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Gonioscopy-Assisted Transluminal Trabeculotomy (GATT) in Patients with Secondary Open Angle Glaucoma following Vitreoretinal Surgery

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Introduction

Trabeculotomy is a blebless surgical procedure intended to lower the intraocular pressure (IOP) by increasing the outflow of aqueous humor through Schlemm's canal and the collector channels.[1] Trabeculotomy has evolved over the past decade from an ab externo procedure[2–6] to a micro incisional ab interno procedure performed with sutures or microcatheters.[1,7]

Gonioscopy-assisted transluminal trabeculotomy (GATT) is a conjunctiva-sparing trabeculotomy approach introduced in 2014.[8] It has been shown to effectively lower glaucoma medication burden and IOP in primary, juvenile, and secondary open-angle glaucomas.[1,8,9] It combines the advantages of goniotomy by being a conjunctiva-sparing procedure with that of filament trabeculotomy by allowing the circumferential treatment of the entire angle.

Currently, there are no reports on the utility of GATT in the treatment of secondary open-angle glaucoma attributed to prior vitreoretinal surgery. The surgical management of retinal disorders, including scleral buckling procedures, pars plana vitrectomy (PPV), and intravitreal injections of gas or silicone oil, can lead to short-term elevations in IOP and long-term glaucomatous damage.[10] The incidence of glaucoma after uncomplicated PPV range from 15–20%.[10] The exact pathogenesis of glaucoma after vitrectomy is unknown and glaucoma in these cases is commonly refractory to conventional therapies. [11] The purpose of this report is to examine the efficacy and safety of GATT in a series of patients who developed glaucoma following PPV.

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Materials and Methods

A retrospective case series was conducted of consecutive patients age 18 years and older with secondary open-angle glaucoma following PPV who underwent GATT by a single surgeon at Bascom Palmer Eye Institute between January 1st, 2015 and June 30th, 2019. The study complied with the requirements of the United States Health Insurance Portability and Accountability Act. The study was approved by the University of Miami Institutional Review Board and abided by the Declaration of Helsinki.

Patients were identified using Current Procedure Terminology codes for “goniotomy,” “trabeculotomy,” and/or “transluminal dilation of aqueous outflow canal; without retention of device.” Records were reviewed and included for analysis if the procedure involved an ab interno incision of the trabecular meshwork followed by the cleavage of the meshwork using a filament device (either a blunted suture, a retractable filament device or an illuminated microcatheter, with or without viscodilation) in eyes with elevated IOP directly attributed to recent vitreoretinal surgery. Eyes were excluded if there was insufficient description of the surgical techniques for inclusion, post-operative follow-up less than 1 month, history primary anterior segment dysgenesis syndromes, and eyes with glaucoma diagnosed prior to vitreoretinal surgery. Basic demographic information including age, gender, laterality, and primary diagnosis was recorded. The postoperative follow-up schedule was 1 day, 1 week, 3 weeks, 3 months, and 6 months. Pre- and post-operative IOP, number of glaucoma and anti-inflammatory medications (topical agents and oral carbonic anhydrase inhibitors) were recorded. SPSS version 25 was used to complete the statistical analysis.

Results

Eight patients were identified. Demographic and ocular characteristics, the extent of trabeculotomy and mean preoperative and final postoperative IOP are presented in Table 1. Gonioscopy was performed in all eyes during the preoperative visit and the angle was noted to be open. All patients developed elevated IOP >30 mmHg and secondary open-angle glaucoma following PPV with the use of gas or silicone oil tamponade. Five of the eight eyes (62.5%) had silicone oil in the vitreous cavity during GATT, none of which had concurrent oil removal. All patients had at least 50% reduction in IOP compared to preoperative IOP at the last follow-up visit (1–25 months; median 4). The average preoperative IOP was 32.7 ± 5.1 mmHg and postoperative IOP was 13.6 ± 1.8 mmHg (p-value < 0.001). The average number of IOP-lowering medications preoperatively was 4.8 ± 0.9 and postoperatively was 1.6 ± 1.4 (p-value <0.001). Aside from a transient IOP elevation and hyphema in the first month following GATT, all hemorrhages have resolved by one month following surgery and there were no long-term complications.

Discussion

To the authors’ knowledge, there are no prior studies on the utility of GATT in the treatment of secondary open-angle glaucoma after PPV, and this is the first study to show the safety and efficacy of GATT in this specific population. In this series of 8 patients, after

undergoing circumferential trabeculotomy, all patients achieved at least 50% reduction in IOP compared to preoperative IOP.

PPV is frequently performed in the treatment of many vitreous and retinal diseases.[10] PPV has been suggested as a risk factor for the development of secondary open-angle glaucoma.[10–12] The exact pathogenesis of late-onset glaucoma after vitrectomy is unknown. Chang postulated that the main reason for the development of glaucoma relates to the diffusion of oxygen from the vitreous cavity to the anterior chamber.[10] Increased molecular oxygen in the anterior chamber angle of post-vitrectomy patients causes alterations in the trabecular meshwork by inducing oxidative stress, ultimately leading to reduced aqueous outflow and a resultant increase in IOP.[13]

Furthermore, intravitreal silicone oil can be used as an adjunct in the surgical repair of complex retinal detachments, especially in eyes with proliferative vitreoretinopathy. The true incidence of glaucoma after silicone oil injection is difficult to ascertain. The rates of elevated IOP or glaucoma range from 2.2% at 6 months to 56% at 8 months, with more recent studies reporting lower rates, likely as a result of improvements in surgical techniques and materials.[14] Higher viscosity silicone oil (5000 centistokes) has been postulated to result in fewer emulsified silicone droplets in the anterior chamber and a lower risk of glaucoma.[15]

If IOP elevation develops after PPV, topical medical therapy with aqueous suppressants are generally used as first-line treatment. In a study by Al-Jazzaf et al., 78% of patients (40 of 51) with glaucoma after PPV and silicone oil injection were treated successfully with medications alone at 12 months.[14] The IOP was controlled in most eyes with topical beta-blockers and prostaglandin analogs.[14] Other treatment options include selective laser trabeculoplasty and transscleral cyclophotocoagulation.[16,17]

Furthermore, filtering and glaucoma drainage device (GDD) surgery may be indicated if medical and laser therapy does not adequately control IOP. Trabeculectomy with mitomycin C is a widely performed glaucoma surgery, but success depends on bleb survival, and conjunctival scarring after ocular surgery is a major risk factor for surgical failure.[18] In a recent study by Inoue et al., higher preoperative IOP and neovascular glaucoma were identified as prognostic factors for surgical failure of trabeculectomy with mitomycin C in vitrectomized eyes.[19] Glaucoma drainage implants offer a good surgical option in cases of refractory glaucoma associated with silicone oil, but there is also a possibility of oil escape via the drainage tube.[20,21]

The benefit of silicone oil removal in patients with elevated IOP remains controversial. The success of IOP lowering after removal of silicone oil has been reported to range from 0 to 93.4%.[22,23] The decision as to whether to concomitantly remove the silicone oil depends on an assessment of the relative risk of redetachment with oil removal. In this case series, the patients in case 1,5, and 6 had persistent IOP elevation after silicone oil removal and subsequently underwent GATT in the affected eye with sufficient IOP reduction.

The ability to cannulate and cleave the trabecular meshwork without violating the conjunctiva is a major advantage. The procedure does not cause scarring of the conjunctiva and therefore preserves the tissue for future bleb-forming procedures if they are needed in

the future. In patients with prior scleral buckling and vitrectomy, there may be significant conjunctiva scarring that may compromise the efficacy of ab externo angle procedures. With the use of new procedures and technology, patients may potentially avoid the major complications common to traditional glaucoma surgeries (such as tubes and trabeculectomies), without sacrificing IOP-lowering efficacy.

Limitations in the study include modest sample size and limited follow-up, given the novel nature of GATT in eyes following vitreoretinal surgery. While the long-term IOP-lowering benefits of GATT in this patient cohort remain uncertain, its excellent safety profile and short-term efficacy makes it an attractive alternative to traditional bleb-forming glaucoma procedures. This study also has weaknesses inherent to all retrospective clinical studies. The decision for surgical intervention was purely at the individual surgeon's discretion. Given the relatively low incidence of secondary open-angle glaucoma following PPV, a prospective study would be challenging.

In conclusion, vitreoretinal surgery is a known risk factor for IOP elevation and progressive glaucomatous damage, and therefore, clinicians must closely monitor these patients postoperatively. Depending on the procedure performed, patients may respond to medical therapy, but laser or glaucoma surgery may be required in some cases. The improved safety profile in GATT compared to traditional bleb-forming procedures makes this an attractive option when faced with open-angle IOP elevation following vitreoretinal surgery, even though potential complications such as prolonged spillover hyphema into the posterior chamber, iatrogenic exacerbation of phacodonesis/lens subluxation and unintentional evacuation of silicone oil into the anterior chamber should be considered. This case series demonstrates that GATT is a safe and effective treatment modality for patients with secondary open-angle glaucoma following PPV.

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Table 1.

Patient demographic and ocular characteristics.

Patient/Eye	Age at surgery (years)	Sex	Prior vitreoretinal procedure	Extent of angle treated (degrees)	Surgical technique	Pre-op VA	Final VA	Pre-op IOP (mmHg)*	Final IOP (mmHg)*	Final % IOP reduction	Pre-op #meds**	Final #meds**	Follow up duration (months)
1/OD	61	M	SB, PPV, oil	360	IMC	HM	CF	24	10	60	5	2	25
2/OD	24	F	SB, PPV, oil	360	IMC	20/20	20/20	40	12	70	5	3	19
3/OD	72	F	PPV, gas,	360	IMC	20/50	20/30	31.5	15	50	5	0	1
4/OD	58	F	SB, PPV, oil	360	IMC	CF	CF	33	14	53	6	0	5
5/OS	18	M	SB, PPV, oil	360	IMC	20/150	20/200	35.3	14	60	5	3	3
6/OD	48	M	PPV, oil	360	IMC	20/200	20/40	30	15	50	3	3	4
7/OD	39	M	PPV, gas	360	BPS	20/20	20/20	38	14	63	4	0	4
8/OD	33	M	PPV, gas	360	IMC	20/60	20/50	30	15	50	5	2	8

Key – BPS (blunted polypropylene suture); CF (count finger), F (female), HM (hand motion), IMC (illuminated microcathether), IOP (intraocular pressure), M (male), PPV (pars plana vitrectomy), OD (right eye), OS (left eye), SB (scleral buckle), SD (standard deviation), #meds (number of medications)

*Pre-op IOP mean 32.7 ± 5.1 mmHg; final IOP mean 13.6 ± 1.8 mmHg (p value < 0.001)

**Pre-op #meds mean 4.8 ± 0.9, final #meds mean 1.6 ± 1.4 (p value <0.001)