Original Article

Cyclophotocoagulation with an illuminated laser probe under a noncontact wide-angle retinoscope: A modified technique of ciliary body photocoagulation

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Purpose: This study aimed to investigate the efficacy of cyclophotocoagulation with an illuminated laser probe under a noncontact wide-angle retinoscope in treating refractory glaucoma. **Methods:** Eleven patients (11 eyes) with refractory neovascular glaucoma were treated with ciliary body photocoagulation. Preoperative and postoperative corrected visual acuity, intraocular pressure (IOP), ophthalmofundoscopy, B-ultrasound and ultrasound biomicroscopy, optical coherence tomography, and fundus fluorescein angiography were performed. **Results:** Preoperative IOP ranged from 45 to 58 mmHg (mean 51.9 mmHg). At postoperative 1, 3, and 6 months, the IOPs ranged between 16 and 33 mmHg (mean 27.1 mmHg), 14–28 mmHg (mean 20.6 mmHg), and 14–28 mmHg (mean 18.5 mmHg), respectively. IOP at the last follow-up (range 7–12 months) was 15–24 mmHg (mean 18.8 mmHg). An average of 63.8% decrease in postoperative IOP was found in these patients with no associated complications. The postoperative fibrotic exudate, anterior chamber hyphema, and exudative choroidal detachment were all well-managed and resolved. No patients experienced intraocular lens deviation or dislocation, hypotonia oculi, atrophy of eyeball, retinal detachment, endophthalmitis, or sympathetic ophthalmia. **Conclusion:** Cyclophotocoagulation with an illuminated laser probe under a noncontact wide-angle retinoscope is a safe and effective technique for the treatment of neovascular glaucoma.

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Refractory glaucoma with uncontrolled intraocular pressure (IOP) is managed with tube-shunt surgery or cyclodestructive procedure.[1,2] Cyclodestructive procedures damage the secretory epithelium of the ciliary body, which reduces aqueous secretion and decreases IOP.[3] Traditionally, these procedures, including cyclophotocoagulation, have been used primarily for pain management in patients with end-stage disease and no remaining vision.[4] However, with the advent of endoscopic cyclophotocoagulation (ECP), complication rates have significantly decreased, and indications for cyclophotocoagulation have remarkably expanded.[5]

Traditional cyclodestructive procedures, such as cyclocryotherapy and transscleral cyclophotocoagulation, can reduce IOP. However, they both carry a significant risk of marked inflammation, hypotonia, and to a lesser extent phthisis.[4-8] ECP is a more recent less invasive technique and is used to treat glaucoma.[9-11] While meta-analyses have shown no significant difference in the clinical efficacy of ECP in comparison to non-ECP techniques, ECP is far more expensive.[12,13] In addition, ECP is potentially associated with a decreased risk of postoperative complications compared with transscleral cyclophotocoagulation.[14] However, the difference in safety and long-term complications remains to be fully evaluated.

Our study aimed to evaluate the efficacy of cyclophotocoagulation with an illuminated laser probe under a noncontact wide-angle retinoscope for the treatment of refractory glaucoma.[15-17]

Methods

Our institutional review board and ethics committee approved the study, and informed consent was obtained from each patient. Patients with a history of refractory glioma were prospectively recruited. The patients [n = 11, Table 1] underwent preoperative assessments of visual acuity, IOP, slit-lamp examination, ophthalmofundoscopy, B-ultrasound and ultrasound biomicroscopy, optical coherence tomography, and fundus fluorescein angiography, if dioptric media permitted. Patients who were deemed to be surgical candidates and consented to the procedure were treated with cyclophotocoagulation with an illuminated laser probe under a noncontact wide-angle retinoscope.

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Surgical technique

All procedures were carried out by a single surgeon. Patients were administered retrobulbar or general anesthesia. If vitrectomy was required due to vitreous hemorrhage or diabetic retinopathy, the patient initially received a conventional 23G/25G three-channel vitrectomy. Cyclophotocoagulation with an illuminated probe under a noncontact wide-angle retinoscope was carried out with a trocar placed above the nose or temporalis. A 23G/25G single-channel trocar was placed 3.5–4.0 mm above the posterior edge of the cornea in patients not requiring a vitrectomy. Cataract surgery was performed first if needed. All procedures were completed using a noncontact wide-angle retinoscope. The surgeon used a constant pressure device to push the sclera upward to expose the ciliary body with one hand and photocoagulated the crown of the ciliary body using the probe with the other hand [Fig. 1]. If the photocoagulation scope was over 180°, another 23G/25G trocar was placed 3.5–4.0 mm posterior to the corneal limbus, forming a 90° angle with the first trocar.

The illuminated laser probe (Synergetics®, Bausch and Lomb, Inc., St. Louis, MO, USA) is an optical fiber with integrated lighting and laser functions and can be connected to various lasers and vitrectomy lighting systems [Fig. 2]. The laser was set to 150–300 mW (532 nm, VISULAS 532s; Zeiss, Germany) and pulsed at intervals ranging between 0.3 and 0.5 s. Photocoagulation was performed after the focus point was adjusted to the ciliary process and was carried out on both the anterior and posterior portions of the ciliary process. The distance of photocoagulation from the ciliary processes was 2–3 mm. The optimal photocoagulation resulted in the ciliary process turning white, collapsing, and wrinkling. The intensity of the laser was adjusted depending on the reaction of the ciliary body to the first attempt of photocoagulation. If the ciliary process bulged after being treated or a "pop" sound was heard, the laser intensity and/or photocoagulation time was decreased, or the distance between the laser and the ciliary process was increased. The laser intensity and photocoagulation time were increased if the ciliary process did not appear to react to the treatment. The degree of photocoagulation ranged between 180° and 360° continuously [Fig. 3]. However, this was adjusted according to the preoperative IOP, any preexisting conditions, or any complications that were encountered during the surgery. If vitrectomy was performed simultaneously, gas–liquid exchange and intraocular tamponade were carried out after

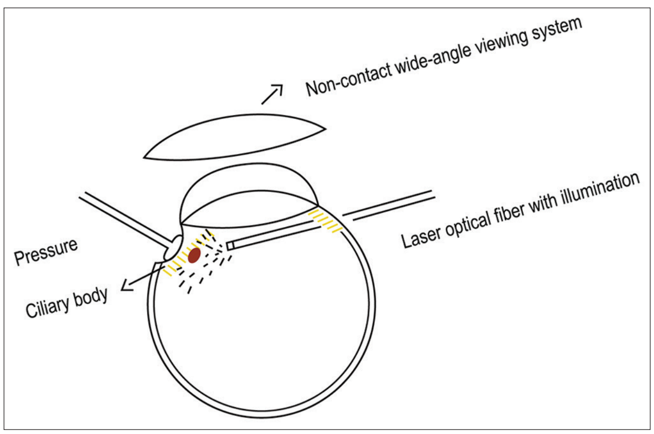

Figure 1: Diagram of the indirect retinoscope in cyclophotocoagulation

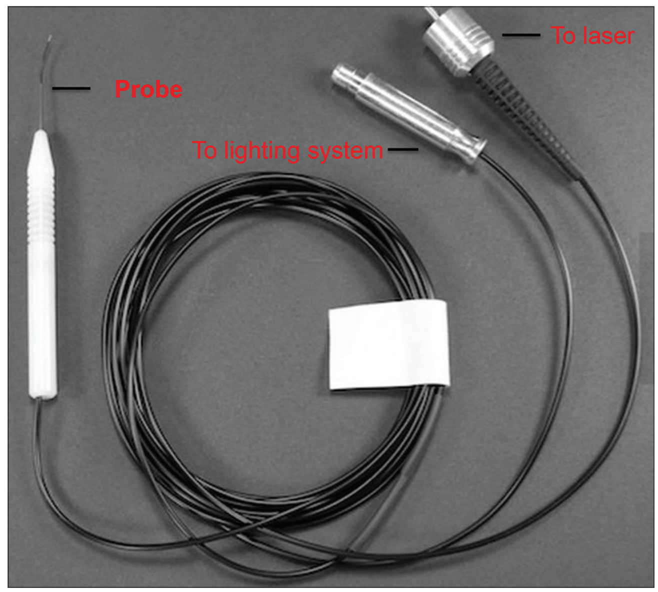

Figure 2: Picture of an illuminated laser probe. It is an optical fiber integrating lighting and laser functions and can be connected to various lasers and vitrectomy lighting systems

Table 1: Patient characteristics and medical history

Patient	Age/sex	Pathomechanism	Previous surgery	Present surgery	Extent of ablation
1	61/M	NVG, DR	PPV, Phaco	ILP CPABL	360°
2	58/M	NVG, DR	PPV, Phaco, ILP	CPABL	270°
3	48/F	NVG, DR	PPV, Phaco, ILP	CPABL	270°
4	65/M	NVG, CRVO	Phaco	ILPC CPABL	180°
5	49/F	NVG, DR	PPV	Phaco, ILP CPABL	360°
6	70/M	NVG, DR	PPV, Phaco	ILP CPABL	270°
7	65/F	NVG, DR	PPV, Phaco	ILP CPABL	360°
8	56/M	NVG, CRVO	Phaco, ILP	CPABL	270°
9	56/M	NVG, DR	PPV, Phaco	ILP CPABL	360°
10	64/M	NVG, DR	PPV, Phaco	ILP CPABL	270°
11	57/M	NVG, DR	PPV	Phaco, ILP CPABL	270°

NVG=Neovascular glaucoma, DR=Diabetic retinopathy, PPV=Pars planavitrectomy, ILP=Illuminating laser probe, CRVO=Central retinal vein occlusion, CPABL=Ciliary body ablation, Phaco=phacoemulsification

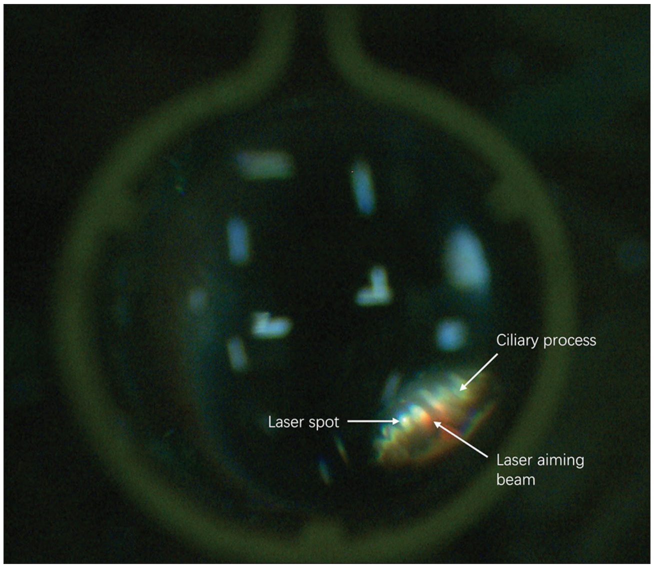

Figure 3: Degree of photocoagulation ranged between 180° and 360° continuously. Operators can observe under a noncontact wide-angle retinoscope, where they push the sclera upward to expose the ciliary body with one hand and photocoagulated the ciliary body using the illuminated laser probe with the other hand

photocoagulation. Then the trocars were withdrawn, and the portals were closed using the 8-0 suture.

Follow-up

The patients were followed up monthly for 7–12 months. If dioptric media permitted, optical coherence tomography was performed four times postoperatively at 1 day, 1 week, 3 weeks, and 6 weeks. Following the procedure, the patients received local corticosteroids, nonsteroidal anti-inflammatory drugs, and antibiotic eye drops. These drugs were discontinued once inflammation of the anterior chamber and vitreous body subsided. During the postoperative 1 week, oral prednisone of 30 mg was administered once daily. An IOP-lowering agent was also used for patients with an elevated IOP. The preoperative medications were continued postoperatively with adjustments based on the IOP.

Statistical analysis

Data were analyzed using SPSS software, version 16.0 (IBM Corporation, Chicago, Illinois, USA). Statistical significance of difference in IOP was calculated by two-tailed *t*-test. A *P* value less than 0.05 was considered statistically significant.

Results

Eleven patients (11 eyes), including eight males and three females age 48–70 years (mean 59 years), with refractory glaucoma were successfully treated [Table 1]. Previous treatments include simple vitrectomy in three patients (27%), phacoemulsification with vitrectomy in five patients (45%), and phacoemulsification with implantation of an intraocular lens in 1 patient (9%). The primary cause of neovascular glaucoma (NVG) was diabetic retinitis in nine patients (81.8%) and central retinal vein occlusion in two patients (18%).

Nine patients received retrobulbar anesthesia and two patients received general anesthesia for the procedure. The mean immediate preoperative IOP was 51.9 mmHg (range 45–58 mmHg). The mean IOP decreased significantly to 27.1 mmHg at 1 month (range 16–33 mmHg), 20.6 mmHg at 3 months (range 14–28 mmHg), 18.5 mmHg at 6 months (range 14–28 mmHg), and 18.8 mmHg at the last follow-up visit (15–24 mmHg). The mean final decrease was 68.2% [Table 2].

Four patients used IOP-lowering agents postoperatively, and their IOP ranged between 16 and 21 mmHg. Another four patients did not require the use of IOP-lowering agents, and none of them experienced ophthalmalgia, headache, or other symptoms. The remaining three patients had an IOP between 22 and 24 mmHg at the last follow-up visit despite the use of IOP-lowering agents both before and after the procedure.

Different degrees of inflammatory reactions were observed. Fibrotic exudates were visible in the pupils of two patients (18.2%) and were absorbed within 1 week. Anterior chamber hyphema appeared postoperatively in three patients (27.3%) and was absorbed 5 days postoperatively. Exudative choroidal detachment occurred in one, and full restoration was achieved in 7 days. At the late stage of follow-up, no patients had intraocular lens deviation or dislocation, hypotonia oruli, atrophy of the eyeball, retinal detachment, end ophthalmitis, or sympathetic ophthalmia.

Discussion

NVG is a severe type of glaucoma and is often secondary to underlying systemic or ocular diseases such as diabetes mellitus or retinal vein occlusion. Treatment of NVG consists of pharmacological treatment with IOP-lowering agents combined with surgical interventions.[18,19] There is no consensus on the optimal surgery for this condition. Trabeculoplasty and trabeculectomy are known to increase filtration and reduce IOP. However, success rates for these procedures vary widely in different studies and remain generally low.[20-22] In addition, they have been associated with complications including ocular hypotony, choroidal detachment, and bleb infections.[23] Use of aqueous drainage implants is another method to decrease IOP through increased filtration. As with filtration surgery, success rates have varied between studies, and treatment effects may decrease over time.[20] A third method is to decrease the production of aqueous humor by destructing the ciliary body. Cyclodestruction is mainly carried out either by cryotherapy or laser photocoagulation, which can be done transsclerally, transpupillary, or endoscopically. Cyclocryotherapy, however, has been associated with a significant loss of vision, hypotony, and phthisis.[19] Although cyclophotocoagulation is associated with vision loss and undertreatment, resulting in failure to reduce IOP, this method is safer and has shown a significantly lower incidence of phthisis and hypotony.[7-9]

Argon laser ablation of the ciliary processes can be applied with an endophotocoagulation probe under direct visualization of the ciliary processes by sclera depression. The greatest challenge with this procedure is that the ciliary processes are difficult or impossible to view *in vivo* except under these unique circumstances.[17,24] Experience with the transvitreal route of ciliary process ablation is limited, and vitrectomy and lensectomy are prerequisites for this method. As viewed through the operating microscope in a low-pressure eye, the endophotocoagulation probe is inserted through a pars plana sclerotomy site. The surgeon's other hand indents the sclera, pushing the ciliary processes into

Table 2: Summary of pre- and postoperative measurements and administered medication

Patient	Preop. IOP (mmHg)	1 mo. IOP (mmHg)	3 mo. IOP (mmHg)	6 mo. IOP (mmHg)	Final IOP (mmHg)	Preop. meds	Postop. meds	Follow-up (mo.)
1	56	24	16	15	18	T, ProP, CAI, P	P	12
2	48	31	20	21	20	T, ProP, CAI, P	P	8
3	51	28	17	19	16	T, ProP, CAI	-	10
4	45	30	26	19	22	T, ProP, CAI, P	P	11
5	57	16	18	20	17	T, ProP, CAI, P	CAI	7
6	45	26	18	20	23	T, ProP, CAI, P	P	7
7	58	33	28	18	18	T, ProP, CAI, P	-	9
8	54	28	28	15	24	T, ProP, CAI, P	CAI, P	8
9	56	21	17	16	18	T, ProP, CAI, P	CAI	8
10	46	32	26	28	15	T, ProP, CAI, P	-	10
11	55	29	14	13	16	T, ProP, CAI, P	-	11

IOP=Intraocular pressure, T=Mannitol, ProP=Propine, CAI=Carbonic anhydrase inhibitor, P=Prostaglandin

view in the papillary space and allowing for microscopic visualization during photocoagulation. This technique, however, is extremely difficult and requires a clear cornea, a low-pressure eye, a widely dilated pupil, and a highly skilled surgeon.[14,16,17] The 810 diode red laser is used for transscleral photocoagulation of the ciliary process, whereas the 532 green laser is used for photocoagulation of the ciliary process under naked eyes.

Intraocular drainage device implants and cyclophotocoagulation are the most common clinical interventions. With the development of ophthalmoendoscopy and laser techniques, ECP has become one of the main treatment modalities for refractory glaucoma. ECP is both safe and effective,[12,25-29] but also has some limitations. The ophthalmoendoscope system is expensive without stereo perception and has a long learning curve for operators.

In our study, we propose a modified technique for ciliary body photocoagulation with an illuminated laser probe under a noncontact wide-angle retinoscope. This technique achieved an average decrease of 68.2% in IOP. Surgical visualization is obtainable directly through a noncontact wide-angle retinoscope in which the ciliary body can be exposed by slightly pressing against the sclera, and cyclophotocoagulation can be completed directly through the 23G/25G single channel for patients who do not need to undergo vitrectomy. Our technique delivers results with stereo perception. Cyclophotocoagulation can be implemented during vitrectomy, which can be done through 23G/25G channel. Our technique has a more stereo vision than ECP and therefore is easier to learn. In addition, our technique requires less equipment than ECP.

Conclusion

Therapeutic interventions of NVG remain a challenge as current treatment options have shown varying degrees of success rates and high incidences of complications. Our modified technique of cyclophotocoagulation is safe and effective for reducing IOP. Compared with ECP, our technique is less dependent on special equipment and surgeon skills.

Contribution details

QYY and BC participated in conception and design, performed experiments, collected and assembled data, involved in data analysis, interpretation, and article writing. JH and LSC performed experiments and collected data. ZSB contributed to data analysis and interpretation. All authors approved the final version of the article.

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Conflicts of interest

There are no conflicts of interest.

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