



The use of endoscopic cyclophotocoagulation in the treatment of glaucoma - a literature review

Review

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Abstract

Glaucoma, a leading cause of irreversible blindness, often necessitates intervention beyond conventional therapies when intraocular pressure (IOP) cannot be adequately controlled. Endoscopic cyclophotocoagulation (ECP), a targeted cyclo-destructive procedure, has emerged as a valuable surgical option due to its ability to precisely coagulate the ciliary processes under direct visualization.

This literature review explores ECP's role in contemporary glaucoma management. It examines its efficacy, safety, and integration with phacoemulsification, novel hybrid procedures, such as ECP with Kahook Dual Blade or iStent insertion and vitrectomy pars plana. Clinical studies consistently demonstrate a significant reduction in IOP and medication burden, particularly when ECP is combined with cataract surgery. While complications such as inflammation and transient IOP spikes are noted, severe adverse outcomes remain uncommon. Pediatric and refractory glaucoma cases show variable responses, emphasizing the need for individualized patient selection.

Comparative studies suggest that ECP provides outcomes that are on par with or superior to traditional surgical options, with a lower complication rate and preservation of conjunctival integrity, which is advantageous for future interventions. However, the predominance of retrospective studies and limited long-term data warrant further randomized, controlled trials to establish definitive guidelines.

ECP represents a promising, minimally invasive strategy in glaucoma care, particularly as part of combination procedures. Growing evidence supports its clinical utility across a wide range of patient populations.

Keywords

cyclophotocoagulation • ciliary body • diode laser • glaucoma

1. Introduction

Glaucoma remains one of the most severe eye conditions, contributing to vision loss and blindness in patients, despite major advances in medical, laser, and surgical treatment [1]. In difficult cases of glaucoma, target intraocular pressure can most often only be achieved after a procedure involving the destruction of the ciliary body, which is responsible for the production of nearly 80-90% of the aqueous humor, directly contributing to increased intraocular pressure [2,3].

Until recently, cyclo-destructive procedures were used only in advanced cases as a therapy of last resort where other methods had failed [4]. Thanks to technological advances, this method is increasingly offered to patients in earlier stages of glaucoma and those with good visual acuity.

ECP, or endoscopic cyclophotocoagulation, is performed using an ophthalmic endoscope developed by Martin Uram in 1992 [5,6], which allows observation of the structures of the anterior segment of the eyeball, including the drainage angle, the ciliary body with its processes, the ciliary sulcus and the anterior part of the retina with simultaneous cyclophotocoagulation [5].

Currently, almost all types of open and closed-angle glaucoma are indications for ECP surgery, except for neovascular glaucoma, which is a relative indication. Advances in medicine and recent studies confirming the efficacy of cyclo-destructive procedures are increasingly changing the approach to ECP [7-9].

Several clinical trials have proven the efficacy and safety of ECP. These trials show better therapeutic results than minimally invasive glaucoma surgery and laser trabeculoplasty and a lower risk of complications than with trabeculectomy or glaucoma seton drainage surgery. Among ECP's most common side effects are ocular inflammatory reactions and tissue destruction associated with photocoagulation, hemorrhage, retinal detachments, and cataracts [9].

Access to the ciliary body processes can be gained via two routes: through the cornea or the pars plana. Surgery through the pars plana requires a vitrectomy for sufficient working space, which increases the risk of complications such as retinal detachment, hemorrhage, or cataracts. Access through the cornea is more common and less risky regarding bleeding. In addition, the continuity of the conjunctiva and sclera is preserved, facilitating possible future anti-glaucoma procedures [10].

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2. Instrumentation for ECP

The E2 Ophthalmic Laser Endoscopy System consists of a laser endoscope and the console to which it is attached. The laser endoscopy console combines a 175- or 300-watt xenon light source, an 810-nm diode laser for photocoagulation, and a video system for intraocular imaging. All these components are contained in an 18-, 19-, 20-, or 23-gauge endoscopic probe. The laser emits a power of up to 1.2 W, while the recommended starting power is 0.25 W, allowing for gradual energy adjustment during the procedure. Endoscopic probes are available in both straight and curved versions. During surgery, the surgeon observes the operation on a monitor, instead of looking through the operating microscope [11].

A key advantage of ECP over other cyclophotocoagulation techniques is its ability to precisely deliver laser energy to the ciliary processes, ensuring controlled treatment. The desired tissue response involves whitening and visible shrinkage of the ciliary processes, achieved using an endoscope 1.0–3.0 mm away. Kahook et al. suggest maintaining approximately 2 mm, typically allowing visualization of six ciliary processes in the endoscope's field. This distance optimizes energy delivery while reducing the risk of overtreatment [12]. The 810 nm diode laser power increases incrementally until the ciliary processes exhibit the intended bleaching and shrinking effects. To achieve significant intraocular pressure (IOP) reduction, treatment covering at least 270° of the ciliary body is often necessary. When using a single incision, the curved endoscope probe facilitates extending the treatment area beyond the capabilities of a straight endoscope [13].

3. Access through the cornea

3.1. ECP + phacoemulsification

Phacoemulsification is a modern, minimally invasive surgical method for treating cataracts. It involves fragmenting and removing the cloudy lens of the eye using ultrasound. With this procedure, the clouded lens can be precisely removed and an artificial intraocular lens inserted, restoring the patient's visual acuity [14].

In a randomized controlled trial involving 707 glaucoma patients managed medically, Berke et al. found that combining phacoemulsification with ECP (626 patients) was more effective than phacoemulsification alone (81 patients) in reducing intraocular pressure (IOP) and the need for anti-glaucoma medications. In the phacoemulsification with ECP group, preoperative IOP was $19.08 \text{ mmHg} \pm 4.14$ with 1.53 ± 0.89 medications, decreasing postoperatively to $15.73 \text{ mmHg} \pm 3.00$ with 0.65 ± 0.95 glaucoma agents. In contrast, the phacoemulsification-only group presented no significant improvement, with preoperative intraocular pressure of $18.16 \text{ mmHg} \pm 3.38$ and 1.20 ± 0.83 glaucoma agents, and postoperative

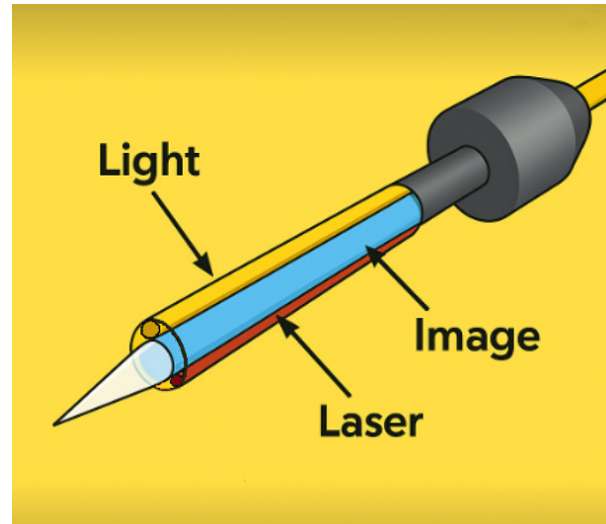


Figure 1. Schematic representation of an ophthalmic endoscope used to perform ECP

IOP of $18.93 \text{ mmHg} \pm 4.12$ with 1.20 ± 0.87 glaucoma agents. Neither group experienced severe complications [15].

Regarding long-term outcomes, Yap et al. evaluated the three-year results of phacoemulsification combined with ECP for patients with primary open-angle glaucoma not previously undergoing surgery. Surgical success was defined as achieving an intraocular pressure (IOP) of 21 mmHg or lower, accompanied by a decrease of at least 20% from baseline at two consecutive follow-up visits, and without the need for additional surgical interventions lowering IOP. Success rates were 70% at one year, 54% at two years, and 45% at three years postoperatively. The procedure resulted in a statistically significant and sustained reduction in mean IOP, which decreased from a preoperative level of 18.4 to 14.3 mmHg at one year, 14.1 mmHg at two years, and further to 13.6 mmHg at three years following surgery. In parallel, the average number of glaucoma agents was decreased from 2.7 to 1.3, 1.7, and 1.8 at one, two, and three years postoperatively, respectively [16].

Bolek et al. evaluated the outcomes of 38 patients (38 eyes) at 5 years after phacoemulsification with ECP. Their intraocular pressure (IOP) before surgery was $22.6 \pm 6.7 \text{ mmHg}$. There was a reduction in IOP to $15.9 \pm 3.9 \text{ mmHg}$ one year after surgery, to $15.9 \pm 2.9 \text{ mmHg}$ after 2 years, to $15.6 \pm 2.7 \text{ mmHg}$ after 3 years, to $15.5 \pm 3.8 \text{ mmHg}$ after 4 years, and to $15.2 \pm 2.6 \text{ mmHg}$ after 5 years. Statistically significant was the reduction in the mean amount of topical medication. At 5 years, nine patients (28.3%) did not achieve the target IOP reduction [17].

In a prospective randomized study, Gayton et al. evaluated the results of combined phacoemulsification with ECP compared to phacoemulsification combined with trabeculectomy. After 2 years, success, defined as achieving IOP below 19 mmHg without needing medication, was achieved by 30% of patients in the ECP

Table 1. Efficacy and complications of phacoemulsification combined with ECP

	Berke et al.	Yap et al.			Bolek et al.				
Duration of follow-up (months)	Postoperatively	12	24	36	12	24	36	48	60
Preop. IOP (mmHg)	19.1	18.4			22.6				
Preop. N of IOP-lowering meds	1.5	2.7			-				
Postop. IOP (mmHg)	15.7	14.3	14.1	13.6	15.9	15.9	15.6	15.5	15.2
Postop. N of IOP-lowering meds	0.7	1.3	1.7	1.8	-	-	-	-	-
IOP reduction (%)	17.8	22.3	23.4	26.1	29.6	29.6	31.0	31.4	32.7
N of IOP-lowering meds reduction (%)	53.3	51.9	37.0	33.3	-	-	-	-	-
Complications	There were no severe complications, and the rates of cystoid macular edema did not exceed those expected for a standard phacoemulsification in any patient.	Uveitis (6%), macular edema (2%), IOP spikes (1%), and corneal decompensation (1%). No episodes of hypotony or retinal detachment were reported.			Corneal edema (25.6%), IOP spikes (20.5%), intraocular lens dislocation (2.6%), uveitis (12.8%). No episodes of hypotony were reported.				

(Preop. N of IOP-lowering meds: preoperative number of IOP-lowering medications used by patients; Postop. N of IOP-lowering meds: postoperative number of IOP-lowering medications used by patients; N of IOP-lowering meds reduction: reduction in the number of IOP-lowering medications.

group and 40% in the trabeculectomy group. The same level of intraocular pressure with medication was achieved by 65% of patients undergoing ECP and 54% of patients undergoing trabeculectomy. Additional treatments were needed in 14% of patients in the ECP group and 10% in the trabeculectomy group. The mean IOP reduction was 8.6 mm Hg in the trabeculectomy group and 8.8 mm Hg in the ECP group, indicating comparable effects [18].

These data confirm the efficacy and safety of endoscopic cyclophotocoagulation (ECP) and phacoemulsification in treating cataracts coexisting with various forms of glaucoma. It is worth noting, however, that most of the available studies are retrospective and lack a control group, making it difficult to determine exactly what effect ECP has on lowering intraocular pressure compared to phacoemulsification alone. Further prospective, randomized studies are needed to more fully evaluate the pressure-lowering effects of ECP and the safety of this method.

3.2. ECP in children

Carter et al. demonstrated the effectiveness of ECP in treating pediatric patients with aphakic and pseudophakic glaucoma. The mean preoperative intraocular pressure (IOP) of 32.9 mmHg was significantly reduced to 22.9 mmHg postoperatively, with a treatment success rate of 53%, defined as achieving a final IOP of ≤ 23 mmHg over an average follow-up of 44.4 months. Notably, in 82% of the 34 eyes, ECP was the primary intervention for glaucoma management [19]. Conversely, later findings by Al-Haddad and colleagues indicated limited success of ECP in managing refractory glaucoma with corneal opacities in children [20].

Despite the moderate long-term success of ECP in pediatric patients, evidence regarding its effectiveness remains mixed.

Study quality varies, and outcomes largely depend on patient selection and disease severity.

3.3. ECP combined with Kahook Dual Blade (KDB)

The Kahook Dual Blade (KDB) is an innovative instrument with a double-sided, pointed tip designed for precise incisions within the trabecular meshwork. This enables the unobstructed flow of aqueous humor into Schlemm's canal. Its unique design minimizes damage to nearby tissues, promoting quicker recovery and reducing the risk of complications [21].

Izquierdo et al. compared two surgical approaches: Phaco/360-degree ECP/goniotomy with the KDB versus Phaco/360-degree ECP. Success was defined as achieving an IOP between 6 and 12 mmHg or a reduction of at least 20% from baseline, with medication (partial success) or without medication (complete success). The mean baseline IOP was 16.96 mmHg for the Phaco/ECP/KDB group and 15.64 ± 4.88 mmHg for the phaco/ECP group. Complete success rates were 37% in the phaco/ECP/KDB group compared to 31% in the phaco/ECP group, while partial success was achieved in 74% and 50% of patients, respectively [22].

Adding KDB to phaco/ECP demonstrated slightly higher success rates, particularly in medication-dependent outcomes. However, the modest baseline IOP and lack of randomization in Izquierdo et al.'s study limit the ability to draw definitive conclusions. While initial results are promising, the evidence remains preliminary and dependent on well-defined patient populations.

3.4. ECP + iStent

The iStent is a 1-millimeter, heparin-coated, non-ferromagnetic, surgical titanium stent that allows direct outflow of aqueous fluid

Table 2. Efficacy and complications of ECP in patients undergoing PPV

	Gorovoy et al. [26]		Boyd et al. [27]	He et al. [28]
Duration of follow-up (months)	1	3	12.2	15.2
Preop. IOP (mmHg)	26.3		20.3	46.3
Preop. N of IOP-lowering meds	2.7		2.3	4.0
Postop. IOP (mmHg)	17.9	16.9	14.6	18.5
Postop. N of IOP-lowering meds	1.3	1.3	2.0	1.0
IOP reduction (%)	31.9	35.7	28.1	60.0
N of IOP-lowering meds reduction (%)	51.9	51.9	13.0	75.0
Complications	One patient developed hypotonia. Postoperative inflammation or discomfort did not exceed what was expected for a standard vitrectomy in any patient.		There were no ocular and systemic complications.	Postoperative inflammation or discomfort did not exceed what was expected for a standard vitrectomy in any patient.

(Preop. N of IOP-lowering meds: preoperative number of IOP-lowering medications used by patients; Postop. N of IOP-lowering meds: postoperative number of IOP-lowering medications used by patients; N of IOP-lowering meds reduction: reduction in the number of IOP-lowering medications)

from the anterior chamber into Schlemm's canal. It requires a short surgical procedure and is inserted into Schlemm's canal through a corneal incision under direct gonioscopic visualization [23].

Pantaloni et al. compared the outcomes of phacoemulsification combined with two iStents and ECP versus phacoemulsification with a single iStent in patients with ocular hypertension or early to moderate open-angle glaucoma. The baseline intraocular pressure was significantly higher in the phaco/ECP/2iStent group (19.97 ± 4.31 mmHg, $n = 63$) compared to the phaco/iStent group (17.63 ± 3.86 mmHg, $n = 46$). One year postoperatively, IOP had decreased by 35% from baseline in the phaco/ECP/2iStent group and by 21% in the phaco/iStent group, with final IOP levels of 13.05 ± 2.18 and 14.09 ± 1.86 mmHg, respectively. The safety profiles of both surgical groups were comparable, with no notable differences in adverse outcomes. Regarding pharmacologic management, the mean number of glaucoma agents was similar at baseline (2.22 ± 1.06 for phaco/ECP/2iStent vs. 2.07 ± 1.02 for Phaco/iStent) and after one year (1.24 ± 1.05 vs. 1.39 ± 1.03 , respectively), indicating a modest yet consistent decrease [24].

While results suggest enhanced efficacy with combined procedures, the evidence remains preliminary and should be interpreted cautiously. Greater IOP reduction with the addition of ECP and a second iStent may have been influenced by the higher baseline IOP. The study was non-randomized, and the follow-up was limited to one year, constraining long-term interpretation.

4. Access via pars plana

Vitrectomy through the pars plana part of the ciliary body, also known as pars plana vitrectomy (PPV), is an intraocular microsurgical procedure used to remove the vitreous body - the gelatinous substance that fills the largest space in the eye, the vitreous chamber [25].

Gorovoy et al., in a retrospective study, evaluated the effectiveness of ECP in patients undergoing PPV with medically uncontrolled glaucoma. The mean intraocular pressure before surgery was 26.3 mmHg with 2.7 medications and was reduced to 17.9 mmHg after 1 month and 16.9 mmHg after 3 months with an average of 1.3 medications. One patient with neovascular glaucoma developed hypotonia [26]. In a study by Boyd et al, PPV combined with ECP also achieved statistically significant reductions in IOP from 20.3 mmHg before treatment to 14.6 mmHg after a mean follow-up of 12.2 months [27].

He et al. reported a 49.4% reduction in intraocular pressure compared to preoperative values in an analysis of 28 patients (30 eyes) with refractory glaucoma who underwent PPV combined with ECP. The mean IOP before surgery was 46.3 mmHg, and after 15.2 (12-20) months of follow-up, there was a reduction to a mean value of 18.5 mmHg. The effect of the surgery on patients' average medication intake was also evaluated, which decreased from 4 to 1 [28].

Multiple retrospective studies suggest combining ECP with PPV can significantly lower IOP, particularly in refractory cases. However, the absence of control groups, small sample sizes, and variability in follow-up durations limit the strength of these findings. While outcomes appear promising, especially in severe glaucoma, higher-quality evidence is needed to confirm long-term efficacy and safety.

5. ECP in refractory glaucoma

Chen et al. demonstrated that ECP can be effective for refractory glaucoma, particularly in cases where prior trabeculectomy and transscleral cyclophotocoagulation had failed. They observed a reduction in intraocular pressure (IOP) from 27.7 mmHg ± 10.3 before surgery to 17.0 ± 6.7 mmHg at the final follow-up,

reflecting a 34% decrease. The success rate, defined as achieving an IOP of ≤ 21 mmHg, was 90%. Additionally, anti-glaucoma medications decreased from 3.0 ± 1.3 before surgery to 2.0 ± 1.3 afterward. Visual acuity loss of two or more lines occurred in only 6% of patients. Reported complications included fibrin exudation (24%), anterior chamber hemorrhage (12%), cystoid macular edema (10%), and choroidal detachment (4%). Importantly, no severe complications such as ocular hypotony or phthisis bulbi were noted [29].

ECP has been compared favorably to other glaucoma surgeries. Lima et al. conducted a prospective study on 68 pseudophakic eyes with previous failed trabeculectomy, finding that ECP achieved a success rate comparable to the Ahmed Glaucoma Valve drainage system while associated with fewer complications [30].

Studies have found highly effective outcomes of ECP for refractory glaucoma, with a 90% success rate, significant IOP reduction, and favorable results compared to the Ahmed Glaucoma Valve. However, both studies' retrospective designs and small sample sizes highlight the need for larger, randomized trials to confirm long-term efficacy and safety.

6. Conclusions

Endoscopic cyclophotocoagulation is a modern method of glaucoma treatment gaining popularity due to its better safety profile and comparable efficacy to traditional cyclo-destructive techniques.

ECP combined with phacoemulsification has shown promising efficacy and safety for treating cataracts with concurrent glaucoma. However, most retrospective studies lack control groups and have limited evidence on their pressure-lowering effects. While some studies suggest ECP improves IOP outcomes when combined with KDB or iStent, the evidence is still preliminary and dependent on patient selection and disease severity. In pediatric patients, the long-term success of ECP remains mixed, with varying study quality and outcomes often influenced by patient-specific factors.

Additionally, while some studies report high success rates for combining ECP with PPV or ECP in refractory glaucoma cases,

especially compared to devices like the Ahmed Glaucoma Valve, the retrospective nature and small sample sizes of these studies hinder the ability to draw definitive conclusions about long-term efficacy.

Although most of the available studies are retrospective, and large prospective studies with control groups are lacking, the results of the analyses to date suggest that ECP may be a valuable alternative to more invasive anti-glaucoma surgery. Further studies are needed to evaluate the long-term efficacy and safety of this method fully.

Abbreviations

ECP	Endoscopic cyclophotocoagulation
IOP	Intraocular pressure
KDB	Kahook Dual Blade
Phaco	Phacoemulsification
PPV	Pars plana vitrectomy

Authors' contributions

Oleksii Kravets: writing - original draft preparation, writing - review and editing, visualization, literature review.

Sebastian Sirek: research concept and design, supervising the project.

Dorota Wyględowska-Promieńska: final proofreading and approval of the version for publication

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Conflict of interest

The authors have no conflicts of interest to declare.

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