Original Article

Surgical outcomes of phacoemulsification/goniosynechialysis with and without endocyclophotocoagulation in patients with chronic angle closure glaucoma

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Purpose: To compare surgical outcomes of patients after phacoemulsification with goniosynechialysis (phaco/GSL) versus phaco with GSL and endocyclophotocoagulation (phaco/GSL/ECP) in patients with chronic angle closure glaucoma (CACG) through 12-month follow-up. **Methods:** A retrospective, nonrandomized, comparative case series was performed. Patients with CACG who underwent phaco in combination with either GSL alone (group 1) or GSL with ECP with intracameral injection of kenalog (group 2) from 2011 to 2018 were included. Group 1 included 6 eyes of 6 patients and group 2 included 11 eyes of 10 patients. All surgeries were performed by a single surgeon (RSA). Primary outcome measures included changes in intraocular pressure (IOP), visual acuity (VA), failure based on IOP (>18 or <6 mmHg at 1 year), and secondary operative procedures and complication rates. Data were analyzed using a paired two-tailed *T*-test. **Results:** The mean preoperative IOP decreased from 23.5 ± 11.2 to 14.2 ± 2.4 mmHg ($P < 0.0073$) in group 1 and 24.4 ± 8.2 to 14.5 ± 2.7 mmHg ($P < 0.0001$) in group 2. The mean % IOP reduction was 33.7% in group 1 and 34.2% in group 2. The mean improvement in VA (logMAR units) was 0.24 ($P = 0.085$) in group 1 and 0.13 ($P = 0.657$) in group 2. The mean number of topical meds decreased from 2.50 ± 1.76 to 1.80 ± 1.64 in group 1 ($P = 0.513$) and from 2.82 ± 1.25 to 1.17 ± 0.98 in group 2 ($P = 0.014$). **Conclusion:** Phaco/GSL and phaco/GSL/ECP both achieve a significant reduction in IOP without the complications associated with traditional glaucoma filtration surgeries.

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Chronic angle closure glaucoma (CACG) is a leading cause of irreversible blindness. It is caused by closure of the angle secondary to peripheral anterior synechiae (PAS), inducing an increase in intraocular pressure (IOP). CACG increases in prevalence with age and frequently coexists with cataract. Although lens removal may effectively lower IOP in some patients with CACG,[1-4] many patients do not experience a sufficient IOP decrease following cataract extraction alone. These patients may therefore require additional glaucoma surgery.[5,6]

Although lens extraction alone or combined with trabeculectomy results in prevention of PAS formation, once formed, PAS are likely to persist and limit aqueous outflow capacity.[7] Combined filtering procedures generally result in a greater decrease in IOP compared With minimally invasive glaucoma surgeries, but carry an increased risk of postoperative complications.[1-4] Goniosynechialysis (GSL) involves the physical breaking of the PAS under direct visualization in an attempt to clear the aqueous pathway to Schlemm's canal (SC) through the trabecular meshwork (TM). Several studies have reported that this procedure combined with cataract extraction effectively lowers IOP, while minimizing significant postoperative complications such as hypotony.[5,8]

Traditional cyclodestructive procedures such as cyclocryotherapy and transscleral cyclophotocoagulation reduce IOP in patients with CACG, but carry an added risk of inflammation, hypotony, and phthisis.[9] This surgery has been modified to an endoscopic procedure, endocyclophotocoagulation (ECP).

ECP uses a diode laser guided by an endoscope which targets ablation of the ciliary body under direct visualization, minimizing surrounding tissue damage. The technique of combining phacoemulsification with ECP (phaco/ECP) has emerged as a viable option to simultaneously treat both cataract and glaucoma.[7,10]

GSL combined with phaco alone or with ECP may provide an alternative solution to patients requiring significant IOP reduction with a better safety profile than traditional filtering procedures. To evaluate the efficacy of these procedures, we retrospectively analyzed the data of a limited number of patients comparing operative outcomes following phaco/GSL versus phaco and GSL with ECP (phaco/GSL/ECP) in patients with CACG through 12-month follow-up.

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Methods

This retrospective, nonrandomized, comparative study received institutional review board approval. Medical records of patients with mild CACG who underwent either phaco in combination with GSL alone (group 1) or those with moderate to severe stage CACG who underwent phaco in combination with GSL and ECP (group 2) were reviewed. Glaucoma severity was determined by the 2010 American Academy of Ophthalmology preferred practice pattern guidelines. All patients were treated by the Glaucoma Service at a tertiary hospital between 2011 and 2018. The decision to perform phaco/GSL or phaco/GSL/ECP was based on glaucoma severity. Patients with mild CACG underwent phaco/GSL, whereas patients with moderate to severe CACG underwent phaco/GSL/ECP. A subset of both groups included patients with plateau iris, defined as an atypical configuration of the anterior chamber angle with anteriorly positioned ciliary processes that critically narrow the anterior chamber recess by pushing the peripheral iris forward. Plateau iris was diagnosed on ultrasound biomicroscopy by the presence of an anteriorly directed ciliary body, an absent ciliary sulcus, presence of a central flat iris plane, a steep iris root from its point of insertion followed by a downward angulation from the corneoscleral wall, and irido-angle contact. There was no difference in surgical technique for patients with plateau iris compared with patients with nonplateau iris.

All surgeries were performed by the same experienced glaucoma specialist (RSA). All patients were referred to the Glaucoma Services for management of glaucoma and underlying cataract. Phaco with intraocular lens implantation was performed in the standard fashion followed by GSL in all cases. GSL was performed under direct visualization of a surgical goniolens. Microforceps 360° were used to gently break PAS on the nasal 240° of the angle, while viscodissection was used on the temporal 120° of the angle. ECP was performed using the E2 diode laser endoscope system from Endoptiks on a curved probe. Diode laser was applied (3 MJ at 0.3 s on continuous mode using a spray painting technique to paint the processes starting at the posterior portion of the ciliary processes and "shooting away from the iris root," treating as much of the ciliary processes as possible and followed by an anterior chamber washout) to the nasal 150° of ciliary processes to induce shrinkage of the processes and facilitation of aqueous outflow. Intracameral diluted kenalog [1 mg/cm^3 diluted with BSS (50:50)] was injected at the end of the procedure into the ciliary sulcus following ECP. Injection of kenalog into the sulcus was performed to allow for maximal number of kenalog particles contacting the ciliary process, thus exerting a prolonged anti-inflammatory effect.

All patients received the same postoperative antibiotic and steroid regimen of moxifloxacin four times daily for 1 week and prednisolone acetate 1% eight times daily for 1 week, followed by a taper of prednisolone over 1 month.

Eyes with a minimum of 12 months of follow-up after surgery were included. Age, race, gender, preoperative and postoperative visual acuity (VA), IOP, and number of glaucoma medications up to 12 months of follow-up and any further surgical intervention and postoperative complications were documented for each patient. The preoperative IOP data were measured with glaucoma medications. There was no washout period in this study. Primary endpoints were IOP failure, operative failure, and visual failure, any of which was sufficient to be considered an overall failure. IOP failure was defined as an IOP >18 mmHg with or without glaucoma medications or IOP <6 mmHg at 12 months of follow-up. Operative failure was defined as the need for additional incisional surgery. Visual failure was defined as loss of more than three lines from baseline that is directly related to the surgical procedure. Data were analyzed using paired two-tailed *T*-test. A *P* value <0.05 was statistically significant.

Results

Group 1 included 6 eyes of 6 patients and group 2 included 11 eyes of 10 patients. There were no differences in patient demographics, previous surgery, pre- or postoperative VA, or IOP between the two groups at 12-month follow-up [Table 1].

The change in IOP for both groups is shown in Table 2 and Graph 1. The mean IOP preoperatively was 23.5 ± 11.2 and 24.4 ± 8.2 mmHg for groups 1 and 2, respectively. At 1 month, 3 months, 6 months, and 12 months after surgery, the IOPs of group 1 were 20.6 ± 11.2 (P = 0.679), 11.5 ± 4.7 (P = 0.047), 18.8 ± 15.5 (P = 0.612), and 12.2 ± 1.8 (P = 0.037), respectively. The IOPs of group 2 were 15.5 ± 5.2 mmHg (P = 0.007), 16.7 ± 4.8 (P = 0.015), 14.2 ± 8.2 (P = 0.027), and 15.1 ± 1.6 (P = 0.002). The phaco/GSL/ECP group showed an earlier reduction in IOP during the first 6 months of follow-up compared with the

Table 1: Baseline demographic characteristics of study patients

Variable	GSL/ECP (*n*=11)	GSL (*n*=6)	Z*/T**
Age at surgery, years	60±8	66±9	–1.305**
Gender (%)			
Male	1 (9)	3 (50)	1.616*
Female	10 (91)	3 (50)	–1.616*
Race (%)			
Caucasian	6 (55)	2 (33)	–0.867*
African-American	5 (45)	4 (67)	0.867*
Hispanic	0 (0)	0 (0)	0.000*
Asian	0 (0)	0 (0)	0.000*
Type of glaucoma (%)			
Mild chronic angle closure glaucoma***	0 (0)	6 (100)	
Plateau iris#	-	1 (17)	
Moderate/severe chronic angle closure glaucoma****	11 (100)	0 (0)	
Plateau iris#	7 (64)	-	

GSL: Goniosynechialysis; ECP: endocyclophotocoagulation. *Z-value comparing phaco/GSL only vs phaco/GSL/ECP groups; significant (Z < –1.96 or >1.96 to reject the null hypothesis); **T-value comparing phaco/GSL only vs phaco/GSL/ECP groups (two-tailed T-test); ***Mild chronic angle closure glaucoma defined as optic nerve abnormalities consistent with glaucoma but no visual field abnormalities on any white-on-white visual field test; ****Moderate/severe chronic angle closure glaucoma defined as optic nerve abnormalities consistent with glaucoma and glaucomatous visual field abnormalities in either one or both hemifields; #Plateau iris defined by presence of an anteriorly directed ciliary body, an absent ciliary sulcus, presence of a central flat iris plane, a steep iris root from its point of insertion followed by a downward angulation from the corneoscleral wall, and irido-angle contact on ultrasound biomicroscopy

phaco/GSL group. The IOPs of all patients were normalized by month 12 and were significantly lower than preoperative values for both groups.

Before surgery, the mean visual acuities of group 1 and group 2 were 0.56 ± 0.82 and 0.51 ± 0.63, respectively. There was no statistical difference between these two groups in VA before surgery. VA of all patients in both groups improved significantly following surgery with no differences between the groups [Table 3].

The number of IOP-lowering medications used by patients was reduced from 2.50 ± 1.76 to 1.80 ± 1.64 in group 1 and from 2.82 ± 1.2 to 1.17 ± 0.98 in group 2 [Table 3]. The angle was closed in all cases at presentation with synechiae adhesions 360° in both groups. Following the surgery, eyes in both groups resulted in angles open to greater than 20°. In group 2, patients with plateau iris resulted in iris root deepening following ECP involving the nasal 180°.

No patient in either group experienced any serious intraoperative or postoperative adverse events within 12 months of follow-up. None of the patients developed hypotony, macular edema, or recurrent angle closure formation. The postoperative inflammation was less than 1+ cells and flare that lasted less than 2 weeks in group 1. Group 2 had a more prolonged postoperative inflammation lasting up to 1 month, which was treated with a tapering dose of topical steroid drop (prednisolone acetate 1% × 8 times/day in the first week followed by four times for 4 weeks). Inflammation did not persist beyond 1 month in any patient in either group.

Discussion

CACG is a common cause of significant visual disability. It results in shallow chambers and obstruction of aqueous outflow secondary to angle closure. It is known that cataract extraction alone reduces IOP by opening the anatomical angle and increasing trabecular outflow in patients with narrow angles. However, patients with synechial adhesions and angle closure require additional procedures to achieve the desired IOP reduction. GSL and ECP are safe alternatives to traditional filtering procedures which may be combined with cataract extraction to open the angle and reduce IOP.

Because of the narrow anatomical configuration of the angle in patients with CACG, surgical treatment designed to deepen the anterior chamber and open the TM/SC complex facilitates

Graph 1: Mean intraocular pressure (IOP) before and after phaco/GSL vs. phaco/GSL/ECP from baseline to 12 months. Error bars represent standard deviation

Table 2: Post-Operative Outcomes of phaco/GSL versus phaco/GSL/ECP Groups up to 12 months

IOP (mmHg), mean±SD	GSL (*n*=6)	GSL/ECP (*n*=11)	*P**
Preoperative	23.5±11.2, *n*=6	24.4±8.2, *n*=11	0.870
1 day	22.2±14.6, *n*=5	17.8±12.1, *n*=11	0.568
1 week	19.6±10, *n*=5	16.7±4.9, *n*=11	0.553
1 month	20.6±11.2, *n*=5	15.5±5.2, *n*=11	0.344
3 months	11.5±4.7, *n*=4	16.7±4.8, *n*=11	0.078
6 months	18.8±15.5, *n*=4	14.2±8.2, *n*=6	0.602
9 months	11.3±3.8, *n*=4	13.9±3.4, n=8	0.270
12 months	12.2±1.8, *n*=5	15.1±1.6, *n*=8	0.012
Last follow-up	14.2±2.4, *n*=6	14.5±2.7, *n*=11	0.824
% Reduction from baseline			
Median (IQR)	33.7% (0%-32%)	34.2% (0%-25%)	0.964
Minimum-maximum	0%-64%	0%-68%	

IOP: Intraocular pressure; SD: Standard deviation; GSL: Goniosynechialysis; ECP: Endocyclophotocoagulation

Table 3: Secondary Outcomes of phaco/GSL versus phaco/GSL/ECP Groups up to 12 months

Variable	GSL (*n*=6)	GSL/ECP (*n*=11)	*P**
Preoperative mean logMAR BCVA	0.56±0.82	0.51±0.63	0.908
Mean logMAR BCVA at 6 months	0.36±0.36	0.58±0.48	0.465
Mean logMAR BCVA at 12 months	0.32±0.37	0.38±0.14	0.248
Preoperative mean number of glaucoma medications	2.50±1.76	2.82±1.25	0.701
Mean number of glaucoma medications at 6 months	2.33±1.37	1.88±1.73	0.590
Mean number of glaucoma medications at 12 months	1.80±1.64	1.17±0.98	0.401

GSL: Goniosynechialysis; ECP: Endocyclophotocoagulation; BCVA: Best-corrected visual acuity

recreation of the natural drainage pathway with fewer complications than traditional filtering surgeries. Removal of the natural lens deepens the anterior chamber. GSL opens the TM/SC complex enhancing aqueous outflow, whereas ECP of the ciliary processes decreases aqueous production and further opens the angle, especially in those with plateau iris syndrome, by shrinking the ciliary processes away from the iris root.

The inherent advantages of phaco/GSL/ECP procedure include restoration of the anterior chamber anatomy, quick recovery period, and effective reduction in IOP.[11] Furthermore, if additional IOP reduction is desired, GSL and ECP spare the conjunctiva leaving the opportunity for filtering surgery to be performed if required in the future.

Our results showed that both phaco/GSL and phaco/GSL/ECP lowered IOP significantly. The phaco/GSL/ECP group showed an earlier reduction in IOP during the first 6 months of follow-up. After 12 months, both groups demonstrated comparable IOP reductions. This may indicate that the additional pressure reduction in the phaco/GSL/ECP compared with the phaco/GSL group at 6 months may be secondary to the effects of ECP. This effect from ECP appears to diminish by 12 months. The inherent decrease in TM outflow in patients with CACG can be successfully increased with the simple act of replacing the 4.5-mm natural lens with a 1.2-mm artificial IOL and GSL in most cases. Adding ECP facilitates this by shrinking the ciliary processes away from the peripheral iris. Our study suggests that both techniques safely reduce the IOP at 12 months. While phaco/GSL alone may be a viable surgical option for patients with mild CACG, phaco/GSL/ECP may better benefit patients with more advanced CACG requiring immediate IOP reduction. This needs to be verified by prospective studies with a large cohort of patients.

The IOPs of all patients were normalized by month 12 and were significantly lower than before surgery for both groups. Additionally, both groups demonstrated an increase in VA and a decrease in the number of glaucoma medications postoperatively. No patients experienced complications.

Traditionally, trabeculectomy and aqueous tube shunts have been the primary approaches for patients with moderate to severe CACG with poorly controlled IOP.[12,13] While trabeculectomies and tubes have been shown to significantly lower IOP, they are associated with significant complications.[12] The rate of reoperation in the Tube Versus Trabeculectomy (TVT) study was 9% in the tube group and 29% in the trabeculectomy group at 5 years.[14] These incisional surgeries can result in failure due to scarring, decreased quality of life due to bleb-related foreign body sensation, induced astigmatism, and secondary cataracts.[15]

The incidence of early postoperative complications within the first month after trabeculectomy was 37% in the TVT study and 50% in the Collaborative Initial Glaucoma Treatment Study (CIGTS).[12,16] In a multicenter randomized clinical trial, the Advanced Glaucoma Intervention Study (AGIS) reported the following postoperative complication rates after trabeculectomy: shallow or flat anterior chamber in 17.3%, wound leak in 6.5%, choroidal effusion in 7.9%, anterior chamber bleeding in 11.4%, and encapsulated blebs in 14.1%.[17] The TVT study reported the following postoperative rates: suprachoroidal hemorrhage in 3%, endophthalmitis in 5%, bleb leak in 6%, and cystoid macular edema (CME) in 3%.[14]

GSL and ECP aim to provide a safer, less invasive means of lowering IOP than traditional filtering surgeries and are associated with significantly fewer complications.[5,7-11,18] In patients with mild-to-moderate glaucoma and surgically naive eyes, Siegel *et al*. demonstrated the following postoperative complication rates of phaco/ECP in 261 eyes: CME in 1.5%, retinal detachment in 0.7%, and transient IOP elevations in 8%, without any cases of hyphema, persistent inflammation, or hypotony.[19] The patients in our study did not experience any surgical complications.

The limitations of this study include the inherent weaknesses of all retrospective studies, including a limited patient population, lack of true randomization, selection bias, and confounding. Additionally, the small number of eyes involved in our study may limit our results. Because this was an observational study, we did not perform a preoperative washout of medications and did not control for cessation or continuation of medications.

Conclusion

Overall, our study found that both combined phaco/GSL and phaco/GSL/ECP achieved a significant reduction in IOP in patients with CACG, with no adverse effects at 12 months of follow-up. Future prospective studies are essential to study the relative efficacy of each of the surgical techniques in control of IOP.

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Conflicts of interest

There are no conflicts of interest.

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