Combined endocyclophotocoagulation and phacoemulsification in the management of moderate glaucoma

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ABSTRACT

Cataract and glaucoma are the leading causes of blindness worldwide and commonly coexist in elderly patients. Endocyclophotocoagulation is a minimally invasive approach for glaucoma management that is amenable to combination with cataract surgery. We review the literature on endocyclophotocoagulation and evaluate intraocular pressure reduction efficacy when combined with phacoemulsification. Several studies demonstrate that phacoemulsification and endocyclophotocoagulation successfully reduces intraocular pressure and decreases medication burden. Phacoemulsification and endocyclophotocoagulation has a minimal side effect profile, and risks are limited to those usual postphacoemulsification. Most importantly, phacoemulsification and endocyclophotocoagulation allow for all future procedures, including trabeculectomy or tube implantation if necessary.

Today, patients with glaucoma have an unprecedented number of management options. Medical management is geared at both reducing aqueous humor production and enhancing aqueous outflow whereas most interventional techniques, such as trabeculectomy and drainage devices, aim to bypass outflow facilities. Cyclophotocoagulation is the use of a diode laser, typically 810 nm, to ablate the ciliary body, thereby decreasing aqueous humor production. Trans-scleral cyclophotocoagulation (TCP) is a well-established technique for managing refractory intraocular pressure (IOP) elevation and glaucoma, although post-operative inflammation may be problematic. More recent minimally invasive endoscopic methods, however, have increased the efficacy, safety, and ease of this approach and are particularly amenable to combination with phacoemulsification. Cyclophotocoagulation is unique because, unlike nearly all other incisional glaucoma surgeries (minimally invasive or otherwise), cyclophotocoagulation is the only procedure to reduce the production of aqueous humor. Simultaneous phacoemulsification endocyclophotocoagulation (PECP) is a viable option in patients with glaucoma and cataract.

1. What is endocyclophotocoagulation?

Endocyclophotocoagulation (ECP) is an ab interno approach that uses the Endo Optiks microprobe laser and endoscopy system with an 810-nm diode laser, a 175-W xenon light source, and a helium neon laser–aiming beam.[9] Unlike TCP which disrupts ciliary body vasculature, ECP causes coagulative necrotic damage to the ciliary body epithelium while relatively sparing vasculature and ciliary muscle.[8] Two probe sizes are available—20 and 18 gauges—that provide a 70° and 110° field of view, respectively. Straight and curved probes allow access to more ciliary processes from a single incision. Direct visualization also allows the endoscope to be used for diagnostic purposes.[9] ECP was introduced in the mid-1990s, but not until recently have outcomes with combination phacoemulsification been described.

2. ECP technique

ECP can be performed under topical/intracameral anesthesia or after retrobulbar block. Two-stage topical anesthesia is given with lidocaine to the cornea and fornices before preparation and draping, followed by intracameral injection of 1% preservative-free lidocaine into the anterior chamber before viscoelastic placement and entry of the probe into the anterior

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chamber. When combined with phacoemulsification, ECP is typically performed just after IOL insertion, although it can be performed in the aphakic state as well. The ECP probe enters the eye through the main wound or an enlarged paracentesis and is held within 2–3 mm of the ciliary processes, allowing for visualization of approximately 6 ciliary processes at a time.[12] Viscoelastic is injected behind the iris before probe placement to inflate the ciliary sulcus to enhance visualization and maneuverability. ECP is then performed with 0.2- to 0.3-W energy on continuous mode typically for 270°–360° delivered in a “painted” fashion (rather than discrete applications) from the anterior to the posterior extent of the ciliary processes.[4] The clinical end point is blanching and shrinking of the ciliary processes. Bubble formation and ciliary process “popping” is indicative of excessive energy application, most likely because the probe is too close to the ciliary process. To reach 360 degrees of the ciliary processes, a second incision opposite to the location of the initial incision may be used. Endocycloplasty is the term used to describe the use of the ECP technique to rotate the ciliary processes posteriorly, potentially opening the angle in cases of narrow or closed angles. After treatment, thorough viscoelastic removal is performed and standard postcataract steroids, nonsteroidal anti-inflammatory drugs, and topical antibiotics are prescribed.[9] Oral acetazolamide and subconjunctival or subtenon steroid injections may be used to provide supplemental IOP and inflammation control.

3. PECP outcomes

PECP reduces IOP in patients with mild-to-moderate glaucoma (Table 1). Siegel and colleagues reviewed 261 eyes after PECP and 52 after phacoemulsification alone with mild-to-moderate glaucoma on at least 1 topical medication before the procedure. Baseline IOP was 17.2 ± 4.8 and 17.7 ± 4.4, respectively, and baseline number of glaucoma medications was 1.3 and 1.5 in the PECP and phacoemulsification groups. Three years after intervention, mean IOP was 14.6 ± 3.1 and 15.5 ± 3.6 mm Hg ($P = 0.34$), and mean medications were 0.2 ± 0.59 and 1.3 ± 0.61 ($P < 0.001$), respectively. Furthermore, 61% of PECP patients achieved at least 20% IOP reduction and a decrease of at least 1 ocular hypertensive medication, compared with only 23% in the phacoemulsification group. Limitations of this study included a small control phacoemulsification group.[11]

Clement and colleagues retrospectively reviewed 63 PECP eyes with mean preoperative IOP 21.13 mm Hg and mean of 2.71 glaucoma medications. At 12 months, mean preoperative IOP and mean IOP lowering medications reduced to 16.09 ± 5.27 ($P < 0.01$) and 1.47 ± 1.30 ($P < 0.01$). Furthermore, 29 of the 63 eyes had previously undergone tube shunt, trabeculectomy, and/or revisions. At 12 months, 55.5% of patients demonstrated at least 20% IOP reduction from baseline IOP. There was a slight correlation in IOP reduction with age and preoperative IOP. Older hypertensive eyes demonstrated greater IOP reduction compared to young normotensive eyes. Most PECP eyes experienced marked visual acuity rehabilitation from preoperative mean logMAR VA 1.01 to 0.33, except 4 eyes where decline in visual acuity was attributed to glaucoma progression and corneal decompensation.[2]

Table 1 – Endocyclophotocoagulation study summary

Study	Clement 2013	Gayton 1999	Lima 2004	Lindfield 2012	Kahook 2007	Siegel 2015	Morales 2015
Comparison	PECP	PECP versus PTRAB	ECP versus Ahmed	PECP	PECP	PECP versus Phaco	PECP
Number of eyes	N = 63	N = 58	N = 68	N = 58	N = 40	N = 313	N = 104
Type	Retrospective	Prospective	Prospective	Retrospective	Retrospective	Retrospective	Retrospective
Baseline IOP	21.13 ± 6.21	24.86 ± 8.6	41.61 ± 3.42	21.54	24.48 ± 8.99	17.2 ± 4.8	17 ± 1.4
Baseline# Meds	2.71 ± 1.06	1.86 ± 0.83	3.0 ± 1.3	1.97	2.56 ± 0.71	1.3	78% on over 3 meds
End-point IOP	16.09 ± 5.27 ($P < 0.01$)	16 ± 9.6 ($P < 0.0002$)	14.07 ± 7.21 ($P < 0.001$)	14.4 ($P < 0.001$)	13.28 ± 9.35 ($P = 0.03$)	14.6 ± 3.1 ($P = 0.34$)	14.3 ± 1.3
End-point# Meds	1.47 ± 1.30 ($P < 0.01$)	1.22 ± 1.26	2.0 ± 1.2 ($P = 0.3$)	2.07 ($P > 0.05$)	0.52 ± 0.59 ($P < 0.0001$)	0.2 ± 0.59 ($P < 0.001$)	46% on over 3 meds
Degrees ECP	≥270	240–270	210	≥300	240–300	270–300	≥180
Approach	Clear cornea	Limbal	Pars plana	Anterior	Anterior	Clear cornea	Data not provided
Steroids	Postoperative	Postoperative	Intracameral and subconjunctival and postoperative	Postoperative	Postoperative	Postoperative	Data not provided
Follow-up (months)	12	24	21.29 ± 6.42	24	6	36	17.3 ± 1.8

ECP, endocyclophotocoagulation; IOP, intraocular pressure; PECP, phacoemulsification endocyclophotocoagulation; PTRAB, phacotrabeculectomy.

Lima and colleagues prospectively randomized 68 eyes with intractable IOP elevation to ECP versus Ahmed drainage implant (New World Medical, Rancho Cucamonga, CA, USA). All eyes had previously undergone trabeculectomy. At mean follow-up of just under 2 years, both procedures equally reduced IOP from 41.32 ± 3.03 (Ahmed) and 41.61 ± 3.42 (ECP) to 14.73 ± 6.44 and 14.07 ± 7.21 ($P = 0.7$), respectively. The Ahmed group also had more postoperative visits and underwent more postoperative procedures compared to the ECP group.[5]

Gayton and colleagues prospectively randomized 58 eyes to receive PECP versus phacotrabeculectomy (PTRAB). Pressure reduction with IOP <19 with and without medications was achieved in 65% and 30% of PECP patients, compared with 52% and 40% in the PTRAB group, respectively, whereas equivalent IOP control was achieved at final follow-up (PECP 95% vs PTRAB 96%).[3]

In summary, several prospective and retrospective long-term studies clearly demonstrate PECP's success in IOP and medication use reduction not only in mild/moderate glaucoma, but also in patients with advanced or refractory glaucoma. Trends seem to indicate PECPs have favorable efficacy in older patients and eyes with higher baseline IOP.[2] PECPs efficacy in different types of glaucoma is unclear and will require larger enrollment of patients with angle-closure and pseudoexfoliation glaucoma in the future.[7]

4. Complications

In Clement's review of 63 eyes after PECP, no intraoperative complications were found.[2] Postoperatively, standard cataract postincisional complications should be applicable, including cystoid macular edema and rare endophthalmitis.

Common complications attributable to PECP include postoperative IOP spikes, hyphema, and fibrinous uveitis. IOP spikes with pressures between 26 and 32 are likely a result of retained viscoelastic or inflammation and occur in about 13% of eyes.[4] Hyphema in the initial postoperative period has been described in up to 17.6% of cases but was also not reported in several series.[4,5] The following complication rates were noted in a review of 63 PCEP eyes: postoperative fibrinous uveitis in 11%, acute IOP rise in 3%, chronic IOP rise in 8%, and CME in 3%.[2] In a review by Kahook and colleagues, there were no cases of persistent inflammation, hyphema, corneal decompensation, or retinal detachment after PCEP.[4] In patients with mild-to-moderate glaucoma and surgically naive eyes, Siegel and colleagues demonstrated lower complication rates in 261 eyes, as follows: CME in 1.5%, retinal detachment in 0.7%, and transient IOP elevations in 8%, without any cases of hyphema, persistent inflammation, or hypotony.[11] Finally, there are no reports in the literature of a snuff-out phenomenon with ECP.[6,10]

In Gayton's study comparing PECP versus PTRAB, complication rates differed significantly: hypotony (0% of PECP vs 24% of PTRAB), hyphema (0% vs 59%, respectively), and lower amounts of inflammation were noted in the PTRAB group.[3] In Lima's review of 68 eyes undergoing Ahmed versus ECP, complication rates were higher in the Ahmed arm for choroidal detachment (Ahmed 17.6% and ECP 2.94%, $P = 0.1$), endophthalmitis (Ahmed 2.9% and ECP 0.0%, $P = 1.0$) and shallow anterior chamber (Ahmed 17.6% and ECP 0.0%, $P = 0.02$) while rates of hyphema (Ahmed 14.7 and ECP 17.6, $P = 1.0$) were essentially equivalent between groups.[5]

Hypotony and phthisis are feared complications of TCP. TCP requires greater power to reach the ciliary body with limited control and ability to titrate power, leading to widespread damage of surrounding sclera and ciliary muscle; however, endoscopic-guided technique allows for direct visualization and ablation of individual ciliary processes and energy titration to prevent blood-aqueous barrier disruption and subsequent inflammation. Histopathologic evaluation of rabbit eyes after TCP and ECP demonstrated more ciliary process reperfusion after ECP compared to TCP, likely accounting for the rare cases of hypotony after ECP.[4] Phthisis bulbi has not been reported after ECP in open-angle glaucoma.

Case reports of hypotony after ECP are generally limited to eyes status post multiple procedures including trabeculectomy and scleral buckle or eyes with neovascular glaucoma.[1,5] Furthermore, hypotony after ECP seems to be correlated with degrees of ablation. Lima and colleagues demonstrated an 18% rate of hypotony after 260° ECP, compared with just 2.9% after 210 degrees of ablation.[5] Postoperative hypotony remains a rare complication after ECP and is typically limited to complicated eyes that are status after multiple surgical procedures.

5. Indications and contraindications

Given the excellent side effect profile and ease of combination with cataract surgery, PECP should be considered earlier in glaucoma management. Furthermore, patients with mild-to-moderate glaucoma who are poor candidates for invasive drainage tubes implantation and trabeculectomies with lifetime risk of failure, blebitis, wound leak, and erosion should be evaluated for PECP as first-line management. The ability to use standard cataract wounds, the minimal incremental operative time compared with combined incisional glaucoma surgeries, and the excellent visual recovery make PECP a valuable option for glaucoma and cataract patients.

Patients with proven noncompliance, medication intolerance, and intractable glaucoma are also excellent candidates for the combined procedure as PECP demonstrates equivalent efficacy in retrospective reviews compared to tube and trabeculectomy while avoiding significant complications. Most importantly, PECP does not manipulate conjunctiva and allows for future trabeculectomy or valve implantation if necessary.

PECP offers efficiency for the management of glaucoma patients at all stages and has a favorable risk-benefit profile. PECP improves vision and sustainably lowers IOP while avoiding the intensive and potentially serious complications of traditional incisional glaucoma surgeries. Patients with advanced glaucoma who require low-target IOPs may not be ideal ECP candidates. ECP is relatively contraindicated in uveitic glaucoma.

6. Conclusion

In retrospective trials comparing PECP to phacoemulsification alone, PECP appears to offer a decrease in 1 topical medication and an additional 5.8% IOP lowering effect.[11] Current PCEP data are limited to retrospective analysis, and results compared to phacoemulsification alone remain to be demonstrated by a prospective randomized controlled trial. Furthermore, as the field of minimally invasive glaucoma surgery evolves, data comparing PECP outcomes to other minimally invasive glaucoma surgery will elucidate the role of PECP in a surgeon's armamentarium. Retrospective data demonstrate IOP reduction until 3 years; however, efficacy beyond this time frame is unknown. Given ciliary vasculature regeneration after ECP, diminishing effects are of concern[2]; however, compared to other interventional techniques, PECP reduces IOP while avoiding the complicated postoperative period and long-term risk for infection with traditional procedures. PECP provides patients with an efficient, safe, and effective option for early glaucoma management without precluding future traditional surgical interventions.

7. Disclosures

Dr. Radcliffe is a consultant for Endo Optiks (Little Silver, NJ) and Iridex (Mountain View, CA), New World Medical (Rancho Cucamonga, CA).

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