

Original article

Comparison of surgical outcomes after phacotrabeculectomy in primary angle-closure glaucoma versus primary open-angle glaucoma



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ABSTRACT

Purpose: To compare postoperative outcomes and assess factors associated with intraocular pressure (IOP) reduction after phacotrabeculectomy in patients with primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG).

Methods: This is a retrospective study of patients who underwent phacotrabeculectomy between 2010 and 2013. Factors including age, gender, visual field (VF), the number of glaucoma medications used, biometric changes, IOP, and surgical success rates were compared between groups.

Results: There were 27 PACG and 34 POAG patients. The PACG group had a greater mean IOP reduction after phacotrabeculectomy compared to the POAG group (5.5 ± 7.9 mmHg versus 2.0 ± 4.2 mmHg; $p = 0.03$). However, the final mean IOP was similar between the two groups (PACG: 12.2 ± 4.8 mmHg, POAG: 12.3 ± 3.1 mmHg; $p = 0.92$). Phacotrabeculectomy resulted in a mean decrease in axial length (AL) of 0.16 ± 0.15 mm in PACG and 0.16 ± 0.11 mm in POAG ($p = 0.96$), and an increase in anterior chamber depth (ACD) of 1.41 ± 0.91 mm in PACG, and 0.87 ± 0.86 mm in POAG ($p = 0.04$). At 2 years follow-up, the cumulative success rate of phacotrabeculectomy was 74% in PACG and 62% in POAG. Multivariate analysis found that early glaucoma stage, greater postoperative increase in ACD, and high preoperative IOP were factors associated with greater IOP reduction.

Conclusion: Postoperative success rates and mean IOP on the final visit after phacotrabeculectomy were similar between the PACG and POAG groups. Factors associated with IOP reduction were greater postoperative increase in ACD, and high preoperative IOP.

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1. Introduction

Glaucoma and cataract incidence increases with age^{1,2}; thus, it is not uncommon in a clinical setting to encounter a glaucoma patient with a coexisting visually disabling cataract. Special considerations are needed when choosing which surgical strategy to undertake when either of these two conditions requires surgical management. When performed prior to cataract surgery, trabeculectomy increases the risk of cataract formation by up to 78%,³ while subsequent

cataract surgery may increase the risk of elevated intraocular pressure (IOP) or trabeculectomy failure.^{4–6} By contrast, when cataract surgery alone is performed in glaucoma patients, an early postoperative IOP spike sometimes requiring medical treatment is commonly reported.⁷ Therefore, phacotrabeculectomy, a procedure that combines the management of these two conditions together in one surgery, may be considered in these situations. Previous studies have shown that phacotrabeculectomy can provide an IOP-lowering effect that is not inferior to that of trabeculectomy alone,^{8,9} and visual and refractive outcomes following this procedure are comparable to those obtained with phacoemulsification alone.^{10,11}

However, in the current literature, studies that directly compare the surgical outcomes of phacotrabeculectomy between patients with primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG) are limited.^{12,13} Furthermore, in the few

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studies that have been published, the association between IOP changes and changes in ocular dimensions after surgery have not been clearly demonstrated. Therefore, the purpose of this study is to compare postoperative outcomes and to assess factors associated with IOP reduction after phacotrabeculectomy in POAG and PACG.

2. Materials and methods

2.1. Patient selection

This study was carried out in accordance with the tenets of the Declaration of Helsinki, and was approved by the Research Ethics Board of Chang Gung Memorial Hospital, Kaohsiung, Taiwan. The medical records of patients who underwent one-site phacotrabeculectomy with mitomycin-C (MMC) at Kaohsiung Chang Gung Memorial Hospital from October 2010 to September 2013 were retrospectively reviewed. Indications for surgery were visually significant cataract formation in patients with suboptimal IOP control under maximal medication, or poor tolerance for glaucoma medications. All surgeries were performed by one experienced glaucoma surgeon (M.C.T.).

All of the patients underwent a comprehensive ophthalmic evaluation that included Goldman applanation tonometry, gonioscopy, and stereoscopic examination of the optic disc with a 90 Diopter lens (Volk Optical Inc., Mentor, OH, USA). Patients were divided into two groups according to the type of glaucoma (PACG versus POAG). PACG was diagnosed based on the symptoms of elevated IOP, in the presence of occludable angles or angle synechia on gonioscopy. Symptoms of elevated IOP included: (1) an episode of acute angle closure; and (2) intermittent blurred vision, halo, or ocular pain. All of the PACG patients received laser iridotomy after diagnosis. POAG was diagnosed in the presence of open angles with Shaffer grading > 2 on gonioscopy, and characteristic glaucomatous optic disc changes with correlating visual field (VF) changes. Patients were excluded if they had any prior intraocular surgery, eye trauma, or a diagnosis of secondary glaucoma. Additional exclusion criteria included a follow-up time of < 3 months and incomplete chart recording. Baseline demographic data were obtained for each patient, including age, gender, type of glaucoma, VF evaluation using the Humphrey Field Analyzer (30-2 program, Carl Zeiss Meditec, Inc., Dublin, CA, USA) performed within 6 months prior to surgery, and the number of glaucoma medications used. Biometric measurements, including axial length (AL) and anterior chamber depth (ACD), were obtained using the IOLMaster (Carl Zeiss Meditec, Inc.) prior to the operation and > 3 months after operation. IOPs were obtained prior to the operation, at postoperative Day 1, and at 1 month, 3 months, 6 months, 9 months, 12 months, 15 months, 18 months, 21 months, and 24 months after the operation. Preoperative IOP was defined as the average IOP of three consecutive office visits prior to the surgery. Total IOP reduction was defined as the IOP difference between preoperative IOP and IOP on the last visit. Surgical success was defined as IOP ≤ 15 mmHg without the need for additional glaucoma medication or surgical intervention to control IOP.

2.2. Surgical methods

Under peribulbar anesthesia, a superior rectus traction suture was placed and a fornix-based conjunctival flap was created. After the conjunctiva and Tenon's capsule were dissected, a sponge soaked with MMC 0.2 mg/mL was placed in the conjunctival pocket between the conjunctiva and episclera for 2 minutes, after which the conjunctival space was irrigated with copious amounts of balanced salt solution. Next, a 2 mm × 4 mm partial thickness scleral flap was created with a crescent knife, and the anterior

chamber was entered at the base of the scleral flap using a 2.75 mm keratome. Phacoemulsification was performed using the divide-and-conquer technique, and a foldable acrylic intraocular lens was placed in the capsular bag. Next, a sclerotomy was created with a scleral punch, followed by a peripheral iridectomy. The scleral flap was loosely closed with one or two interrupted 10-0 nylon sutures, depending on the amount of leakage underneath the scleral flap. The conjunctiva was closed using a running 10-0 nylon suture. Postoperatively, all patients were treated with topical corticosteroids and antibiotics four times daily, which was gradually tapered over a 4-week course.

2.3. Statistical analysis

Statistical analyses were performed using SPSS software version 17.0 (IBM Corp., Armonk, NY, USA). Differences between the two groups were evaluated with the Student *t* test for continuous variables, and with the χ^2 test for categorical variables. Kaplan-Meier analysis was used to analyze the cumulative success rate after surgery in the POAG and PACG groups, and differences in success rates were assessed using the log-rank test. Independent variables relevant to IOP reduction and operation success were identified using multivariate analysis by linear regression and binary logistic regression, respectively. A *p* value < 0.05 was considered statistically significant. All data are expressed as mean ± standard deviation.

3. Results

A total of 61 eyes of 51 patients (mean age, 70.3 ± 6.8 years; range, 59–87 years) with a mean follow-up time of 19.1 ± 9.9 months (range, 3–40 months) were included in this analysis. Twenty-seven eyes in the PACG group were compared to 34 eyes in the POAG group (Table 1).

The mean preoperative IOP was 17.7 ± 7.4 mmHg in the PACG group and 14.3 ± 4.7 mmHg in the POAG group (*p* = 0.04). IOP throughout the follow-up period after surgery was not statistically different between the two groups (Fig. 1). At the final follow-up, the mean IOP was similar between the PACG (12.2 ± 4.8 mmHg) and the POAG (12.3 ± 3.1 mmHg) groups (*p* = 0.92). However, the PACG group had a significantly greater mean total IOP reduction after phacotrabeculectomy compared to the POAG group (5.5 ± 7.9 mmHg versus 2.0 ± 4.2 mmHg; *p* = 0.03).

Phacotrabeculectomy resulted in a decrease in AL from 24.91 ± 1.97 mm to 24.64 ± 1.50 mm in the POAG group, and from 22.55 ± 0.66 mm to 22.47 ± 0.67 mm in the PACG group. There was also an increase in ACD from 3.17 ± 0.42 mm to 3.94 ± 0.54 mm in the POAG group, and from 2.46 ± 0.23 mm to 3.66 ± 0.53 mm in the PACG group. The total change in AL was similar between the two

Table 1
Baseline demographic characteristics of the primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG) groups.

	POAG group	PACG group	<i>p</i>
No. of eyes	34	27	
Age (y)	69.0 ± 6.4	71.9 ± 7.2	0.10
Sex (male:female)	16:18	10:17	0.28
Visual field mean deviation (dB)	-14.08 ± 8.46	-13.52 ± 8.88	0.81
No. of preoperative glaucoma medications	2.2 ± 1.4	2.8 ± 1.5	0.09
Preoperative IOP (mmHg)	14.3 ± 4.7	17.7 ± 7.4	0.04
Preoperative AL	24.91 ± 1.97	22.55 ± 0.66	< 0.001
Preoperative ACD	3.17 ± 0.42	2.46 ± 0.23	< 0.001
Follow-up duration (mo)	17.2 ± 9.7	20.4 ± 10.1	0.65

Data are presented as mean ± SD, unless otherwise indicated.

ACD = anterior chamber depth; AL = axial length; IOP = intraocular pressure; PACG = primary angle-closure glaucoma; POAG = primary open-angle glaucoma.

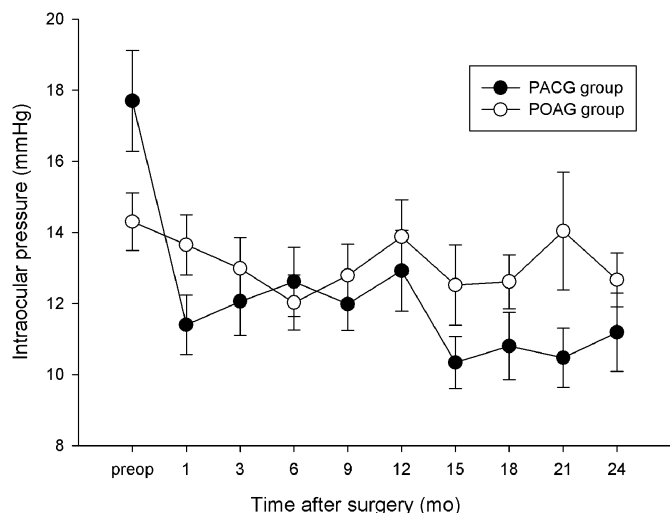


Fig. 1. Intraocular pressure profiles in the primary angle-closure glaucoma (PACG) and the primary open-angle glaucoma (POAG) groups.

groups with a mean change in AL of -0.16 ± 0.15 mm in the PACG group and -0.16 ± 0.11 mm in the POAG group ($p = 0.96$). However, in the PACG group, the increase in ACD after surgery was significantly greater than in the POAG group (1.41 ± 0.91 mm versus 0.87 ± 0.86 mm, respectively; $p = 0.04$; Table 2).

Kaplan-Meier survival analysis (Fig. 2) shows that most of the surgical failures occurred in the first 3–6 months in the PACG group, while in the POAG group, most of the surgical failures occurred within 1 year. At 2 years follow-up, the cumulative success rate of those that qualified for complete surgical success was 74% in

Table 2
Changes in ocular dimensions in primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG).

	POAG group	PACG group	<i>p</i>
Total change in axial length (mm)	-0.16 ± 0.11	-0.16 ± 0.15	0.96
Total change in ACD (mm)	0.87 ± 0.86	1.41 ± 0.91	0.04

Data are presented as mean \pm SD.

ACD = anterior chamber depth.

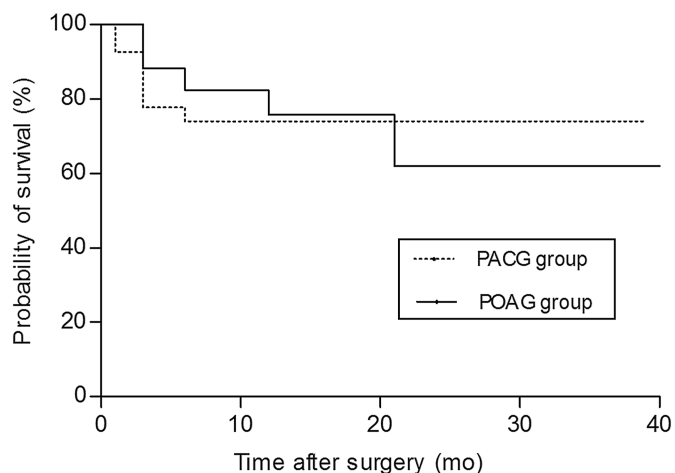


Fig. 2. Kaplan-Meier cumulative probability curve for complete success after phacotrabeculectomy, as defined by intraocular pressure < 15 mmHg without any additional medications or surgery, in primary angle-closure glaucoma and primary open-angle glaucoma.

the PACG group and 62% in the POAG group, which was not significant (log-rank test; $p = 0.90$). The number of glaucoma medications used decreased from 2.8 ± 1.5 medications to 0.31 ± 0.17 medications ($p < 0.001$) in the PACG group, and from 2.2 ± 1.4 medications to 0.74 ± 0.22 medications ($p < 0.001$) in the POAG group. The number of patients that remained medication-free (with or without further bleb revision) throughout the follow-up period after the operation for the PACG group and the POAG group was similar, at 78% and 70%, respectively (Table 3).

Multivariate analysis showed that a greater ACD change (β coefficient = 0.248, $p = 0.03$), higher baseline IOP (β coefficient = 1.611, $p < 0.001$), and a lower mean deviation on VF (β coefficient = -0.297 , $p = 0.05$) were independent factors associated with greater IOP reduction after phacotrabeculectomy (Table 4). Older age (odds ratio: 1.052, $p = 0.02$) and fewer preoperative medications (odds ratio: 0.501, $p = 0.04$) were factors associated with surgical success (Table 5).

4. Discussion

Due to the advantage of being able to treat coexisting cataracts and glaucoma in one surgery, phacotrabeculectomy has gained popularity among ophthalmic surgeons over the past decade.^{8,12–16}

Table 3
Comparison of postoperative interventions.

	Number of patients (%)	
	POAG group	PACG group
Numbers of medications used		
0	24 (70)	21 (78)
1	2 (6)	3 (11)
2	3 (9)	2 (7)
3	3 (9)	0 (0)
4	2 (6)	1 (4)
Surgical intervention		
Needle revision	4 (12)	5 (19)

PACG = primary angle-closure glaucoma; POAG = primary open-angle glaucoma.

Table 4
Multivariate analysis of factor associated with a greater postoperative intraocular pressure (IOP) reduction.

	Beta coefficient	<i>p</i>	95% CI
Sex (male)	0.148	0.12	-0.374 – 3.174
Age	0.007	0.95	-0.105 – 0.111
Visual field mean deviation	-0.297	0.05	-0.261 – 0.002
Type of glaucoma (POAG)	-0.183	0.07	-3.738 – 0.1333
Preoperative baseline IOP	1.611	< 0.001	0.506 – 0.843
Total ACD change	0.248	0.03	0.104 – 2.395
Total AL change	0.034	0.78	-5.748 – 8.146

ACD = anterior chamber depth; AL = axial length; CI = confidence interval; IOP = intraocular pressure; POAG = primary open-angle glaucoma.

Table 5
Multivariate analysis of factors associated with surgical success. Surgical success was defined as intraocular pressure (IOP) ≤ 15 mmHg without the need for additional glaucoma medication or surgical intervention to control IOP.

	<i>p</i>	Odds ratio	95% CI
Sex (male)	0.76	1.267	0.279 – 5.747
Age	0.02	1.052	1.009 – 1.098
Type of glaucoma (POAG)	0.51	0.602	0.135 – 2.682
Visual field mean deviation	0.783	1.014	0.919 – 1.119
Number of preoperative medications	0.04	0.501	0.258 – 0.973
Preoperative IOP	0.91	1.007	0.889 – 1.140

CI = confidence interval; IOP = intraocular pressure; POAG = primary open-angle glaucoma.

One of the major pitfalls of trabeculectomy is the deterioration in visual acuity¹⁷ and the increased incidence of cataract formation after surgery,³ which can be overcome in combined cataract extraction and glaucoma surgery. Furthermore, despite being a more complex surgery, phacotrabeculectomy has been shown to achieve a favorable visual and refractive outcome that is comparable to phacoemulsification alone.^{10,11} Moreover, even though trabeculectomy has traditionally been considered the gold standard for surgical control of IOP in glaucoma patients, with improvements and advances in surgical techniques, such as the use of intraoperative adjuvant MMC in the conjunctival pocket, fornix-based conjunctival flap, two-site procedure using temporal wound for cataract extraction,^{15,16} IOP can be effectively lowered after surgery. In a retrospective study comparing trabeculectomy with MMC and phacotrabeculectomy with MMC, Murthy et al⁸ found that there was no difference in postoperative IOP between the two groups for up to 2 years. Similarly, Tsai et al⁹ found that at 3 years postoperatively in a group of PACG patients, the surgical success rate was similar ($p = 0.903$) between trabeculectomy (54%) and phacotrabeculectomy (56%), with no significant IOP differences throughout the follow-up period.

Consistent with the previous comparative studies,^{12,13} we found a greater IOP reduction after phacotrabeculectomy in the PACG group. In a study by Lai et al,¹² the PACG group had a mean IOP reduction of 12.7 ± 8.3 mmHg, whereas the POAG group showed a mean IOP reduction of 5.0 ± 5.7 mmHg ($p < 0.05$). Rao et al¹³ reported a mean IOP reduction of 8.1 ± 8.4 mmHg in PACG and 5.5 ± 7.3 mmHg in POAG ($p = 0.03$) after phacotrabeculectomy without MMC. In our study, the mean IOP reduction was not as great as that reported in the previous studies; however, this may be explained by the relatively higher preoperative baseline IOP in their patients (Lai et al¹²: 27.4 mmHg in PACG and 20.4 mmHg in POAG; Rao et al¹³: 23.0 mmHg in PACG and 20.3 mmHg in POAG) compared to our patients (17.7 ± 7.4 mmHg in PACG and 14.3 ± 4.7 mmHg in POAG).

In addition, our study is different from the previous studies because in the study by Lai et al,¹² MMC was used mostly in PACG patients and only selectively used among POAG patients, whereas in the study by Rao et al,¹³ MMC was not applied at all. MMC is an important adjunct to glaucoma filtration surgery because of its wound-modulating and antifibrotic properties.¹⁸ In a systematic review that included four randomized clinical trials and two cohort studies investigating the effects of MMC on IOP, Jampel et al¹⁶ concluded that IOP reduction was greater in cases that used MMC in combined cataract and glaucoma surgery than in those that did not. In our study, a fixed concentration of 0.2 mg/mL MMC for 2 minutes was used on the scleral surface in all cases. Even though there is a possibility that the lack or variable use of MMC might have influenced the surgical outcomes in the previous studies,^{12,13} we found that even with the routine use of adjuvant MMC in both POAG and PACG patients, a greater IOP reduction was consistently found in the PACG group.

Previous studies have demonstrated that after cataract extraction, deepening of the anterior chamber and widening of the angle occurs in PACG patients.^{19,20} In a study by Hayashi et al,¹⁹ cataract extraction resulted in a mean increase of 2.08 ± 0.39 mm in ACD, and 17.8° widening in the angle width in PACG patients 12 months after surgery. Lai et al²⁰ found that phacoemulsification resulted in a decrease in the extent of synechial closure of the angle to $< 90^\circ$ in 33.3% of their PACG patients. Both of these studies showed that the anatomic changes led to a reduced IOP and decreased the need for glaucoma medications in glaucoma patients.^{19,20} To our knowledge, there have been no studies that directly assessed the role of AL and ACD changes in IOP reduction after phacotrabeculectomy.

In our study, the PACG group had an ACD that was significantly shallower than the POAG group prior to surgery. However, after

surgery, the mean ACD in the PACG group increased to a depth similar to the POAG group (3.66 ± 0.53 mm and 3.94 ± 0.54 mm, respectively, $p = 0.08$), leading to a greater total change in ACD in the PACG group (PACG: 1.41 ± 0.91 mm, and POAG: 0.87 ± 0.86 mm; $p = 0.04$). The PACG group also had a greater total IOP reduction after phacotrabeculectomy compared to the POAG group (5.5 ± 7.9 mmHg versus 2.0 ± 4.2 mmHg; $p = 0.03$). Even though in our study the PACG group had a higher baseline IOP than the POAG group (17.7 ± 7.4 mmHg and 14.3 ± 4.7 mmHg, respectively, $p = 0.04$), which may have contributed to a greater IOP reduction after surgery, multivariate analysis showed that both the total ACD change and preoperative baseline IOP were independent factors associated with IOP reduction. Thus, the greater increase in ACD after phacotrabeculectomy has a definite role in the greater IOP reduction we observed in the PACG group.

Following glaucoma filtration surgery, most cases showed a shortened AL,^{21,22} which has been associated with younger age, myopia, exposure to antimetabolites, IOP drop > 30 mmHg,²¹ and choroidal thickening.²² A postoperative decrease in AL was also found in this study, but the change was small in both groups, and it was not associated with IOP reduction.

With a mean follow-up period of 19.9 months, the surgical success rate of phacotrabeculectomy at 2 years was 74% in the PACG group and 62% in the POAG ($p = 0.90$). We found that older age and fewer preoperative medications were factors associated with surgical success. In a cohort of 120 patients, Rao et al¹³ found that younger age at surgery was significantly associated with surgical failure. Other reported prognostic indicators for surgical failure after combined glaucoma and cataract extraction surgery include a glaucoma diagnosis other than primary glaucoma,²³ diabetes mellitus, African-American race, > 2 preoperative glaucoma medications, and having a preoperative IOP of > 20 mmHg.²⁴

This study's main limitations are its retrospective study design and the small sample size, which may influence the validity of the study results. Selection bias may exist because this was a retrospective chart review, and patients with incomplete medical charts were excluded from this study. However, we intended to minimize this effect by matching the two groups of patients by age, sex, VF, numbers of preoperative medications used, and follow-up duration. Another limitation of this study is that we only assessed changes in ACD prior to and after surgery and not the actual anatomic changes in anterior chamber angle width; thus, the status of the angle can only be assumed based on the ACD. Because most of our patients lacked a record of postoperative gonioscopic evaluation, we did not include changes in angle width as one of the study outcome parameters. However, since a clear association between ACD and anterior chamber angle has been well established in the published literature,²⁵ we feel that we can reliably use the ACD change to explain the greater IOP reduction observed in the PACG group.

In conclusion, the results of this study show that phacotrabeculectomy with MMC can reduce IOP and the number of glaucoma medications needed in both PACG and POAG patients. Postoperative success rates and IOP levels after phacotrabeculectomy were similar between the PACG and POAG groups. Older age and fewer preoperative glaucoma medications were factors associated with surgical success, and factors associated with IOP reduction were greater postoperative increase in ACD, and a high preoperative IOP.

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