• Brief Report •

Gonioscopy-assisted transluminal trabeculotomy in the management of uncontrolled Posner-Schlossman syndrome: a retrospective study

Lin Jing, Yu He, Han-Ying Fan, Su-Zhen Wang, Mei Xin, Liu-Zhi Zeng

Department of Ophthalmology, Chengdu Integrated TCM&Western Medicine Hospital, Chengdu 610041, Sichuan Province, China

Correspondence to: Liu-Zhi Zeng. Chengdu Integrated TCM&Western Medicine Hospital, No.18, Wanxiang North Road, High-tech Zone, Chengdu 610041, Sichuan Province, China. 676681961@qq.com

Received: 2025-02-07 Accepted: 2025-09-29

Abstract

● **AIM:** To explore the efficacy and safety of gonioscopy-assisted transluminal trabeculotomy (GATT) in the treatment of Posner-Schlossman syndrome (PSS).

● **METHODS:** A retrospective review was conducted on participants diagnosed with PSS and uncontrolled intraocular pressure (IOP) who underwent GATT between 2023 and 2024. Clinical outcome measures including visual acuity, IOP, gonioscopic findings, complications, and relapses were collected for postoperative visits: 1d, 1wk, 1, 3, 6mo and 1y.

● **RESULTS:** Eleven participants (mean age 43.00±13.82y, 5 females and 6 males) were enrolled. Nine participants were followed up for 12mo after the surgery, 1 participant underwent trabeculectomy to decrease the uncontrolled IOP, another participant was followed up for 6mo because of loss of follow-up. The mean IOP before GATT was 33.64±6.21 mm Hg (range: 23–46 mm Hg). The mean number of antiglaucoma medications prior to surgery was 2.73±0.66. At 6mo after the surgery, the mean IOP decreased to 17.36±6.17 mm Hg (47.15%±17.35% reduction). Nine participants were followed up for 12mo, and their mean IOP decreased to 16.22±2.49 mm Hg, with an average IOP reduction of 46.83%±16.93% (P<0.01). The number of anti-glaucoma medications significantly decreased to 0.91±0.83 at the last follow-up (P<0.05). Two eyes were considered treatment failures due to reintervention and uncontrolled IOP. The preoperative IOP of qualified success cases were significantly lower than that of failed cases. The most common complications were intraoperative anterior chamber blood reflux (100%) and IOP spikes (45.45%), both of which resolved within 1wk. During the follow-up period, 7 participants experienced recurrent attacks of PSS. Nevertheless, peak IOP during relapse was significantly reduced compared to preoperative values (P<0.05).

● **CONCLUSION:** GATT seems to be a reliable and effective method for the management of PSS with uncontrolled IOP. Higher preoperative IOP maybe the factor of surgical failure. Although it may not prevent relapse of PSS, it might potentially reduce the peak IOP. Longer-term follow-up and a larger sample size are recommended for more in-depth analysis.

● **KEYWORDS:** gonioscopy-assisted transluminal trabeculotomy; Posner-Schlossman syndrome; trabeculotomy

DOI:10.18240/ijo.2026.10.23

Citation: Jing L, He Y, Fan HY, Wang SZ, Xin M, Zeng LZ. Gonioscopy-assisted transluminal trabeculotomy in the management of uncontrolled Posner-Schlossman syndrome: a retrospective study. *Int J Ophthalmol* 2026;19(10):2076-2082

INTRODUCTION

Posner-Schlossman syndrome (PSS), also known as glaucomatocyclitic crisis, was first published by Posner and Schlossman[1] in 1948. It is a unilateral ocular disorder characterized by recurrent episodes of acute nongranulomatous anterior uveitis and increased intraocular pressure (IOP)[1]. The condition tends to affect young men between 20 and 50 years of age. It usually causes only minor eye discomfort, accompanied by a few fine white keratic precipitates (KP) and mild anterior chamber inflammation. The IOP will be elevated to as high as 40–60 mm Hg during an attack, and gonioscopy will show an open angle. PSS is usually self-limited and lasts from days to weeks. Treatment is aimed at IOP and intraocular inflammation reduction. Recent reports have shown that viral and bacterial infection play a pathogenic role in some PSS participants[2-5].

Although PSS was initially considered to be benign at first, long-term research shows that repeated attacks might lead to secondary glaucomatous optic nerve changes. An increase of IOP caused by some episodic changes in the trabecular meshwork may occur during the intermission stage, accompanied by permanent glaucomatous damage[6] and loss of corneal endothelial cells[7]. To prevent further optic nerve damage and visual field defects, surgical interventions should be selected when there is uncontrolled IOP or progressive glaucomatous damage. Trabeculectomy is considered to be an effective treatment for PSS, but postoperative complications associated with filtering procedures and scarring of the filtering channel may lead to surgical failure. The aim of this study is to investigate the efficacy and safety of gonioscopy-assisted transluminal trabeculotomy (GATT) in a series of participants diagnosed with PSS and uncontrolled IOP.

PARTICIPANTS AND METHODS

Ethical Approval The procedures were in accordance to the Declaration of Helsinki and the International Code of Medical Ethics. This study was approved by the Medical Ethic Review Committee of Chengdu Integrated TCM&Western Medicine Hospital (YJS No. 040, 2023). Written informed consent for publication of their clinical details and clinical images was obtained from the participants.

Participants This study was a retrospective analysis of 11 participants (5 females and 6 males) diagnosed with PSS and uncontrolled IOP at Chengdu Integrated TCM&Western Medicine Hospital who underwent GATT by a single surgeon between 2023 and 2024.

All surgery participants were identified by the following selection criteria: 1) mild recurrent episodes of acute nongranulomatous anterior uveitis; 2) IOP elevated to 30–60 mm Hg during an attack; 3) only minor eye discomfort, no nausea, vomiting, or headache; 4) accompanied by a few fine white KP; 5) gonioscopy showing an open angle; 6) accompanied by uncontrolled IOP with or without progressive glaucomatous damage.

Surgical Procedure All surgery were performed by a single surgeon. Participants can use either a microcatheter or a 5-0 nylon suture according to their individual situation. Topical proparacaine 0.5% was applied preoperatively, and standard sterile preparations were performed. An anterior chamber tap was performed to analyze cytomegalovirus (CMV) by high-throughput sequencing method in all participants with their permission. After making an inferior temporal and a superior nasal limbal paracentesis by a 15° microsurgery knife, a 1.8 mm incision was created in the superior temporal cornea, then the anterior chamber was filled with a viscoelastic agent (sodium hyaluronate). A surgical gonioscope was used to observe the trabecular meshwork. Schlemm's canal was incised by 2 mm on the nasal side using a microsurgical blade. The tip of a microcatheter or a 5-0 nylon suture was placed into the anterior chamber. The viscoelastic agent was used to expand the incision at Schlemm's canal. The rounded tip of a microcatheter or a 5-0 nylon suture was then inserted into Schlemm's canal using 23-gauge forceps and was advanced through the canal circumferentially 360°. The tip was pulled out through the same opening. The microcatheter was then withdrawn to tear trabecular meshwork exposing the external wall of Schlemm's canal, providing an up to 360° trabeculotomy. The viscoelastic material and blood were then removed from the anterior chamber. Postoperatively, oral *Callicarpa nudiflora* was prescribed for 3d to reduce hyphema, topical steroid eye drops (prednisolone acetate) were prescribed 4 times daily for a week and 2 times daily for another week. Topical levofloxacin were used 4 times daily for 2wk, nonsteroid anti-inflammatory drugs were administered 4 times daily for 3mo. To prevent peripheral anterior synechia (PAS) and relapse, pilocarpine 2% was used 3 times daily a week after surgery and lasted for 3mo. Topical ganciclovir gel was applied 4 times daily for 6wk as an antiviral therapy. The IOP-lowering medications were reintroduced as required in physician's judgment.

Postoperative Follow-up Clinical information was collected for the following postoperative visits: 1d, 1wk, 1, 3, 6mo and 1y. At each follow-up visit, the following data were collected: visual acuity, IOP, number of glaucoma medications, gonioscopic findings, complications and relapses. Effect judgments: 1) Complete success: IOP under 21 mm Hg without any postoperative use of antiglaucoma medication; 2) Qualified success: IOP under 21 mm Hg with antiglaucoma medications. 3) Failure: Need for repeated surgery for glaucoma, persistent elevated IOP over 21 mm Hg despite medical therapy, or persistent hypotony (IOP<5 mm Hg).

Statistical Analysis Clinical data were analyzed by SPSS 25.0 software. Comparisons of pre- and postoperative IOP, medication number, and visual acuity were performed using a Wilcoxon signed-rank test, Kaplan-Meier methods was conducted to calculate cumulative rates of success. One way analysis of variance (ANOVA) analysis was used to compare age, duration of PSS, preoperative IOP, mean best-corrected visual acuity (BCVA), peak IOP, duration of elevated intraocular pressure (EIOP) and times of occurrence in the complete success cases with the qualified success cases and failed cases, Fisher's exact test was used to analyze the number of participants in three groups, $P<0.05$ was considered to be statistically significant.

RESULTS

Table 1 describes the mean age, sex, mean history of PSS, previous history of procedure, preoperative IOP, preoperative BCVA, number of anti-glaucoma medications, cup/disc

ratio, peak IOP, duration of EIOP and frequency. Two of the participants had previously undergone trabeculectomy, and all the participants were followed for 10.55±2.12mo (Table 1).

A 360° trabeculotomy was typically achieved in all eyes included in the study, with two eyes using a 5-0 nylon suture. The mean preoperative IOP was 33.64±6.21 mm Hg, which decreased to 16.36±3.64 mm Hg on postoperative day 1 (reduction: 48.19%±19.08%, P<0.01). Five participants experienced IOP spikes (>30 mm Hg) within 2wk, which normalized within one week with medication. Nine participants were followed for 12mo, mean IOP was 16.22±2.49 mm Hg (reduction: 46.83%±16.93%, P<0.01). Two participants with previous trabeculectomy developed elevated IOP due to bleb scarring and decreased to normal levels after GATT. Figure 1 shows ultrasound biomicroscope and slit lamp photograph gonioscopy images 6mo after surgery. Table 2 illustrates the significant reduction in IOP throughout the follow-up period.

The mean number of antiglaucoma medications decreased significantly from 2.73±0.66 preoperatively to 0.91±0.83 at the last follow-up (P<0.05). Visual acuity showed no significant change (P>0.05; Table 3). One participant with 30-year history of PSS required trabeculectomy at 8mo due to uncontrolled IOP of 32 mm Hg, progressive optic nerve damage and PAS formation despite maximal medical therapy. Another participant experienced recurrence at 3mo, with IOP reaching 25 mm Hg despite medication, and was lost to follow-up. Six eyes achieved IOP<21 mm Hg without medication. Therefore, the complete and qualified success rates were 54.5% and 81.8% respectively, at the last follow-up. Figure 2 shows the Kaplan-Meier curve shows the cumulative proportion of eyes that met the definition of success, with failures occurring at 3 and 8mo. Tables 4 and 5 compared the age, duration of PSS, preoperative IOP, mean BCVA, peak IOP, duration of EIOP, times of occurrence, gender, CMV infections and post operative recurrence in the complete success cases with the qualified success cases and failed cases. Preoperative IOP was significantly lower in the qualified success group than in the failure group. Other factors showed no significant differences. However, participants who achieved complete success seem to have a much lower CMV infection positivity rate.

Table 6 represents the complications, the most common complication was intraoperative anterior chamber blood reflux, which occurred in 11 eyes (100%). Postoperative transient hyphema occurred in 2 eyes (18.18%), resolving within 1wk. IOP spikes were seen in 5 eyes (45.45%), administration of antiglaucoma medications reduced IOP to normal within 1wk. No incidences of hypotony, shallow anterior chamber, choroidal detachment or infection were noted. Two eyes were considered failures due to the reintervention and uncontrolled IOP.

Table 1 Baseline characteristics of participants

Characteristics	Data
Age (y)	43.00±13.82 (11–67)
Sex (male/female)	6/5
Right/left eye	6/5
Duration of PSS (y)	6.91±6.58 (1–30)
Previous history of procedure	2 (trabeculectomy)
Months followed (mo)	10.55±2.12 (6–12)
Preoperative IOP (mm Hg)	33.64±6.21 (23–46)
Mean BCVA (logMAR)	0.22±0.27
Medication number	2.73±0.66 (2–4)
Cup/disc ratio	0.57±0.13 (0.2–0.95)
Peak IOP, mm Hg (mean±SD)	47.73±4.60 (38–58)
Duration of EIOP (d)	13.00±7.28 (7–30)
Frequency (times per year)	3.62±1.37 (1–6)

Data are presented as the mean±SD (range). IOP: Intraocular pressure; BCVA: Best-corrected visual acuity; logMAR: Logarithmic minimum angle of resolution; EIOP: Elevated intraocular pressure; PSS: Posner-Schlossman syndrome; SD: Standard deviation.

Table 2 Course of IOP and reduction of IOP from baseline mean±SD

Time after surgery	IOP (mm Hg)	Reduction from baseline (%)	P	Eyes (n)
Day 1	16.36±3.64	48.19±19.08	0.003	11
Week 1	19.60±7.65	52.77±25.93	0.005	11
Month 1	16.00±3.22	50.96±11.52	0.003	11
Month 3	19.55±6.61	39.90±21.31	0.003	11
Month 6	17.36±6.17	47.15±17.35	0.003	11
Year 1	16.22±2.49	46.83±16.93	0.008	9

P value for comparison of postoperative *vs* preoperative IOP using the Wilcoxon signed-rank test; IOP: Intraocular pressure; SD: Standard deviation.

Among the 11 participants who had high-throughput sequencing of aqueous humor samples, 7 of them (63.6%) were positive for CMV. At the last follow-up, relapses were noted in 7 eyes (63.6%) with the presence of KP and elevated IOP while 6 of them were positive for CMV. Peak IOP during relapse was significantly reduced compared to preoperative values (P<0.05). The duration of EIOP and recurrence frequency decreased slightly but not significantly after surgery (Table 7). Among the 7 relapsed eyes, 5 eyes IOP reduced to normal with administration of antiglaucoma medications by 1wk.

DISCUSSION

The mechanisms of IOP in PSS are still not clear, increased production of aqueous humor and a reduced coefficient of outflow might play an important role. Animal experiments have shown that prostaglandin (PG) in aqueous humor increases during PSS attack. The vasodilatation of PG may lead to an increase in the permeability of the blood-aqueous barrier[8], thereby increasing the aqueous humor resulting

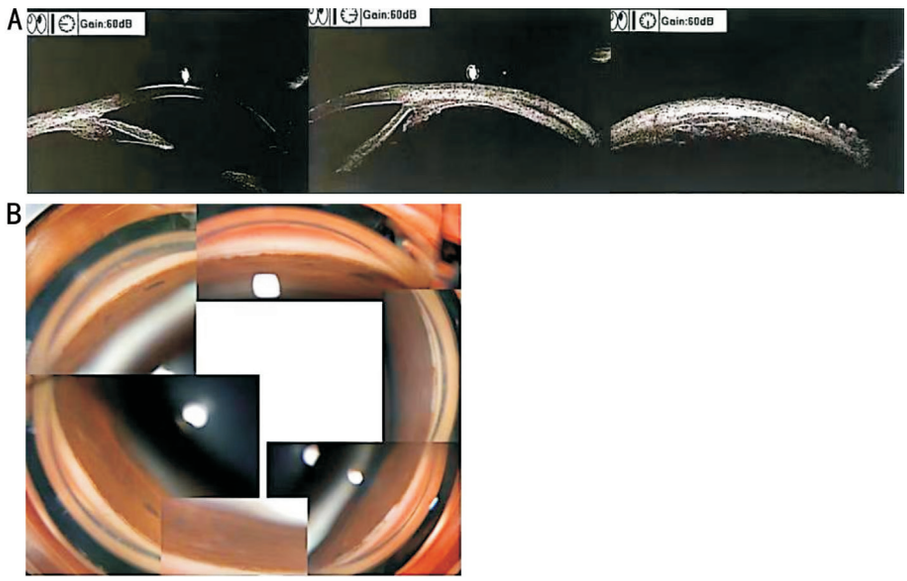

Figure 1 Follow-up at 6mo after surgery A: Ultrasound biomicroscopic image of the operated eye at 6mo post-surgery; B: Gonioscopic slit-lamp photograph of the operated eye at 6mo post-surgery.

Table 3 Number of anti-glaucoma medications and mean best-corrected visual acuity after surgery

Parameters	Preoperation	Last follow-up	*P*	Eyes (*n*)
Anti-glaucoma medications (*n*)	2.73±0.66	0.91±0.83	0.004	11
Mean best-corrected visual acuity (logMAR)	0.22±0.27	0.24±0.31	0.599	11

logMAR: Logarithmic minimum angle of resolution.

Table 4 Age, history of PSS, preoperative IOP, mean BCVA, peak IOP, duration of EIOP and frequency of occurrence in the complete success cases with the qualified success cases and failed cases mean±SD

Groups	Eyes (*n*)	Age (y)	Duration of PSS (y)	Pre-IOP (mm Hg)	Mean BCVA (logMAR)	Peak IOP, mm Hg	Duration of EIOP (d)	Frequency (times per year)
Complete success	6	35.50±14.90	5.67±7.17	35.33±6.89	0.30±0.47	45.00±5.62	14.40±9.40	3.00±1.09
Qualified success	3	59.33±11.59	3.67±2.08	26.00±3.61	0.12±0.16	51.33±5.77	9.33±4.04	3.60±2.08
Failed	2	41.00±19.80	15.50±20.51	40.00±1.41	0.13±0.04	50.50±7.78	18.50±16.26	4.50±2.12
F		2.589	1.098	4.119	0.315	1.389	0.569	0.728
P		0.136	0.379	0.059	0.739	0.304	0.590	0.512

BCVA: Best-corrected visual acuity; EIOP: Elevated intraocular pressure; IOP: Intraocular pressure; PSS: Posner-Schlossman syndrome; logMAR: Logarithm of the minimum angle of resolution; SD: Standard deviation.

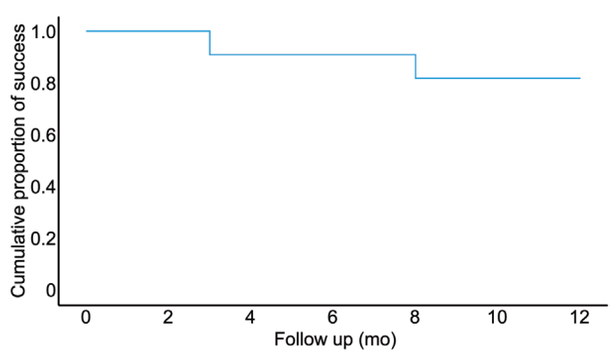

Figure 2 Kaplan-Meier curve representing the cumulative proportion of eyes that met the definition of success.

from ultrafiltration and diffusion. Meanwhile, increased PG inhibits the release of noradrenaline (NE) from sympathetic nerves, antagonizing the biological effects of NE directly. NE is an important medium for regulating the outflow of aqueous humor. The loss of regulation of the trabecular meshwork leads to a decreased of outflow facility and an increased IOP.

However, a previous study showed that inflammatory cells, proteins and inflammation mediators, such as cytokines, in the aqueous humor could lead to obstruction of aqueous outflow[9], and trabecular meshwork edema may also generate IOP elevation in PSS[10]. In addition, steroids are one of the most commonly prescribed drugs in the PSS, they can also play a crucial role in causing elevated IOP, mostly due to the increase of the resistance in the outflow mechanisms of the trabecular meshwork[11-12].

Maruyama *et al*[13] reported a retrospective case-series analysis of 17 participants diagnosed with PSS who underwent trabeculectomy to control IOP. This study found that PSS

Table 5 The gender, CMV infections and post operative recurrence in the complete success cases with the qualified success cases and failed cases

Outcome	Gender (M/F)	CMV infections (-/+)	Recurrence (-/+)
Complete success (*n*=6)	4:2	1:5	2:4
Qualified success (*n*=3)	2:1	2:1	1:2
Failed (*n*=2)	0:2	1:1	1:1
P	0.416	0.288	0.664

Fisher's exact test was used to analyze the gender; CMV infections and post operative recurrence, $P<0.05$ were considered statistically significant; CMV: Cytomegalovirus.

Table 6 Intraoperative and postoperative complications *n* (%)

Complications	Participants
Intraoperative	
Anterior chamber blood reflux	11 (100.0)
Postoperative	
Transient hyphema	2 (18.2)
IOP spike (>20 mm Hg)	5 (45.5)
Procedure failure	2 (18.2)

IOP: Intraocular pressure.

Table 7 Peak IOP, duration of EIOP, and frequency after surgery

mean±SD

Parameters	Preoperation	Post-operation	*P*	Eyes (*n*)
Peak IOP, mm Hg	49.14±6.62	37.71±4.92	0.018	7
Duration of EIOP (d)	16.57±9.69	11.14±8.78	0.109	7
Frequency (times per year)	4.06±1.54	3.50±2.26	0.129	7

IOP: Intraocular pressure; EIOP: Elevated intraocular pressure; SD: Standard deviation.

participants with a higher IOP and progressive visual field defects required glaucoma surgery more often, and these characteristics might indicate a need for surgery. Trabeculectomy is considered to be an effective treatment for uveitic glaucoma[14]. Not only does it decrease IOP, but it reduces inflammation because it can drain the anterior chamber inflammatory cells to the filtering bleb, thereby reducing the severity of uveitis attack[15-16]. Jap *et al*[17] performed trabeculectomy surgery in 9 PSS participants with uncontrolled IOP and progressive visual field defects. They used antimetabolite in the surgery to improve the success rate, and the IOP decreased significantly after surgery at 37mo (6–15 mm Hg). Nine participants reported at least 3–4 recurrences per year before surgery, 6 of them had no recurrence in the first year, 2 participants had 1 recurrence, and 1 participant developed failed filtering blebs and progressive visual field defects after 15 recurrences. Therefore, although trabeculectomy is effective, postoperative complications associated with filtering procedures such as hypotony, wound leak, flat anterior chamber, and choroidal effusion may occur[18]. In addition, subconjunctival fibroblasts, lymphocytes and macrophages in participants with PSS may increase the risk of scarring of the filtering channel and lead to surgical failure[19]. Trabeculectomy with mitomycin C was less effective in maintaining intraocular pressure reduction in uveitic glaucoma (UG) eyes, including PSS, than in primary open angle glaucoma (POAG) eyes[16].

Theoretically, reducing the outflow resistance of aqueous humor at the trabecular meshwork can achieve the purpose of decreasing IOP. Murata *et al*[20] performed surgery in a PSS cohort (10 trabeculectomy, 4 trabeculotomy) with uncontrolled IOP, and the IOP after surgery showed no significant difference between the 2 groups. However, the success rate of trabeculectomy was 90% (9/10), and the success rate of trabeculotomy was 75% (3/4). Pahlitzsch *et al*[21] retrospectively analyzed 7 participants with uncontrolled PSS who underwent 120° Trabectome. After 1y of follow-up, IOP in all participants was reduced to normal levels, the mean number of medications was reduced to 0.8±1.1 from 3.1±0.4 prior to the surgery, and no recurring attack of glaucomatocyclitic crisis occurred. Hence, trabeculotomy and trabectome can also effectively reduce IOP, with a low rate of bleb-related complications, while maintaining more ocular surface structure and function. It has also been reported that *ab interno* trabeculotomy can be used successfully in participants with steroid-induced glaucoma[22].

GATT is a kind of minimally invasive glaucoma surgery (MIGS). Since there was a case report performed by Tang *et al*[23] presenting that GATT could significantly lower the IOP of the PSS participants with uncontrolled IOP. But there were few clinical research looking specifically at the efficacy of GATT for PSS. In our study, we performed circumferential trabeculotomy to reduce the outflow resistance of aqueous humor at Schlemm's canal and trabecular meshwork on a greater scale. Not only does it retain the advantages of trabeculotomy compared with trabeculectomy, but it can also reduce IOP more effectively. Our results showed that the percent lowering of IOP of 11 participants was 47.15%±17.35% at 6mo, and the number of antiglaucoma medications decreased prominently after surgery. Two participants with previously trabeculectomy also achieved the effect of lowering the IOP after GATT. Although intraoperative anterior chamber blood reflux and IOP spike was a common occurrence, they were resolved within 1wk. The postoperative complications typically associated with filtering procedures were not seen. GATT is an effective, minimally invasive procedure with a short time of operation and less complication, so it seems to be an appropriate choice for the management of PSS with uncontrolled IOP. Two participants were considered failures because of the reintervention and uncontrolled

IOP. The clinical features of the complete success cases, qualified success cases and failed cases were compared to identify the risk factor of GATT failure, our data showed that the preoperative IOP of qualified success cases were significantly lower than that of failed cases, Therefore, the higher preoperative IOP maybe the factor of surgical failure, meanwhile a high CMV infection positivity rate appears to be a potential risk factor for GATT failure in participants with PSS.

In our study, 7 participants were positive for CMV which was similar to the previous research[24], it was reported that the PSS surgical-requiring participants had higher rate of CMV infection than the non-surgical participants[13], topical ganciclovir gel was applied four times daily for 6wk in our study, there were 6 participants who still had relapse with KP increase at 1y after surgery. Previous studies have shown that the use of antivirals in participants with PSS were effective for lower the recurrence rate, clearing the viral load, assisting the IOP control, and preserving the corneal endothelium[25-27]. In our study, we choose the topical ganciclovir administration as a relatively economical option, however, some investigators have reported that systemic therapy is more effective in controlling inflammation than topical therapy, possibly because a higher therapeutic concentration of ganciclovir is maintained in the aqueous humor. The high frequency of CMV recurrence has led some investigators to recommend an extended course of antiviral therapy, however, other have suggested that long-term use leads to CMV-resistant strains and systemic side effects. the maintenance therapy should not exceed 6mo in order to control CMV virus replication while reducing the risk of relapse[28]. In conclusion, a systemic therapy and a longer-term continuation of topical antivral treatment may be needed for our participants.

A slight reduction in peak IOP and duration of EIOP after surgery was noted in our study, but it showed no obvious statistical significance because of our small sample size. Ye *et al*[29] also reported that the mean peak IOP during attacks and episodes in participants with PSS was decreased after penetrating canaloplasty, which was similar to our results. It can be assumed that the effect of lowering peak IOP can be achieved by removing the resistance of the trabecular meshwork and internal wall of Schlemm's canal. In addition, the outflow of inflammatory mediators, including prostaglandin, increased after GATT. The effect of prostaglandin and other inflammatory mediators on aqueous humor production and the TM were reduced, making the IOP easier to be controlled. These cases are still being followed up, more research is needed to confirm the theory.

In conclusion, our study shows that GATT should be a safe and effective method for the management of glaucomatocyclitic crisis with uncontrolled IOP. However, our study had some inevitable limitations due to lack of the control group, the small sample size and the retrospective design.

ACKNOWLEDGEMENTS

Authors' Contributions: Jing L: Writing-original draft (main manuscript text); He Y: Methodology; Fan HY: Conceptualization; Wang SZ: Formal analysis; Xin M: Conceptualization; Zeng LZ: Writing-review & editing.

Data Availability Statement: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

AI-Generated Content Disclosure: During manuscript preparation, Doubao was used only for English language polishing and grammatical revision. All intellectual content of this manuscript was produced solely by the authors, who have fully reviewed and approved the final version of the manuscript and take full responsibility for its content.

Conflicts of Interest: Jing L, None; **He Y,** None; **Fan HY,** None; **Wang SZ,** None; **Xin M,** None; **Zeng LZ,** None.

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