as an attempt to decrease glaucoma medications.

RESULTS

Eighty-five patients were recruited in the cataract extraction–alone group (control group). After those who did not meet the minimum follow-up period were excluded, 80 patients remained for analysis and were matched on the basis of baseline IOP and age to patients in the ECP with cataract extraction group (study group) who had a minimum of 24 months of follow-up. Table 1 shows the baseline and demographic data in the 2 groups. Although there were no statistically significant between-group differences in follow-up, age, or baseline IOP, the number of glaucoma medications at baseline was statistically significantly higher in the control group.

Table 2A and Table 2B compare the IOP and number of glaucoma medications, respectively, between the 2 groups. Both groups had a reduction in IOP postoperatively. The IOP reduction was statistically significant greater in the study group than in the control group at all timepoints.

Table 1. Comparison of demographics and baseline measures between the study group and control group.

Parameter	Study Group (n = 80)	Control Group (n = 80)	*P* Value*
Age (y)			
Mean ± SD	70.0 ± 6.3	69.7 ± 6.9	.76*
Median	70	70	
Range	55, 84	56, 84	
Sex, n (%)			.87‡
Female	37 (46.3)	38 (47.5)	
Male	43 (53.8)	42 (52.5)	
Optic nerve c/d			
Mean ± SD	0.74 ± 0.2	0.71 ± 0.2	.37*
Eyes (n)	70	71	
Follow-up (mo)			.75†
Median	36	36	
Range	24, 36	24, 36	
Preop IOP (mm Hg)			
Mean ± SD	18.1 ± 3.0	18.1 ± 3.0	1.0*
Preop meds (n)			
Mean ± SD	1.5 ± 0.8	2.4 ± 1.0	<.001†

c/d = cup-to-disc ratio; IOP = intraocular pressure
*Independent-samples *t* test
†Wilcoxon rank-sum test
‡Chi-square test

Two patients (2.5%) in the study group developed an anterior chamber hemorrhage. In the control group, 2 patients (2.5%) had significant inflammation, 3 patients (3.8%) developed CME, and 1 patient (1.3%) developed a hemorrhage.

Table 3 shows the distribution of the number of glaucoma medications required before and after surgery. In the study group, 36 patients (44%) used 2 or more medications preoperatively. By the end of follow-up, the number using 2 or more medications had decreased to 15 patients (19%). In the control group, 25 patients (32%) used 2 or more medications preoperatively. At the final visit, the number using 2 or more medications had increased to 30 patients (38%). In addition, the percentage of patients controlled without any glaucoma medications at last follow-up was statistically significantly higher in the study group than in the control group.

Figure 3 and Table 4 show the results of the Kaplan-Meyer survival analysis. The success rate was statistically significantly higher in the study group than in the control group at all timepoints ($P < .01$).

DISCUSSION

The clinical presentation of a patient with visually significant cataract and glaucoma is common; however, the individual scenarios may vary significantly based on the severity of the disease and the degree of IOP control. This study was designed to explore the treatment of patients with mild to moderate glaucomatous disease who were medically controlled and had coexisting visually significant cataract. Specifically, the results of combined ECP and phacoemulsification (study group) were compared with those of phacoemulsification alone (control group). Patients in the 2 groups were matched in age and baseline IOP.

Endoscopic cyclophotocoagulation was initially reported in the treatment of a variety of refractory glaucomas; its use was expanded to include combined cataract extraction and ECP.[20–26,28–39] Results in human histopathologic studies[40–42] indicate that ECP is specifically ablative to the ciliary epithelium only, sparing underlying structures, especially the ciliary blood vessels. In contrast, the transscleral approach causes widespread damage of the ciliary processes, including vasculature, and eventually leads to replacement with scar tissue. This observation has led to the adoption of ECP by some surgeons as a combined procedure with cataract extraction in medically controlled glaucoma to reduce dependence on glaucoma medications.

The initial study of combined surgery in uncontrolled glaucoma was reported by Uram.[21] Treatment involved 180 degrees of ECP through a limbal incision combined with phacoemulsification. After 19.2 months, the mean preoperative IOP of 31.4 mm Hg had decreased to a mean of 13.5 mm Hg and all patients had a reduction in the number of glaucoma medications.

Gayton et al.[39] performed a randomized trial comparing phacoendoscopic cyclophotocoagulation and phacotrabeculectomy in uncontrolled glaucoma. The IOP reduction was similar between the 2 groups. With the combined trabeculectomy, the mean IOP was 24.6 ± 6.2 mm Hg at baseline and was reduced by 8.6 ± 8.2 mm Hg; with the combined ECP, the mean IOP was 24.8 ± 8.6 mm Hg at baseline and was reduced by 8.8 ± 9.6 mm Hg.

Berke[37] first described combining ECP with phacoemulsification in interventional case series patients with medically controlled OAG. There was a significant mean decrease in IOP and glaucoma medications over up to 2 years of postoperative follow-up.

More recent studies have elucidated the effect of combined phacoemulsification and ECP on IOP and medications. Kahook et al.[43] report a reduction in IOP and medications after phacoemulsification and ECP, with a greater reduction in IOP and medications when the procedure was performed through 2 incisions versus 1 (with a corresponding greater area of treatment). Two retrospective studies[44,45] also found a reduction in IOP with phacoemulsification and

Table 2A. Between-group comparison of preoperative and postoperative IOP.

Parameter	Study Group	Control Group	*P* Value Between Groups†
IOP (mm Hg)			
Preop			
Mean ± SD	18.1 ± 3.0	18.1 ± 3.0	1.00
Eyes (n)	80	80	
Postop			
6 mo			
Mean ± SD	15.6 ± 2.5	17.9 ± 3.5	<.001
Eyes (n)	78	80	
12 mo			
Mean ± SD	16.0 ± 2.8	17.5 ± 3.6	.004
Eyes (n)	79	80	
24 mo			
Mean ± SD	16.0 ± 3.3	17.3 ± 3.2	
Eyes (n)	80	80	.01
36 mo			
Mean ± SD	15.4 ± 2.5	17.2 ± 3.0	.003
Eyes (n)	45	43	
Postop decrease (%)			
6 mo			
Mean ± SD	12.4 ± 16.7	0.7 ± 13.1	<.001
P value (from baseline)*	<.001	NS	
12 mo			
Mean ± SD	10.2 ± 17.1	2.7 ± 16.2	.005
P value (from baseline)*	<.001	NS	
24 mo			
Mean ± SD	10.1 ± 18.7	0.8 ± 12	.02
P value (from baseline)*	<.001	NS	
36 mo			
Mean ± SD	13.6 ± 15.1	5.1 ± 10.4	.003
P value (from baseline)*	<.001	.01	

IOP = intraocular pressure; NS = not significant
*Paired *t* test
†Independent-samples *t* test

Table 2B. Between-group comparison of preoperative and postoperative glaucoma medications.

Parameter	Study Group	Control Group	*P* Value Between Groups†
Medications (n)			
Preop			
Mean ± SD	1.5 ± 0.8	2.4 ± 1.0	<.001
Median	1	2	
Postop			
6 mo			
Mean ± SD	0.3 ± 0.7	1.5 ± 1.2	<.001
Median	0	1	
12 mo			
Mean ± SD	0.4 ± 0.7	1.8 ± 1.2	<.001
Median	0	2	
24 mo			
Mean ± SD	0.4 ± 0.7	2.0 ± 1.0	
Median	0	2	<.001
36 mo			
Mean ± SD	0.4 ± 0.7	2.3 ± 1.0	<.001
Median	0	2	
Last			
Mean ± SD	0.5 ± 0.7	2.2 ± 1.1	<.001
Median	0	2	
Postop change (n)			
6 mo			
Mean ± SD	−1.1 ± 0.8	−0.9 ± 1.2	.24
P value (from baseline)*	<.001	<.001	
12 mo			
Mean ± SD	−1.0 ± 0.9	−0.6 ± 0.9	.006
P value (from baseline)*	<.001	<.001	
24 mo			
Mean ± SD	−1.1 ± 0.9	−0.4 ± 0.8	<.001
P value (from baseline)*	<.001	<.001	
36 mo			
Mean ± SD	−1.0 ± 0.9	−0.1 ± 0.8	<.001
P value (from baseline)*	<.001	NS	
Last			
Mean ± SD	−1.0 ± 0.9	−0.2 ± 0.8	<.001
P value (from baseline)*	<.001	NS	

IOP = intraocular pressure; NS = not significant
*Paired *t* test
†Wilcoxon rank-sum test

ECP, although with varying effects on glaucoma medications.

Several studies[46–48] have evaluated the effects of phacoemulsification alone on IOP and the need for medications postoperatively in glaucoma patients. The evidence supports a significant reduction in IOP, and in some cases a significant decrease in glaucoma medications, after cataract extraction. The study with the longest follow-up[46] retrospectively evaluated the changes in IOP and glaucoma medications in OAG patients, glaucoma-suspect patients, and normal patients at a 3-year and 5-year follow-up. They found a mean reduction in IOP of 1.4 ± 3.3 mm Hg in the glaucoma group at 3 years and 1.8 ± 3.5 mm Hg at last follow-up, with no change in the number of medications. The present study also found a reduction in IOP in the cataract extraction–alone group but not a significant reduction in medications. The results of our

Table 3. Distribution of glaucoma medications before and after surgery (at last follow-up) by group.

	Number (%)			
	Study Group (n = 80)		Control Group (n = 80)	
Meds (n)	Preop	Postop	Preop	Postop
0	6 (7.5)	48 (60.0)*	15 (18.8)	19 (23.8)*
1	38 (47.5)	17 (21.3)	40 (50.0)	31 (38.8)
2	25 (31.3)	10 (12.5)*	21 (26.3)	27 (33.8)*
3	8 (10.0)	4 (5.0)	3 (3.8)	2 (2.5)
4	3 (3.8)	1 (1.3)	1 (1.3)	1 (1.3)

Meds = medications
*Statistically significant difference in postoperative values between study group and control group ($P < .05$)

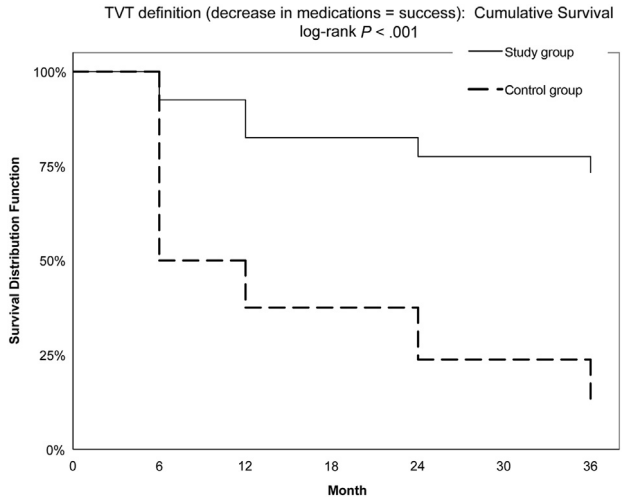

Figure 3. Kaplan-Meyer survival analysis. Success is defined as IOP between 5 mm Hg and 21 mm Hg and reduction in glaucoma medications with no rise in IOP compared with baseline (TVT = Tube Versus Trabeculectomy Study[18]).

follow-up of 3 or more years indicate that there is a diminution in the IOP response over time, with an increase toward baseline.

Data from the Ocular Hypertensive Treatment Study[49] indicate that a significant reduction in IOP can occur after phacoemulsification in patients with ocular hypertension. They found a decrease in the mean baseline IOP of 23.9 ± 3.2 mm Hg to 19.8 ± 3.2 mm Hg at the 1-year follow-up. The group of patients without surgery had no change in IOP over this time period. Although the intervention group did not have glaucoma and were not using glaucoma medications, the study showed that IOP can be reduced by phacoemulsification cataract extraction.

Table 4. Kaplan-Meier survival analysis outcomes.

	Cumulative Success Rate (%)	
Outcome	Study Group	Control Group
Successful reduction in medication		
6 months	92.5	50.0
12 months	82.5	37.5
24 months	77.5	23.8
36 months	73.3	11.9
Partial success		
6 months	37.5	7.5
12 months	21.3	5.0
24 months	13.8	3.8
36 months	11.5	3.8
Complete success		
6 months	35.0	7.5
12 months	18.8	5.0
24 months	1.3	3.8
36 months	1.0	3.8

Complete success = no medications; Partial Success = with or without medications; Successful Reduction in Medications = successful reduction of glaucoma medication without rise in intraocular pressure with the same remaining criteria excluding reduction of IOP 20% below baseline

The present study yielded several findings. First, adding ECP to phacoemulsification was effective in decreasing the IOP and the number of glaucoma medications. Second, cataract extraction alone resulted in medication reduction in a minority of the patients; the majority of these eyes continued with the same number of medications or had to use more medications over the long term. Third, both groups had an initial downward trend in IOP that seemed to be at its maximum at the end of the first postoperative year. The eyes having ECP and cataract extraction remained stable at this level throughout the following 2 to 3 years, while the eyes having cataract extraction alone showed regression to a level somewhat higher than the initial IOP. Fourth, adding ECP did not increase the risk for serious complications compared with cataract extraction alone.

The strengths of this study include the prospective collection of data, the large numbers of patients in both groups, the length of follow-up, and the matched control arm of cataract extraction alone for comparison with combined ECP and cataract extraction. The study also has several limitations. Although there was a study group and comparable control group, they were not randomized and may be subject to selection bias. The decision to perform combined ECP and cataract extraction or cataract extraction alone was based on the availability of the device at the time and location of the patient's treatment as well as on patient preference rather than on different patient characteristics between the 2 groups. However, a

bias due to the nonrandomization of groups cannot be excluded. The investigators were not masked to treatment and may have been more likely to perceive the study group as more successful during postoperative evaluations.

Although both groups were matched for baseline IOP and age, there was a difference in the number of baseline medications, with the cataract extraction–alone group having a higher mean. This difference has the potential to bias in favor of a higher number of medications at last follow-up in the cataract extraction–alone group compared with the combined surgery group. Because there was no randomization between the 2 groups, it is possible that the cataract extraction–alone group had glaucoma or IOP that was more difficult to control, and this would invalidate direct comparison between groups. However, it is also possible that the higher number of preoperative medications would make it more likely to be able to decrease medications in the cataract extraction–alone group. With regard to complications, the ability to detect CME in both groups may have been limited by performing retinal angiography only on patients with decreased visual acuity. However, if macular edema does not affect visual acuity, it may not be considered clinically significant.

The reduction in medications postoperatively was done systematically as described in the Patients and Methods section. However, because there was no washout of medications before surgery, it was not possible to tell which medications were successful and which were not successful before or after surgery. Jampel et al.[50] found that after medication washout, a substantial proportion of glaucoma patients showed only a small change in IOP and that the second and third medications had a smaller IOP-lowering effect than the first. Similarly, Neelakantan et al.[51] describe decreasing efficacy of adding a third or fourth medication to preexisting glaucoma medical therapy. Thus, the reduction in glaucoma medications after surgery in this study may not necessarily reflect successful treatment or better control of glaucoma.

Because this is not a randomized controlled trial, we cannot unequivocally state that combined ECP and cataract extraction results in lower IOP and fewer glaucoma medications than cataract extraction alone. However, this study characterizes the largest report on ECP performed in conjunction with cataract surgery to date. In addition, the matched control comparison with cataract extraction alone gives insight into the possibility of additional IOP and glaucoma medication–lowering benefits of the ECP procedure beyond that attained by cataract extraction alone. The data indicate that combining ECP with phacoemulsification in the setting of medically controlled glaucoma significantly lowers IOP and lowers the long-term need for glaucoma medication as well, while not substantially adding to the risks of phacoemulsification alone.

WHAT WAS KNOWN

- Endoscopic cyclophotocoagulation has been shown to lower IOP and dependence on glaucoma medications in the treatment of advanced glaucoma and as a primary procedure in conjunction with cataract extraction by phacoemulsification.
- Cataract surgery has also been shown to lower IOP, especially in cases with higher baseline preoperative IOPs.

WHAT THIS PAPER ADDS

- Endoscopic cyclophotocoagulation added to cataract extraction resulted in greater reduction in IOP and glaucoma medications than cataract extraction alone over a 3-year period.

REFERENCES

1. Watson PG, Jakeman C, Ozturk M, Barnett MF, Barnett F, Khaw KT. The complications of trabeculectomy (a 20-year follow-up). Eye 1990; 4:425–438. Available at: http://www.nature.com/eye/journal/v4/n3/pdf/eye199054a.pdf. Accessed June 6, 2014
2. Kao SF, Lichter PR, Musch DC. Anterior chamber depth following filtration surgery. Ophthalmic Surg 1989; 20:332–336
3. Stewart WC, Shields MB. Management of anterior chamber depth after trabeculectomy. Am J Ophthalmol 1988; 106:41–44
4. Brubaker RF, Pederson JE. Ciliochoroidal detachment. Surv Ophthalmol 1983; 27:281–289
5. Gressel MG, Parrish RK II, Heuer DK. Delayed nonexpulsive suprachoroidal hemorrhage. Arch Ophthalmol 1984; 102:1757–1760
6. Ruderman JM, Harbin TS Jr, Campbell DG. Postoperative suprachoroidal hemorrhage following filtration procedures. Arch Ophthalmol 1986; 104:201–205
7. Freedman J, Gupta M, Bunke A. Endophthalmitis after trabeculectomy. Arch Ophthalmol 1978; 96:1017–1018
8. Zaidi AA. Trabeculectomy: a review and 4-year follow-up. Br J Ophthalmol 1980; 64:436–439. Available at: http://bjo.bmj.com/content/64/6/436.full.pdf. Accessed June 6, 2014
9. Akafo SK, Goulstine DB, Rosenthal AR. Long-term post trabeculectomy intraocular pressures. Acta Ophthalmol (Copenh) 1992; 70:312–316
10. Mills KB. Trabeculectomy: a retrospective long-term follow-up of 444 cases. Br J Ophthalmol 1981; 65:790–795. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1039663/pdf/brjopthal00191-0076.pdf. Accessed June 6, 2014
11. Molteno ACB, Bosma NJ, Kittelson JM. Otago glaucoma surgery outcome study; long-term results of trabeculectomy—1976 to 1995. Ophthalmology 1999; 106:1742–1750
12. D'Ermo F, Bonomi L, Doro D. A critical analysis of the long-term results of trabeculectomy. Am J Ophthalmol 1979; 88:829–835

13. Francis BA, Hong B, Winarko J, Kawji S, Dustin L, Chopra V. Vision loss and recovery after trabeculectomy; risk and associated risk factors. Arch Ophthalmol 2011; 129:1011–1017. Available at: http://archopht.jamanetwork.com/data/Journals/OPHTH/22540/ecs05117_1011_1017.pdf. Accessed June 6, 2014
14. Bindlish R, Condon GP, Schlosser JD, D'Antonio J, Lauer KB, Lehrer R. Efficacy and safety of mitomycin-C in primary trabeculectomy; five-year follow-up. Ophthalmology 2002; 109:1336–1341; discussion by GL Spaeth, C Terzidou, A Bhan, 1341–1342
15. Song A, Scott IU, Flynn HW Jr, Budenz DL. Delayed-onset bleb-associated endophthalmitis; clinical features and visual acuity outcomes. Ophthalmology 2002; 109:985–991
16. Soltau JB, Rothman RF, Budenz DL, Greenfield DS, Feuer W, Liebmann JM, Ritch R. Risk factors for glaucoma filtering bleb infections. Arch Ophthalmol 2000; 118:338–342. Available at: http://archopht.jamanetwork.com/data/Journals/OPHTH/9870/ecs90078.pdf. Accessed June 6, 2014
17. DeBry PW, Perkins TW, Heatley G, Kaufman P, Brumback LC. Incidence of late-onset bleb-related complications following trabeculectomy with mitomycin. Arch Ophthalmol 2002; 120:297–300. Available at: http://archopht.jamanetwork.com/data/Journals/OPHTH/6775/ECS10036.pdf. Accessed June 6, 2014
18. Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD. Budenz DL on behalf of the Tube Versus Trabeculectomy Study Group. Three-year follow-up of the Tube Versus Trabeculectomy Study. Am J Ophthalmol 2009; 148:670–684
19. Ramulu PY, Corcoran KJ, Corcoran SL, Robin AL. Utilization of various glaucoma surgeries and procedures in Medicare beneficiaries from 1995 to 2004. Ophthalmology 2007; 114:2265–2270.e1
20. Uram M. Ophthalmic laser microendoscopy ciliary process ablation in the management of neovascular glaucoma. Ophthalmology 1992; 99:1823–1828
21. Uram M. Combined phacoemulsification, endoscopic ciliary process photocoagulation, and intraocular lens insertion in glaucoma management. Ophthalmic Surg 1995; 26:346–352
22. Gayton JL. Combined surgery with an endoscopic laser. In: Gayton JL, ed, Maximizing Results; Strategies in Refractive, Corneal, Cataract and Glaucoma Surgery. Thorofare, NJ, Slack, 1996
23. Mora JS, Iwach AG, Gafney MM, Wong PC, Nguyen N, Ma AS, Dickens CJ. Endoscopic diode laser cyclophotocoagulation with a limbal approach. Ophthalmic Surg Lasers 1997; 28:118–123
24. Chen J, Cohn RA, Lin SC, Cortes AE, Alvarado JA. Endoscopic photocoagulation of the ciliary body for treatment of refractory glaucomas. Am J Ophthalmol 1997; 124:787–796
25. Uram M. Endoscopic cyclophotocoagulation in glaucoma management. Curr Opin Ophthalmol 1995; 6(2):19–29
26. Uram M. Endoscopic cyclophotocoagulation in glaucoma management. Ophthalmic Practice 1995; 13:173–185
27. Bengtsson B, Olsson J, Heijl A, Rootzén H. A new generation of algorithms for computerized threshold perimetry, SITA. Acta Ophthalmol Scand 1997; 75:368–375. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0420.1997.tb00392.x/pdf. Accessed June 6, 2014
28. Wallace DK, Plager DA, Snyder SK, Raiesdana A, Helveston EM, Ellis FD. Surgical results of secondary glaucomas in childhood. Ophthalmology 1998; 105:101–111
29. Plager DA, Neeley DE. Intermediate-term results of endoscopic diode laser cyclophotocoagulation for pediatric glaucoma. J AAPOS 1999; 3:131–137
30. Jacobi PC, Dietlein TS. Endoscopic surgery in glaucoma management. Curr Opin Ophthalmol 2000; 11:127–132
31. Neely DE, Plager DA. Endocyclophotocoagulation for management of difficult pediatric glaucomas. J AAPOS 2001; 5:221–229
32. Kawai K. The microendoscope for ciliary process photocoagulation in neovascular glaucoma. Tokai J Exp Clin Med 2002; 27:27–34. Available at: http://mj.med.u-tokai.ac.jp/pdf/270104.pdf. Accessed June 6, 2014
33. Barkana Y, Morad Y, Ben-nun J. Endoscopic photocoagulation of the ciliary body after repeated failure of trans-scleral diode-laser cyclophotocoagulation. Am J Ophthalmol 2002; 133:405–407
34. Lin S. Endoscopic cyclophotocoagulation. Br J Ophthalmol 2002; 86:1434–1438. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1771381/pdf/bjo08601434.pdf. Accessed June 6, 2014
35. Valmaggia C, de Smet M. Endoscopic laser coagulation of the ciliary processes in patients with severe chronic glaucoma. Klin Monatsbl Augenheilkd 2004; 221:343–346
36. Lima FE, Magacho L, Carvalho DM, Susanna R Jr, Ávila MP. A prospective, comparative study between endoscopic cyclophotocoagulation and the Ahmed drainage implant in refractory glaucoma. J Glaucoma 2004; 13:233–237
37. Berke SJ. Endolaser cyclophotocoagulation in glaucoma management. Tech Ophthalmol 2006; 4:74–81
38. Yu MB, Huang SS, Ge J, Guo J, Fang M. [The clinical study of endoscopic cyclophotocoagulation on the management of refractory glaucoma]. [Chinese] Zhongua Yan Ke Za Zhi 2006; 42:27–31
39. 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
40. Lin M, Ge J, Huang S, Yu M, Zheng J. [The histopathologic changes of human eyes after laser endoscope cyclophotocoagulation]. [Chinese] Yan Ke Xue Bao 2004; 20:233–236
41. Lin SC, Chen MJ, Lin MS, Howes E, Stamper RL. Vascular effects on ciliary tissue from endoscopic versus trans-scleral cyclophotocoagulation. Br J Ophthalmol 2006; 90:496–500. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1856979/pdf/496.pdf. Accessed June 6, 2014
42. Pantcheva MB, Kahook MY, Schuman JS, Noecker RJ. Comparison of acute structural and histopathological changes in human autopsy eyes after endoscopic cyclophotocoagulation and trans-scleral cyclophotocoagulation. Br J Ophthalmol 2007; 91:248–252. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1857599/pdf/248.pdf. Accessed June 6, 2014
43. Kahook MY, Lathrop KL, Noecker RJ. One-site versus two-site endoscopic cyclophotocoagulation. J Glaucoma 2007; 16:527–530
44. Lindfield D, Ritchie RW, Griffiths MFP. 'Phaco-ECP': combined endoscopic cyclophotocoagulation and cataract surgery to augment medical control of glaucoma. BMJ Open 2012; 2:e000578. Available at: http://bmjopen.bmj.com/content/2/3/e000578.full.pdf. Accessed June 6, 2014
45. Clement CI, Kampougeris G, Ahmed F, Cordeiro MF, Bloom PA. Combining phacoemulsification with endoscopic cyclophotocoagulation to manage cataract and glaucoma. Clin Exp Ophthalmol 2013; 41:546–551
46. Shingleton BJ, Gamell LS, O'Donoghue MW, Baylus SL, King R. Long-term changes in intraocular pressure after clear corneal phacoemulsification: normal patients versus glaucoma suspects and glaucoma patients. J Cataract Refract Surg 1999; 25:885–890
47. Mathalone N, Hyams M, Neiman S, Buckman G, Hod Y, Geyer O. Long-term intraocular pressure control after clear

corneal phacoemulsification in glaucoma patients. J Cataract Refract Surg 2005; 31:479–483
48. Shingleton BJ, Pasternack JJ, Hung JW, O'Donoghue MW. Three and five year changes in intraocular pressures after clear corneal phacoemulsification in open-angle glaucoma patients, glaucoma suspects, and normal patients. J Glaucoma 2006; 15:494–498
49. Mansberger SL, Gordon MO, Jampel H, Bhorade A, Brandt JD, Wilson B, Kass MA; for the Ocular Hypertension Treatment Study Group. Reduction in intraocular pressure after cataract extraction; the Ocular Hypertension Treatment Study. Ophthalmology 2012; 119:1826–1831
50. Jampel HD, Chon BH, Stamper R, Packer M, Han Y, Nguyen QH, Ianchulev T. Effectiveness of intraocular pressure-lowering medication determined by washout. JAMA Ophthalmol 2014; 132:390–395
51. Neelakantan A, Vaishnav HD, Iyer SA, Sherwood MB. Is addition of a third or fourth antiglaucoma medication effective? J Glaucoma 2004; 13:130–136

FINANCIAL DISCLOSURES

Drs. Francis and Noecker are consultants to Endo Optiks, the makers of the endoscopic cyclophotocoagulation technology. They were not involved in patient recruitment, treatment, or data collection. No other author has a financial or proprietary interest in any material or method mentioned.

First author:
Brian A. Francis, MD, MS

Doheny Eye Institute, Department of Ophthalmology, David Geffen School of Medicine of the University of California Los Angeles, Los Angeles, California