Combined Phacoemulsification With Goniosynechialysis Under Ophthalnic Endoscope for Primary Angle-closure Glaucoma After Failed Trabeculectomy

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Precis: Phacoemulsification with goniosynechialysis under an ophthalmic endoscope (Phaco-OE-GSL) is safe and able to lowering intraocular pressure (IOP) for failed trabeculectomy in primary angle-closure glaucoma with cataract. The larger pupil diameter and younger age are identified as the 2 risk factors for surgical outcome.

Purpose: To investigate the efficacy and safety of combined Phaco-OE-GSL for primary angle-closure glaucoma with cataract after failed trabeculectomy.

Materials and Methods: Twenty-five patients (25 eyes) were enrolled in this retrospective study. IOP, best-corrected visual acuity, and number of glaucoma medications at baseline and each postoperative follow-up visit were recorded. Peripheral anterior synechia (PAS) was recorded using gonioscopy. Binary logistic regression was used to analyze the risk factors of surgical failure.

Results: The mean follow-up duration was 17.9 ± 11.4 months. The mean IOP was significantly lower than the preoperative baseline at all time points (P < 0.001). The mean IOP was reduced from 24.4 ± 6.5 mm Hg at baseline to 14.2 ± 3.0 mm Hg at the last follow-up. The mean preoperative number of glaucoma medications was 2.2 ± 1.2, which reduced to 0.9 ± 1.1 at the last follow-up. The complete success rates at 1 year and the last follow-up were 70.6% and 68%, respectively. The total success rates were 96% and 92%, respectively. The most common postoperative complications were IOP spikes (48%) and hyphemas (32%). All eyes had degrees of PAS progression.1 After failed trabeculectomy, some patients with PACG require repeat glaucoma medications and surgical interventions due to bleb scarring.1,2 The approach of this subsequent surgery requires further study and discussion.

Traditionally, repeated trabeculectomy or implantation of drainage devices would be performed after failed trabeculectomy.3–5 Since irreversible damage might occur in the trabecular meshwork (TM) in areas of synechial closure after a longer duration, eyes that have undergone 1 failed filtering procedure have a higher risk of surgical failure in subsequent procedures.1 Goniosynechialysis (GSL) has been suggested to be used before irreversible histologic change occurs.6 Combined lens extraction with GSL restores the normal aqueous outflow pathway and, at the same time, improves vision due to the removal of the cataract.2,7 However, the onset of irreversible change is challenging to determine. The relationship between the deterioration of the TM and the duration of angle closure is yet to be determined. In our previous study, we performed phacoemulsification and GSL (Phaco-GSL) on PACG patients without former trabeculectomy, with only 1 eye failing to be controlled within 21 mm Hg from a total of 38 eyes. The mean glaucoma duration was 38.9 months, and the longest was up to 7 years.8 The results revealed that phacoemulsification with GSL under an ophthalmic endoscope (Phaco-OE-GSL) was beneficial to some PACG patients after a long period of angle closure.

To the best of our knowledge, the outcome of Phaco-GSL after failed trabeculectomy in eyes with angle closure has been seldom reported. In this study, we aimed to investigate the efficacy and safety of Phaco-OE-GSL in PACG after failed trabeculectomy.

MATERIALS AND METHODS

Patients and Study Design

This research was approved by the Ethics Committee of Wenzhou Medical University. The research protocol adhered to the tenets of the Declaration of Helsinki. Patients with PACG and cataract who underwent Phaco-OE-GSL after trabeculectomy with failed surgical outcomes at the Eye Hospital of Wenzhou Medical University from July 2014 to December 2017 were included. The diagnosis of PACG was based on the diagnostic criteria of the International Society of Geographic and Epidemiologic Ophthalmology. The inclusion criteria were...
PACG patients with intraocular pressure (IOP) > 21 mm Hg after trabeculectomy under glaucoma medications, reduction in visual function due to various degrees of cataract, and an angle closure of more than 90 degrees. Exclusion criteria included secondary angle-closure glaucoma, malignant glaucoma, or those who had undergone ophthalmic surgeries other than trabeculectomy, laser peripheral iridotomy, or laser peripheral iridoplasty. Patients with a follow-up period of < 4 months were excluded. All patients included in this study underwent GSL directed by an ophthalmic endoscope (Polydiagnost, Germany) after phacoemulsification and intraocular lens implantation.

**Preoperative Examinations**

Preoperative data included age, sex, number of glaucoma drugs, history of previous surgery, or laser treatment. Upon enrollment, each patient underwent a complete ophthalmic examination including logMAR best-corrected visual acuity (BCVA), and IOP measured by Goldmann applanation tonometry, slit-lamp biomicroscopy, goniocopy, axial length by IOLMaster (Carl Zeiss Meditec AG, Jena, Germany), visual field by Humphrey Field Analyzer (Model 750; Carl Zeiss Meditec AG), anterior chamber depth (ACD), and pupil diameter by ultrasound biomicroscopy (UBM) examination (Suwei, Tianjin, China), and corneal endothelial cell density using a noncontact specular microscope (Tomey EM3000; Nagoya, Japan). All the results obtained preoperatively were defined as the baseline values of this study.

**Follow-up Examinations**

Patients were evaluated after surgery at 1 day, 1 week, and 1, 3, 6, 12, 18, and 24 months, or more frequently when required. BCVA, IOP, and slit-lamp biomicroscopy were obtained at every visit. Postoperative complications and a history of all medication details were recorded. Noncontact specular microscopy, UBM, and gonioscopy were examined at 4 to 6 months postoperatively. A final gonioscopy examination was also performed for analysis. Complete success was determined by having an IOP value between 5 and 21 mm Hg and a decrease in IOP of 20% or more from baseline IOP without medications and further glaucoma surgery. Qualified success was defined as having an IOP value between 5 and 21 mm Hg and a decrease in IOP of 20% or more from baseline IOP with glaucoma medications. Total success includes cases of complete and qualified success. Hypotony was defined as an IOP < 5 mm Hg at 2 consecutive follow-up time points.

**Surgical Procedure**

Proparacaine HCl (0.5%) was applied 10 minutes before surgery for topical anesthesia. A 2.2-mm clear corneal main incision and 1-mm lateral incision were made for phacoemulsification. A viscoelastic agent (DuoVisc; Alcon) was used to separate the posterior iris synechia in the anterior chamber. The iris retractor was utilized to dilate the pupil when the pupil was small enough to affect the operation. After that, continuous curvilinear capsulorhexis, phacoemulsification, residual cortex removal, and implantation of a foldable intraocular lens in the capsular bag were performed. It was important to maintain a stable ACD and put the probe inside the capsular bag during phacoemulsification, which could reduce injury to the corneal endothelium. A viscoelastic agent was injected into the anterior chamber to open the appositional peripheral anterior synechia (PAS; visco-GSL) by pressing down the iris foot. Then, the angle was investigated using an ophthalmic endoscope. A 23-G endoscopic probe with a diameter of 0.6 mm was inserted into the anterior chamber near the angle. If residual PAS was found, further mechanical GSL was performed to separate the TM using a modified iris repositor until the TM was observed. After GSL, Ringer solution was injected into the anterior chamber to replace the viscoelastic agent, and the incision was closed by stromal hydration or 10-0 nylon suture. Subconjunctival injection of dexamethasone was administered to some patients. All surgical procedures were performed by the same surgeon (Dr W.P.).

All patients were prescribed topical nonsteroidal anti-inflammatory drugs and tobramycin with dexamethasone eye drops 4 times daily, and 0.5% pilocarpine eye drops twice a day for 4 weeks.

**Statistical Analysis**

All statistical analyses were carried out using SPSS version 20.0 (Chicago, IL). Data are expressed as a mean ± SD. A 1-way analysis of variance with repeated measures was used to analyze the differences over time in IOP and BCVA. Nonparametric χ²-related sample tests were used to analyze the difference in medication numbers at different time points. The generalized estimating equation was used to analyze the differences over time in PAS. An independent sample t test was used to analyze PAS between the complete success and qualified success groups. A paired t test was used to compare endothelium cell density and ACD. Success rates were evaluated using Kaplan-Meier survival analysis curves. A univariate logistic regression analysis was performed to analyze the risk factors for surgical failure, and the factors with a P-value of < 0.1 underwent multivariable logistic regression analysis. A P-value of < 0.05 was considered statistically significant.

**RESULTS**

Data from 1 eye per patient were included in the final analysis. For patients that had both eyes treated, data from the right eye were used. A total of 25 eyes from 25 subjects were enrolled. The mean age was 59.0 ± 9.1 years (range, 44 to 77 y), and included 8 males and 17 females. The trabeculectomy interval was 36.2 ± 37.1 months (range, 1 to 120 mo). The axial length was 22.7 ± 0.8 mm (range, 21.8 to 24.1 mm). The cup-disc ratio was 0.8 ± 0.2 (range, 0.6 to 1.0). The pupil diameter was 3.1 ± 1.2 mm (range, 1.6 to 5.2 mm). The mean follow-up duration was 17.9 ± 11.4 months (range, 4 to 42 mo), and 17 patients had a follow-up duration longer than 12 months. The mean IOP was significantly lower than the preoperative baseline IOP at every time point after surgery (P < 0.001) (Fig. 1). In particular, the mean preoperative IOP was 24.4 ± 6.5 mm Hg (range, 14 to 41 mm Hg) and decreased to 14.1 ± 3.4, 15.2 ± 3.3, and 14.2 ± 3.0 mm Hg at 1, 2 years, and the last follow-up after surgery, respectively. No postoperative hypotony was observed.

The mean preoperative number of glaucoma medications was 2.2 ± 1.2 (range, 1 to 4), while it was 0.8 ± 1.1, 1.0 ± 1.3, 0.9 ± 1.1 at 1, 2 years, and the last follow-up, respectively, with 7 patients using 1 to 3 types of eye drops at the last follow-up. The number of medications was significantly lower than that at baseline (P < 0.001) (Fig. 1), except for day 1 after surgery. The number of medications was 1.3 ± 1.2 on the first postoperative day, and there was no significant difference when compared with the baseline (P = 0.097).
The complete success rates at 1 and 2 years post-operatively and at the last follow-up were 70.6%, 60.0%, and 68.0%, respectively, and the total success was 96.0%, 88.0%, and 92.0%, respectively. The Kaplan-Meier survival curve for complete and total success rates of the surgery over time is shown in Figure 2. Reoperation for glaucoma was performed in 1 patient during the follow-up period at 13 months postoperatively, which consisted of 1 additional Ahmed glaucoma valve implantation.

Postoperative BCVA significantly improved compared with baseline at all time points (P = 0.001) (Fig. 3). The visual acuity was 1.1 ± 1.0 at baseline (range, 0.1 to 4) and 0.6 ± 1.0 (range, 0 to 4) at the last follow-up. Sixteen eyes (64.0%) achieved improved BCVA, and 6 eyes (24.0%) attained stable BCVA. Three eyes (12.0%) had a decline in BCVA at the last follow-up, with 1 of them suffering from central retinal vein occlusion (CRVO), and the remaining 2 had posterior capsule opacification.

Intraoperative complications included hyphema in 15 eyes (60%), which achieved hemostasis by compression with a viscoelastic agent. All patients underwent GSL successfully. Postoperative complications included hyphema in 8 eyes (32%) and exudation of the anterior chamber in 4 eyes (16%), which were absorbed within 1 week. Twelve eyes (48%) had IOP spikes that lasted for 2.1 ± 2.7 days (range, 2 h to 6 d), which was treated with anterior chamber paracentesis or local glaucoma medications. Corneal edema occurred in 3 eyes (12%) postoperatively and restored transparency after local dexamethasone eye drop treatment. No complications such as iridodialysis, endophthalmitis, or corneal endothelial decompensation were observed.

The range of PAS was 274.8 ± 81.5 degrees before surgery. The angle could not be completely opened after visco-GSL in all cases. The residual PAS after visco-GSL was reduced to 239.8 ± 86.4 degrees, although this was not statistically significant when compared with preoperative PAS (P = 0.124). The residual PAS was treated by mechanical manipulation to achieve a completely open angle. All 25 eyes had various degrees of PAS recurrence, with a range of 96.1 ± 52.5 degrees (range, 30 to 210 degrees) at 4 to 6 months postoperatively. Although a high ratio of PAS recurrence was obtained, the range of PAS was significantly decreased when compared with the baseline (P < 0.001). We compared the range of PAS at 4 to 6 months postoperatively. Although a high ratio of PAS recurrence was obtained, the range of PAS was significantly decreased when compared with the baseline (P < 0.001). We compared the range of PAS at 4 to 6 months postoperatively. Although a high ratio of PAS recurrence was obtained, the range of PAS was significantly decreased when compared with the baseline (P < 0.001). We compared the range of PAS at 4 to 6 months postoperatively.

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The success rate at 3 years postoperatively was 78.3%. However, combined with phacoemulsification. In our previous report using Ex-PRESS implantation (without medication) of about 78% at 2 years after trabeculectomy.

2865) cells/mm² at 4 to 6 months postoperatively. The decrease ranged from 28% after Baerveldt drainage device implantation to 42% of the previous surgeries. The failure rate of the devices. In a study, failed trabeculectomy consisted of 33% to 80% in the first year.

The most common intraoperative complication in this study was hyphema (15 eyes, 60%), which was higher than the PAS after trabeculectomy. The complete success rates at 1 and 2 years postoperatively were 70.6% and 60.0%, respectively, and the total success rates were 96.0% and 88.0%, respectively. Our results may reverse the previous opinion on the treatment of PACG eyes after failed trabeculectomy and also the effect of Phaco-GSL on these eyes. This may indicate that eyes with angle closure after failed trabeculectomy may still preserve functional TM. Phaco-GSL can successfully resolve the PAS in these eyes, as supported by the high total success rate in eyes after failed trabeculectomy.

In our study, we first resolved PAS using a viscoelastic agent, which could reduce the PAS range from 274.8 ± 81.5 to 239.8 ± 86.4 degrees. However, all the cases required subsequent mechanical GSL to achieve a complete open angle. In our previous study on PACG patients without trabeculectomy, 23.7% of PAS in these cases could be completely resolved by visco-GSL. These results suggested that the iris after trabeculectomy was more adhesive, where visco-GSL was not enough to resolve the PAS after trabeculectomy. Therefore, mechanical GSL was necessary to resolve the residual PAS in such situations.

The most common intraoperative complication in this study was hyphema (15 eyes, 60%), which was higher than in PACG patients without trabeculectomy (13.2%). The higher incidence of hyphema may be related to more severe PAS after trabeculectomy. The most common postoperative

DISCUSSION

Trabeculectomy has been the classic surgical method for primary glaucoma since 1968. The reported complete success rate of trabeculectomy was between 38% and 83%. Kirwan et al. reported a large sample study, including 428 eyes that showed a complete success rate (5 mm Hg < IOP < 18 mm Hg without medication) of about 78% at 2 years after trabeculectomy. In our previous report using Ex-PRESS implantation combined with phacoemulsification in PACG, the complete success rate at 3 years postoperatively was 78.3%. However, the prognosis of patients with PACG after failed trabeculectomy has seldom been reported individually. Most of the relevant cases reported were either mixed with cases of open-angle glaucoma or other types of glaucoma with the use of a valve or other drainage devices. In a study, failed trabeculectomy consisted of 33% to 42% of the previous surgeries. The failure rate of the first year ranged from 28% after Baerveldt drainage device implantation and 43% after Ahmed valve implantation, to 34% and 51% in the third year, respectively. High failure rates show the importance of exploring an effective and safe surgical strategy to manage PACG after failed trabeculectomy.

Phaco-GSL was effective in lowering IOP with a success rate from 57.9% to 100%. In a previous study, the success rate was found to be as high as 100%, with a mean follow-up of 8.9 months. However, some studies did not obtain an additional effect of lowering the IOP when comparing Phaco-GSL to Phaco-alone. Such differences in results may be attributable to a less severe stage of glaucoma in the subject patients, or different baseline data between subgroups in different centers.

Information on the success rate of PACG eyes after failed trabeculectomy was lacking in previous studies. In this study, we demonstrated that Phaco-OE-GSL could significantly lower the IOP and reduce the number of medications to PACG patients with failed trabeculectomy. The complete success rates at 1 and 2 years postoperatively were 70.6% and 60.0%, respectively, and the total success rates were 96.0% and 88.0%, respectively. Our results may reverse the previous opinion on the treatment of PACG eyes after failed trabeculectomy and also the effect of Phaco-GSL on these eyes. This may indicate that eyes with angle closure after failed trabeculectomy may still preserve functional TM. Phaco-GSL can successfully resolve the PAS in these eyes, as supported by the high total success rate in eyes after failed trabeculectomy.
complication was IOP spikes, with an average duration of 2.1 days. The mechanism of the spike may be due to the obstruction of aqueous outflow by residual viscoelastic agent, debris, or hemorrhage in the TM, the edematous TM, or the newly opened TM which has not yet regained its ability to drain aqueous humor. As we enrolled patients with high IOP and PAS, IOP spikes after surgery were prevalent and observed in 48% of all patients, which was higher than the incidence (26%) in the uneventful phacoemulsification of patients with cataracts.22 As the elevation of postoperative IOP may damage the optic nerve, careful management of the IOP spike is crucial.

The reported mean endothelium cell density loss is 5.3% to 17.2% in the simple phacoemulsification of senile cataract.8 In this study, the loss was 15.1%, which was a little more than in our previous study (11.54%)8 and another previous study (9.0%)19 in PACG patients without trabeculectomy history after Phaco-GSL. It is not clear whether such an increase in endothelial cell loss is due to GSL or posttrabeculectomy eyes. Performing phacoemulsification after trabeculectomy is usually challenging because of the posterior synechia of the iris, constricted or distorted pupil, and shallow anterior chamber.23,24 GSL may increase the chance of damaging corneal endothelial cells when the

FIGURE 4. A 53-year-old female who had undergone trabeculectomy 10 years prior. She presented to our hospital with a flat filtering bleb, 1.44 mm anterior chamber depth (ACD), and peripheral anterior synechia (PAS) in all 4 quadrants. After phacoemulsification with goniosynechialysis under an ophthalmic endoscope, the ACD increased to 3.25 mm, with a 120-degree PAS recurrence at 11-1 and 2 to 4 o’clock. The postoperative intraocular pressure at 15 months was 16.7 mm Hg without medications. I indicates inferior; N, nasal; S, superior; T, temporal. Figure 4 can be viewed in color online at www.glaucomajournal.com.
surgical instruments enter the anterior chamber. Both of these factors may lead to increased endothelial cell damage. In our study, the lowest density of the corneal endothelium was 820 cells/mm², and transient postoperative corneal edema was found in 12% of the patients. No corneal endothelial decompensation was observed.

In this study, the regression analysis suggested that a large pupil diameter preoperatively was a risk factor for surgical failure. After trabeculectomy, the enlarged pupil may be induced by tropicamide, and adhesion of the posterior iris may occur because of the inflammatory reaction or atrophied iris after acute attack. Although GSL transiently opened the closed angle, the enlarged pupil might cause the accumulation of peripheral iris at the angle or even readhesion onto the angle. Therefore, the IOP can become elevated again.

The major limitations of this study are that it is a retrospective study with a small sample size and relatively short follow-up time. Another limitation is the lack of a control group. Moreover, all the eyes in this study suffered various degrees of PAS recurrence, but a detailed examination of the progression of PAS through gonioscopy was lacking. More detailed monitoring of the progression of PAS is required. In addition, a prospective and randomized study with a larger sample size is necessary to understand the efficacy of Phaco-OE-GSL better.

In conclusion, we demonstrated that Phaco-OE-GSL is safe for PACG eyes after failed trabeculectomy. This method can lower IOP and reduce the number of glaucoma medications with a favorable success rate. This method may serve as an alternative for PACG eyes after failed trabeculectomy because it is easy to manage with fewer adverse complications.

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