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ORIGINAL RESEARCH

Visual Acuity, Not Pressure Control, Distinguishes Phacotrabeculectomy from Trabeculectomy in Primary Open-Angle Glaucoma: A Six-Month Comparative Cohort Study

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ABSTRACT

Background: Primary open-angle glaucoma often coexists with cataract, but Indonesian evidence comparing trabeculectomy with combined phacotrabeculectomy is scarce.

Objective: To compare six-month pressure, medication, surgical, and visual outcomes after trabeculectomy versus phacotrabeculectomy and quantify between-group precision.

Methods: This retrospective, non-randomised comparative cohort included 74 consecutive patients with primary open-angle glaucoma (54 trabeculectomy; 20 phacotrabeculectomy) at an Indonesian university ophthalmology department. Outcomes were intraocular pressure, topical medication burden, surgical success, and visual acuity. Within-group changes used paired t tests with Holm adjustment; between-group contrasts used Welch and Fisher exact tests, Hedges g, and Newcombe intervals.

Result: Pressure fell at every timepoint in both groups (all adjusted $p < 0.001$). Six-month reductions were 13.02 and 12.10 mmHg; the between-group difference was 0.92 mmHg (95% CI −5.27 to 3.43; $p = 0.670$). Complete success was 55.6% versus 75.0% (odds ratio 2.40, 95% CI 0.76–7.55; $p = 0.181$). Visual acuity favoured phacotrabeculectomy (0.37 versus 0.99 logMAR; Hedges $g = 0.70$, 95% CI 0.18–1.23; $p = 0.020$). The cohort could not resolve pressure differences below 5.99 mmHg.

Conclusion: Both procedures achieved large, sustained reductions in pressure and medication burden; equivalence in pressure control was not established. Phacotrabeculectomy produced better visual acuity, although cataract confounded procedure selection and acuity. When cataract coexists with primary open-angle glaucoma, the combined procedure may provide comparable pressure control and better acuity in one admission.

1. Introduction

Glaucoma is the leading cause of irreversible blindness worldwide and its burden is concentrated in Asia. Contemporary global syntheses project a continuing rise in the affected population to 2060, with the increase falling disproportionately on Asian populations and on adults beyond middle age[1,2]. Analyses of the global burden of low vision and blindness attributable to glaucoma over the three decades to 2021 show the same pattern, and regional estimates place South-East Asia among the areas carrying a share out of proportion to their population[3,4]. Indonesia sits inside that burden and adds a structural problem of its own: national survey data describe wide inter-provincial variation in blindness and cataract prevalence, and the proportion of glaucoma that is never diagnosed until irreversible field loss has occurred remains high[4,5]. The practical consequence for a referral service is that patients arrive late, with pressures far above target and with a lens that is often already opaque.

Intraocular pressure is the only risk factor for glaucomatous progression that can be modified, and its reduction remains the single therapeutic objective for which randomised evidence exists[6,7]. Treated glaucoma nonetheless carries a real lifetime risk of blindness, which is what makes the adequacy of surgical pressure control a functional and not merely a numerical question[8]. Elevated pressure in primary open-angle glaucoma (POAG) arises from increased resistance at the trabecular meshwork and juxtacanalicular tissue, while the injury it produces is expressed at the lamina cribrosa as progressive loss of retinal ganglion cell axons, thinning of the neuroretinal rim and of the retinal nerve fibre layer, and corresponding visual field defects[9,10]. That the therapeutic lever is outflow facility rather than aqueous production has been shown directly in interventional work[11], which is the resistance a guarded fistula bypasses. Management escalates from topical monotherapy through combination therapy and laser to incisional surgery, and a reduction of 20% to 30% from untreated baseline pressure is the conventional target once the disease is manifest[7,12]; increasingly, documented progression rather than a pressure threshold alone is taken as the trigger for surgical escalation[13]. Prolonged exposure to preserved topical medication is not neutral: it primes conjunctival inflammation, degrades the ocular surface and is itself a determinant of subsequent filtration failure[14,15]. Medication burden is therefore both a marker of disease severity and a modifiable predictor of surgical outcome.

Trabeculectomy, in which a guarded fistula is created between the anterior chamber and the subconjunctival space, remains the operation against which all others are measured[16]. Contemporary cohorts report that primary trabeculectomy in advanced open-angle disease reduces pressure into the low teens and leaves a substantial proportion of eyes controlled without medication[17,18], and device-assisted filtration has not been shown to outperform it[19]. The price is a bleb that must be watched: early scarring and failure are common and often require revision[20,21]. Newer alternatives have not displaced it: an overview of Cochrane reviews and a network meta-analysis found the evidence for minimally invasive glaucoma surgery to be of low certainty, and none of those procedures matched trabeculectomy for the magnitude of pressure reduction[22]. Upstream, primary selective laser trabeculoplasty reduces the eventual need for incisional surgery[23], but where laser capacity is limited the surgical caseload reaching a department is correspondingly larger and later.

A substantial minority of eyes requiring filtration surgery also carry a visually significant cataract, and how best to sequence the two operations is unresolved. Removing the lens deepens the anterior chamber and may reduce the risk of postoperative shallowing, and lens extraction alone lowers pressure in open-angle glaucoma; combining phacoemulsification with trabeculectomy in one sitting therefore has an obvious attraction[16,24]. The counterargument is that the additional surgical trauma increases the fibroblast response at the bleb and compromises the filtration result. Published comparisons have not settled the question. A systematic review with meta-analysis of combined cataract-filtration approaches found equivalent pressure reduction across techniques[25]; a two-year cohort found trabeculectomy and phacotrabeculectomy comparable in open-angle disease[26]; a five-year series reached the same conclusion[27]; and a combined series in a comparable low-resource setting found the acuity gain more consistent than any pressure difference[28]. Working against the combined procedure is evidence that filtration performs less well in an eye already operated for cataract, and that phacoemulsification energy delivered to an eye with an existing bleb predicts subsequent filtration failure[29,30]. Device cost and the absence of long-term regional data further constrain the surgical menu available in Asia-Pacific practice[31].

These considerations bear directly on Indonesian practice. The Jaminan Kesehatan Nasional scheme has extended coverage to most of the population but continues to face supply-side constraints in specialist and surgical services[32], so the number of theatre episodes a patient requires is a resource question as well as a clinical one. Insurance membership is itself a strong determinant of whether a patient receives eye surgery at all[33], so how many funded episodes a treatment pathway consumes has consequences well beyond the individual patient, and no published rule prescribes how to sequence the two operations when cataract and glaucoma coexist. Against that background the present study reports a consecutive surgical series managed at the Department of Ophthalmology, Faculty of Medicine, Andalas University, Indonesia. Success was defined by the criteria endorsed in international guidance[18,26], and the six-month horizon was chosen because it is the interval over which the source records were complete, while acknowledging that success measured at six months systematically overstates durable success[18]. The objectives were to quantify, with confidence intervals and standardised effect sizes rather than significance labels alone, the change in intraocular pressure and in topical medication burden after each procedure; to compare surgical success, failure and visual acuity between them; and to state explicitly what magnitude of difference a cohort of this size could and could not have detected.

2. Methods

Study design and setting

This was a retrospective, non-randomised, comparative cohort study of consecutive patients with primary open-angle glaucoma who underwent incisional pressure-lowering surgery at the Department of Ophthalmology, Faculty of Medicine, Andalas University, Indonesia. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cohort studies[34]. The flow of participants from the source population to the analysed groups, together with the exclusions applied at each stage, is set out in Figure 1.

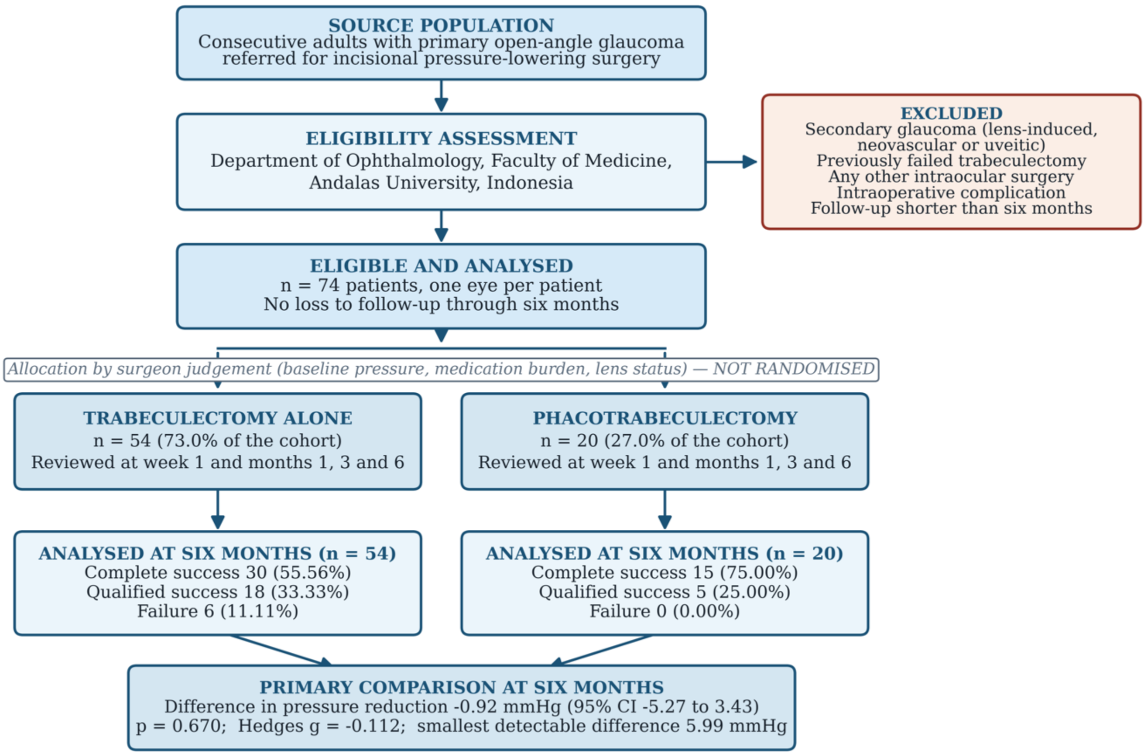


Figure 1. *Flow of participants through the study, reported to the STROBE convention. Allocation to trabeculectomy or phacotrabeculectomy followed surgeon judgement and was not randomised.*

Two surgical strategies were compared: trabeculectomy alone, and phacoemulsification combined with trabeculectomy in a single sitting (phacotrabeculectomy). Allocation was not randomised and no allocation rule was applied prospectively. The operating surgeon selected the procedure for each patient on clinical grounds, principally the presenting intraocular pressure, the number of topical agents already in use and the presence of a visually significant lens opacity. This indication-driven allocation is the defining structural feature of the design and is treated throughout as a source of confounding rather than as a nuisance to be adjusted away.

Participants

Eligible patients were adults with an established diagnosis of primary open-angle glaucoma who underwent one of the two study procedures, in whom the operation was uncomplicated and for whom at least six months of postoperative follow-up was documented. One eye contributed per patient, so all observations are independent. Patients were excluded if they had secondary glaucoma of any kind, including lens-induced, neovascular and uveitic glaucoma; a previously failed trabeculectomy; or any other previous intraocular surgery. Consecutive eligible patients within the accrual window were included without further selection, which is the principal protection against selection bias available to a retrospective design. 74 patients met all criteria: 54 (73.0%) underwent trabeculectomy alone and 20 (27.0%) underwent phacotrabeculectomy, as shown in Figure 1.

Outcome definitions and measurement

The two primary outcomes were the change from baseline in intraocular pressure and the change from baseline in the number of topical pressure-lowering agents used per day, each assessed at four fixed timepoints: postoperative week 1 and months 1, 3 and 6. Secondary outcomes were the trichotomous surgical outcome at six months and best-corrected visual acuity. Following criteria endorsed in international guidance[18,26], complete success was defined as an intraocular pressure below 21 mmHg achieved without any pressure-lowering medication; qualified success as a pressure below 21 mmHg achieved with medication; and failure as a pressure of 21 mmHg or above despite medication, or a pressure below 5 mmHg. Snellen visual acuities were converted to the logarithm of the minimum angle of resolution (logMAR) for analysis, so that a lower value denotes better acuity and a difference of 0.1 logMAR corresponds to one line on the chart. Continuous variables are summarised as mean and standard deviation and categorical variables as counts and percentages.

Statistical analysis

Analyses were performed on the group summary statistics for the whole cohort; individual-level records were not available for this analysis, which constrains what could be estimated in the ways set out in the Limitations, and is the reason no multivariable model, survival analysis or threshold-based classification analysis is reported. No imputation was required, no record having been lost to follow-up within the six-month window. Baseline comparability was assessed for age, sex, intraocular pressure, medication burden and visual acuity, and is reported in Table 1. Continuous baseline variables were compared with the Welch unequal-variance t test rather than the pooled-variance test, because the group variances differ and the group sizes are unbalanced at approximately 2.7:1 — the condition under which the pooled test is least robust. Categorical variables were compared with Fisher's exact test throughout, in preference to the chi-square test, because the smaller group contains only 20 eyes and several cells have low expected counts. Association strength for categorical comparisons is reported as Cramér's V.

The dispersion accompanying each change score in the source dataset was identified as the standard error rather than the standard deviation by a convergence test: multiplying each printed value by its group's square root of n recovers group-specific standard deviations that agree with one another to within 0.49% at all four pressure timepoints, which can occur only if the printed quantities scale as $1/\sqrt{n}$. Both the standard error and the reconstructed standard deviation are reported for every cell, and all standardised effect sizes are computed on the reconstructed standard deviation scale.

Within-group change from baseline was tested at each of the four timepoints with a paired t statistic recovered from the reported mean change and its standard error. Because this produces a family of 16 tests across two outcomes, two groups and four timepoints, all within-group p values were adjusted by the Holm-Bonferroni step-down procedure; adjusted values are the ones reported. The family was defined conservatively: treating the pressure and medication tests as two families of eight would give smaller adjusted values, and every conclusion is insensitive to the choice because all sixteen survive at the wider definition. The eight between-group contrasts are reported unadjusted, because none is used to support a positive claim and adjustment could only render an already-null result more null. Between-group contrasts in change score used Welch t tests with the standard error of the difference computed as the root of the summed squared standard errors, which is correct for two independent groups. The four timepoint contrasts are not, however, independent of one another: the same eyes contribute to all four, so the four rows of any between-group column describe one correlated pattern rather than four separate pieces of evidence. Standardised effect sizes are reported as Hedges g with a small-sample correction for independent contrasts, and as Cohen's d_z for paired within-group change; for the visual acuity contrast the normal-theory probability of superiority is also given, which is the model-based equivalent of an area under the receiver-operating-characteristic curve.

Proportions are reported with Wilson score 95% confidence intervals, which behave correctly near 0% and 100% where the normal approximation does not. Differences between proportions are reported with Newcombe square-and-add intervals[35], and associations as odds ratios with Woolf logit intervals; where a cell contained a zero count, a Haldane-Anscombe continuity correction of 0.5 was applied to every cell of that table before the odds ratio was computed, and this is flagged in the relevant table note. Exact p values are given to three decimal places and are not thresholded into significance categories; interpretation rests on the interval estimate and the effect size, following current guidance on statistical reporting[36].

Two further analyses were specified to prevent a null result from being misread. First, because absence of a significant difference is not evidence of equivalence[37], the primary between-group contrast was subjected to two one-sided tests against a pre-specified equivalence margin of 3 mmHg. Margins of 2, 3 and 5 mmHg all appear in the glaucoma non-inferiority literature; 3 mmHg was chosen by the authors before analysis as the conservative option, and the margin at which equivalence would in fact have been established is reported alongside the test so that a reader preferring a different threshold can substitute it. Second, a reverse precision analysis was computed: rather than reconstructing a sample-size formula that was never applied — the size of this series was fixed by the surgical caseload, not by a power calculation — the analysis reports the smallest difference the realised sample could have detected with 80% power at a two-sided alpha of 0.05, computed as shown in Equation 1. Power against the differences actually observed is also given, with the caveat that power computed from an observed effect is a monotone transformation of the corresponding p value and is offered as an aid to interpretation rather than as independent evidence; power against a pre-specified difference of 15 percentage points in complete success is reported alongside it as the version that does not suffer that objection. These quantities are displayed alongside the effect estimates in Figure 4. All computations were performed in Python 3 with the SciPy library, and the analysis script is available from the corresponding author so that every value in this paper can be regenerated from the summary data.

$$\delta_{min} = (z_{1-\alpha/2} + z_{1-\beta}) \times SD_{change} \times \sqrt{(1/n_1 + 1/n_2)} \qquad (1)$$

where δ_{min} is the smallest detectable difference in mean change, $z_{1-\alpha/2}$ = 1.96 and $z_{1-\beta}$ = 0.84 for a two-sided alpha of 0.05 and 80% power, SD_{change} is the pooled standard deviation of the change score (8.17 mmHg at six months), and n_1 and n_2 are the group sizes. Substituting the realised values gives δ_{min} = 5.99 mmHg.

Ethical considerations

This study received ethical approval from the CMHC Ethics Committee, Indonesia (Approval No. 2026/0193). All records were de-identified before analysis and no individual patient can be identified from any table or figure presented here. The study was conducted in accordance with the Declaration of Helsinki.

3. Results

Cohort and baseline comparability

74 patients contributed one eye each, 54 to the trabeculectomy group and 20 to the phacotrabeculectomy group; the derivation of the analysed sample is shown in Figure 1. Mean age across the whole cohort was 62.2 ± 10.2 years and 50 of 74 patients (67.6%, 95% CI 56.3 to 77.1) were men. The full baseline profile of both groups, with the test statistic and standardised effect size for each comparison, is detailed in Table 1.

Table 1. Baseline demographic and clinical characteristics by surgical group.

Variable	Trabeculectomy (n = 54)	Phacotrabeculectomy (n = 20)	p-value	Effect size (95% CI)
Age (years)			0.008	g = 0.60 (0.08 to 1.11)
Mean ± SD	60.6 ± 10.8	66.6 ± 7.1		
Range	40–83	58–81		
Sex, n (%)			0.174	V = 0.163
Male	39 (72.22)	11 (55.00)		
Female	15 (27.78)	9 (45.00)		
Intraocular pressure (mmHg)			0.232	g = 0.27 (−0.24 to 0.78)
Mean ± SD	27.79 ± 8.12	25.70 ± 5.92		
Range	15–44	20–44		
Topical agents per day, n (%)			0.979	V = 0.024
One agent	6 (11.11)	2 (10.00)		
Two agents	42 (77.78)	16 (80.00)		
Three agents	6 (11.11)	2 (10.00)		
Mean ± SD	2.00 ± 0.48	2.00 ± 0.46		
Best-corrected acuity (logMAR)			0.680	g = 0.15 (−0.36 to 0.66)
Mean ± SD	1.06 ± 0.96	0.93 ± 0.55		
Range	0.00–3.00	0.40–2.30		

SD, standard deviation; CI, confidence interval; g, Hedges g; V, Cramér's V; logMAR, logarithm of the minimum angle of resolution. Continuous variables were compared with the Welch unequal-variance t test and categorical variables with Fisher's exact test; the medication distribution was compared with the Pearson chi-square test across three ordered categories ($\chi^2(2) = 0.043$.

The two groups were closely matched on the variables that determine filtration outcome but differed in age. Patients selected for phacotrabeculectomy were on average 6.0 years older (66.6 ± 7.1 versus 60.6 ± 10.8 years; Welch $t(51.9) = 2.773$, $p = 0.008$; Hedges $g = 0.60$, 95% CI 0.08 to 1.11), which is the expected consequence of selecting the combined procedure for eyes with a visually significant lens opacity. Sex distribution did not differ ($p = 0.174$; Cramér's V = 0.163). Baseline intraocular pressure was 27.79 ± 8.12 mmHg in the trabeculectomy group and 25.70 ± 5.92 mmHg in the phacotrabeculectomy group, a difference of 2.09 mmHg (95% CI −1.38 to 5.56; $p = 0.232$). Baseline acuity was also comparable (1.06 ± 0.96 versus 0.93 ± 0.55 logMAR; $p = 0.680$).

The two groups were, remarkably, identical in medication burden at baseline — the group means agree to three decimal places. In the trabeculectomy group 6 eyes (11.11%) were on one agent, 42 (77.78%) on two and 6 (11.11%) on three; in the phacotrabeculectomy group the corresponding counts were 2 (10.00%), 16 (80.00%) and 2 (10.00%). Both group means were exactly 2.00 agents per day, and the distributions did not differ ($\chi^2(2) = 0.043$, $p = 0.979$). Because preoperative medication number is itself an independent predictor of bleb failure[38], this exact balance removes one of the strongest confounders of a non-randomised surgical comparison and is a genuine strength of the series.

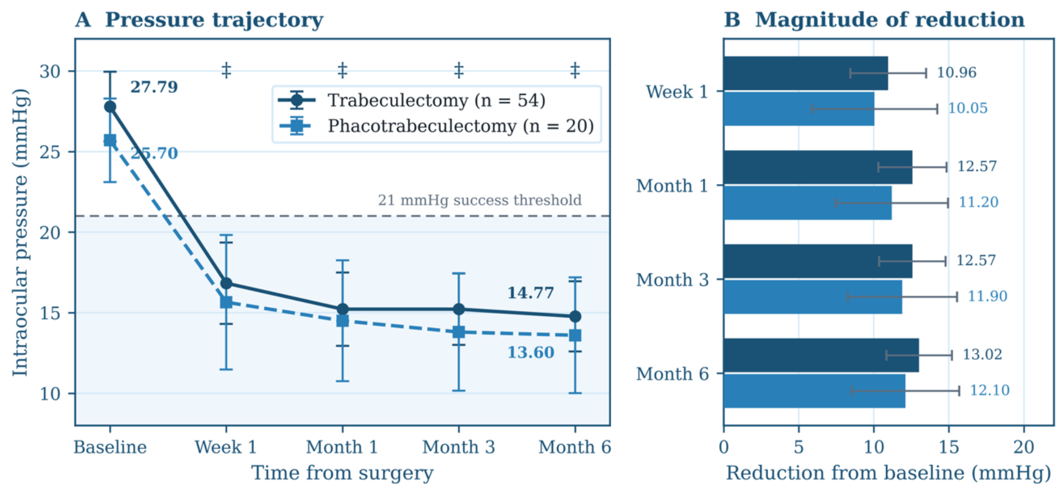
Intraocular pressure

Intraocular pressure fell steeply in both groups between baseline and the first postoperative week and then remained stable to six months, as shown in Figure 2. Every one of the eight within-group comparisons against baseline was significant after Holm adjustment across the full family of 16 tests, the largest adjusted p value in the entire family being 0.00015. The magnitude of reduction at each timepoint, with its confidence interval, its within-group effect size and the between-group contrast, is presented in Table 2.

Table 2. Change in intraocular pressure from baseline, by timepoint and surgical group.

Timepoint and group	Change (mmHg), mean ± SE	Derived SD	95% CI of change	Effect size	Adjusted p
Postoperative week 1					
Trabeculectomy	−10.96 ± 1.29	9.48	−13.55 to −8.37	1.16	<0.001
Phacotrabeculectomy	−10.05 ± 2.13	9.53	−14.51 to −5.59	1.06	<0.001
Between-group difference	−0.91	—	−5.97 to 4.15	−0.095	0.717
Postoperative month 1					
Trabeculectomy	−12.57 ± 1.16	8.52	−14.90 to −10.24	1.47	<0.001
Phacotrabeculectomy	−11.20 ± 1.91	8.54	−15.20 to −7.20	1.31	<0.001
Between-group difference	−1.37	—	−5.91 to 3.17	−0.159	0.544
Postoperative month 3					
Trabeculectomy	−12.57 ± 1.13	8.30	−14.84 to −10.30	1.51	<0.001
Phacotrabeculectomy	−11.90 ± 1.86	8.32	−15.79 to −8.01	1.43	<0.001
Between-group difference	−0.67	—	−5.09 to 3.75	−0.080	0.760
Postoperative month 6					
Trabeculectomy	−13.02 ± 1.11	8.16	−15.25 to −10.79	1.60	<0.001
Phacotrabeculectomy	−12.10 ± 1.83	8.18	−15.93 to −8.27	1.48	<0.001
Between-group difference	−0.92	—	−5.27 to 3.43	−0.112	0.670

SE, standard error; SD, standard deviation; CI, confidence interval. Negative values denote a fall in pressure. Effect size is Cohen's d_z for within-group change and Hedges g for the between-group contrast. Within-group p values are Holm-adjusted across the family of 16 within-group tests spanning both outcomes, both groups and all four timepoints; between-group p values are from Welch t tests and are unadjusted; values below 0.001 are reported as <0.001. The four between-group rows derive from the same eyes and are therefore correlated, not four independent comparisons. The dispersion printed in the source dataset was the standard error; the derived standard deviation column is obtained as SE × $\sqrt{n}$ and the two groups' derived values agree to within 0.49% at every timepoint.



Error bars are 95% confidence intervals. ‡ p < 0.001 versus baseline within group (paired t test, Holm-adjusted across 16 tests).

Figure 2. *Intraocular pressure over six months. (A) Mean pressure at each timepoint with 95% confidence intervals; the shaded region lies below the 21 mmHg success threshold. (B) Magnitude of reduction from baseline at each timepoint.*

At six months the trabeculectomy group had reduced pressure by 13.02 mmHg (95% CI 10.79 to 15.25; Cohen's d_z = 1.60) and the phacotrabeculectomy group by 12.10 mmHg (8.27 to 15.93; d_z = 1.48). Expressed proportionally these are reductions of 46.9% and 47.1% from baseline, both comfortably beyond the 20% to 30% target conventionally sought in manifest disease. Derived mean pressure at six months was 14.77 mmHg after trabeculectomy and 13.60 mmHg after phacotrabeculectomy.

The between-group difference in pressure reduction at six months was 0.92 mmHg in favour of trabeculectomy, with a 95% confidence interval of −5.27 to 3.43 mmHg ($t(33.9) = 0.430$, $p = 0.670$; Hedges g = 0.112). The same pattern held at every earlier timepoint, the largest between-group difference being 1.37 mmHg at month 1 (95% CI −5.91 to 3.17; $p = 0.544$). Two one-sided tests against a 3 mmHg margin returned $p = 0.169$, so equivalence was not established: the confidence interval remains compatible with a difference of up to 5.27 mmHg in either direction. Equivalence would have been established at any margin above 5.27 mmHg, which is the quantity a reader preferring a less conservative threshold should use.

Medication burden

Both procedures abolished the need for topical therapy in the immediate postoperative period and both permitted a substantial and sustained reduction thereafter, as displayed in Figure 3. From an identical baseline of 2.00 agents per day, the trabeculectomy group was using 0.80 agents per day at six months and the phacotrabeculectomy group 0.50. The reduction from baseline was 1.20 agents (95% CI 0.92 to 1.48) and 1.50 agents (1.00 to 2.00) respectively; all eight within-group comparisons were again significant after Holm adjustment. The full trajectory is tabulated in Table 3.

Table 3. Change in the number of topical pressure-lowering agents from baseline.

Timepoint and group	Change (agents/day), mean ± SE	Derived mean in use	95% CI of change	Effect size	Adjusted p
Postoperative week 1					
Trabeculectomy	−2.00 ± 0.06	0.00	−2.12 to −1.88	4.54	<0.001
Phacotrabeculectomy	−2.00 ± 0.11	0.00	−2.23 to −1.77	4.07	<0.001
Between-group difference	0.00	—	−0.26 to 0.26	0.000	1.000
Postoperative month 1					
Trabeculectomy	−1.52 ± 0.12	0.48	−1.76 to −1.28	1.72	<0.001
Phacotrabeculectomy	−1.70 ± 0.19	0.30	−2.10 to −1.30	2.00	<0.001
Between-group difference	0.18	—	−0.28 to 0.64	0.204	0.429
Postoperative month 3					
Trabeculectomy	−1.33 ± 0.13	0.67	−1.59 to −1.07	1.39	<0.001
Phacotrabeculectomy	−1.55 ± 0.22	0.45	−2.01 to −1.09	1.58	<0.001
Between-group difference	0.22	—	−0.30 to 0.74	0.226	0.395
Postoperative month 6					
Trabeculectomy	−1.20 ± 0.14	0.80	−1.48 to −0.92	1.17	<0.001
Phacotrabeculectomy	−1.50 ± 0.24	0.50	−2.00 to −1.00	1.40	<0.001
Between-group difference	0.30	—	−0.27 to 0.87	0.285	0.288

SE, standard error; CI, confidence interval. Both groups began from an identical mean of 2.00 agents per day. Negative values denote a reduction. The derived column gives the mean number of agents actually in use at that timepoint, obtained as baseline plus change. Effect size is Cohen's d_z within groups and Hedges g between them. Within-group p values are Holm-adjusted across the same family of 16 tests described in Table 2; values below 0.001 are reported as <0.001.

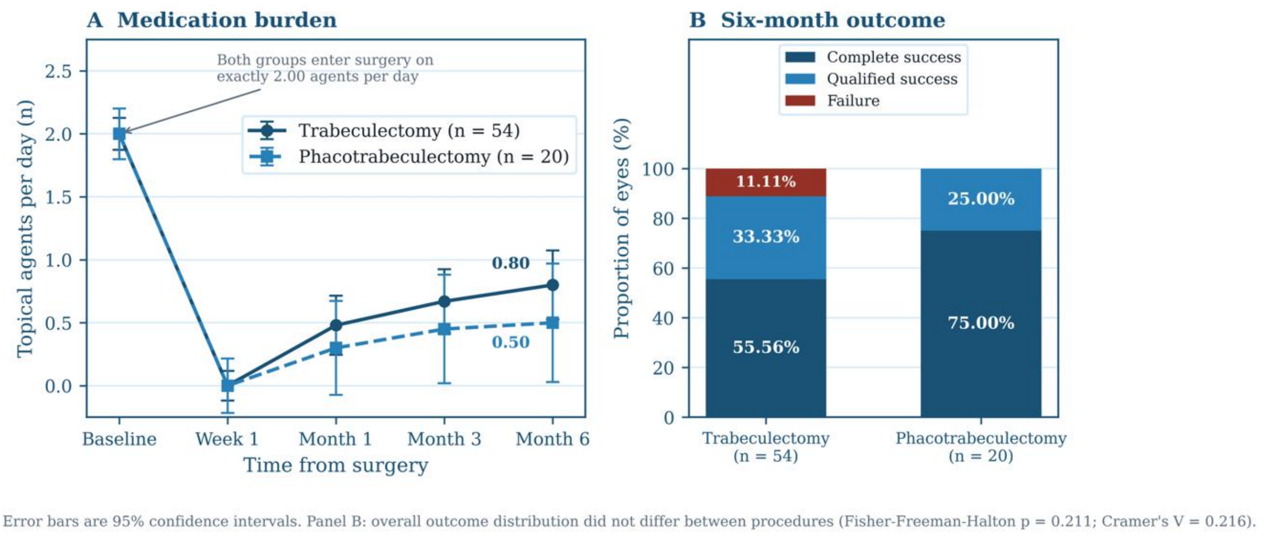


Figure 3. *Medication burden and surgical outcome. (A) Mean number of topical agents per day with 95% confidence intervals; both groups began from an identical baseline of 2.00 agents. (B) Distribution of complete success, qualified success and failure at six months.*

The between-group difference at six months was 0.30 agents per day in favour of phacotrabeculectomy (95% CI −0.27 to 0.87; p = 0.288; Hedges g = 0.285). Both groups showed the same shape of response: a nadir at week 1 followed by a gradual reintroduction of adjunctive therapy, such that by six months the typical patient in either arm required approximately one agent, or none.

Surgical success and failure

Complete success at six months was achieved by 30 of 54 eyes after trabeculectomy (55.56%, 95% CI 42.4 to 68.0) and 15 of 20 after phacotrabeculectomy (75.00%, 95% CI 53.1 to 88.8). The odds ratio favouring the combined procedure was 2.40 (95% CI 0.76 to 7.55; Fisher exact p = 0.181), corresponding to an absolute risk difference of 19.44 percentage points (95% CI −5.72 to 38.54). Because that interval crosses zero, the associated number needed to treat — a point estimate of 5.1 eyes — has a discontinuous confidence interval and should not be quoted as a bounded quantity. The complete distribution of outcomes, with every interval and effect size, is given in Table 4 and displayed in Figure 3.

Table 4. Surgical outcome at six months, with interval estimates and measures of association.

Outcome	Trabeculectomy (n = 54), n (%, 95% CI)	Phacotrabeculectomy (n = 20), n (%, 95% CI)	Risk difference, pp (95% CI)	Odds ratio (95% CI)	p-value
Complete success	30 (55.56; 42.4–68.0)	15 (75.00; 53.1–88.8)	19.44 (−5.72 to 38.54)	2.40 (0.76 to 7.55)	0.181
Qualified success	18 (33.33; 22.2–46.6)	5 (25.00; 11.2–46.9)	−8.33 (−27.51 to 16.19)	0.67 (0.21 to 2.13)	0.580
Failure	6 (11.11; 5.2–22.2)	0 (0.00; 0.0–16.1)	−11.11 (−22.19 to 6.05)	not estimable†	0.182
Pressure controlled (complete or qualified)	48 (88.89; 77.8–94.8)	20 (100.00; 83.9–100.0)	—	not estimable†	0.182

pp, percentage points; CI, confidence interval. Proportions carry Wilson score intervals; risk differences carry Newcombe square-and-add intervals; odds ratios carry Woolf logit intervals and are oriented so that a value above 1 favours phacotrabeculectomy. p values are from Fisher's exact test; values below 0.001 are reported as <0.001 throughout. † With no events in one arm the odds ratio is not estimable: a continuity-corrected value would be an artefact of the correction rather than an estimate, so the exact test and the Wilson bound on the zero-event arm are given instead. Across the full three-category outcome the two procedures did not differ (Fisher-Freeman-Halton exact p = 0.211; Cramér's V = 0.216). The number needed to treat for complete success is 5.1, but because the risk-difference interval spans zero its own interval is discontinuous and is deliberately not quoted.

Qualified success occurred in 18 eyes (33.33%) after trabeculectomy and 5 (25.00%) after phacotrabeculectomy (p = 0.580). Failure occurred in 6 eyes (11.11%, 95% CI 5.2 to 22.2) after trabeculectomy and in no eye after phacotrabeculectomy (0.00%, 95% CI 0.0 to 16.1; p = 0.182). With no events in one arm the odds ratio for failure is not estimable — a continuity-corrected value would be an artefact of the correction rather than an estimate — so the informative quantities are the exact test and the upper Wilson bound of 16.1% on the failure risk in twenty eyes with no observed failure. Considering the two success categories together, pressure was brought below 21 mmHg with or without medication in 48 of 54 trabeculectomy eyes (88.89%) and in all 20 phacotrabeculectomy eyes (100.00%), giving an overall control rate across the cohort of 91.89% (95% CI 83.4 to 96.2). Across the whole three-category outcome the two procedures were not distinguishable (Fisher-Freeman-Halton p = 0.211; Cramér's V = 0.216, a small association).

Visual acuity

Visual acuity was the one endpoint on which the two procedures separated. From statistically indistinguishable baselines, mean best-corrected acuity at six months was 0.99 ± 0.99 logMAR after trabeculectomy and 0.37 ± 0.37 logMAR after phacotrabeculectomy, a difference of 0.62 logMAR (95% CI 0.30 to 0.94; p = 0.020) — approximately six lines on a Snellen chart. The standardised effect was moderate to large (Hedges g = 0.70, 95% CI 0.18 to 1.23), and the normal-theory probability of superiority was 0.69, meaning that a randomly chosen eye from the combined-surgery group would be expected to see better than a randomly chosen eye from the trabeculectomy group on roughly 69 occasions in 100. That quantity assumes approximate normality, which these logMAR distributions are unlikely to satisfy — both are bounded below at 0.00 and each group's standard deviation approaches its mean, the signature of right skew — so it is reported to two decimals and should be read as an approximation. For the same reason the rank-based Mann-Whitney test is the primary analysis for this contrast; it makes no distributional assumption, and its p value of 0.020 is quoted from the original analysis because a rank statistic cannot be recovered from means and standard deviations. It is the one value in this report that is not independently reproducible from the published summaries. The acuity data and the summary of all between-group contrasts are set out in Table 5.

Table 5. Visual acuity at six months and summary of all between-group contrasts.

Contrast	Trabeculectomy	Phacotrabeculectomy	Difference (95% CI)	Standardised effect (95% CI)
Visual acuity, logMAR (mean ± SD)	0.99 ± 0.99	0.37 ± 0.37	0.62 (0.30 to 0.94)	g = 0.70 (0.18 to 1.23)
Range	0.00–3.00	0.00–1.30	—	PS = 0.691 (0.552 to 0.807)
Pressure reduction, month 6 (mmHg)	13.02	12.10	−0.92 (−5.27 to 3.43)	g = −0.112 (−0.620 to 0.397)
Medication reduction, month 6 (agents/day)	1.20	1.50	0.30 (−0.27 to 0.87)	g = 0.285 (−0.225 to 0.795)
Derived pressure at month 6 (mmHg)	14.77	13.60	—	—
Proportional pressure reduction (%)	46.9	47.1	—	—
Minimum detectable pressure difference (mmHg)	—	—	5.99	observed 0.92
Margin at which equivalence would hold (mmHg)	—	—	5.27	tested against 3: not met

SD, standard deviation; CI, confidence interval; g, Hedges g; PS, normal-theory probability of superiority (the model-based equivalent of an area under the receiver-operating-characteristic curve). For acuity, lower logMAR denotes better vision, so a positive difference favours phacotrabeculectomy; the acuity p value is 0.020 by Mann-Whitney U test as originally analysed, and the parametric cross-check gives Welch t(72.0) = 3.922, p = <0.001. Equivalence of pressure reduction against a 3 mmHg margin was not established (two one-sided tests, p = 0.169); it would have been established at any margin above 5.27 mmHg. Power against the observed effects was 31.8% for complete success and 76.8% for acuity, and 20.3% against a pre-specified 15 percentage-point difference in complete success.

The dispersion of outcomes differed as markedly as the means. Postoperative acuity ranged from 0.00 to 3.00 logMAR after trabeculectomy but only from 0.00 to 1.30 logMAR after phacotrabeculectomy, and the standard deviation was 0.99 against 0.37. The combined procedure therefore not only improved average acuity but eliminated the tail of very poor visual outcomes, which is the clinically relevant property.

What this sample could resolve

The null between-group findings must be read against the precision the design could deliver. With 54 and 20 eyes and a standard deviation of change of 8.17 mmHg, the smallest difference in pressure reduction detectable with 80% power at a two-sided alpha of 0.05 was 5.99 mmHg — 6.5 times larger than the 0.92 mmHg actually observed. For the complete-success comparison the achieved power was 31.8%, and detecting a difference of the observed size at 80% power with the same 2.7:1 allocation would have required approximately 240 eyes. Against a pre-specified difference of 15 percentage points rather than the observed one, power was 20.3%. Only the visual acuity contrast was adequately powered, at 76.8%; power figures computed from observed effects are restatements of their p values and are given only as an aid to reading the null results. These quantities, together with every between-group effect estimate on a common standardised scale, are displayed in Figure 4.

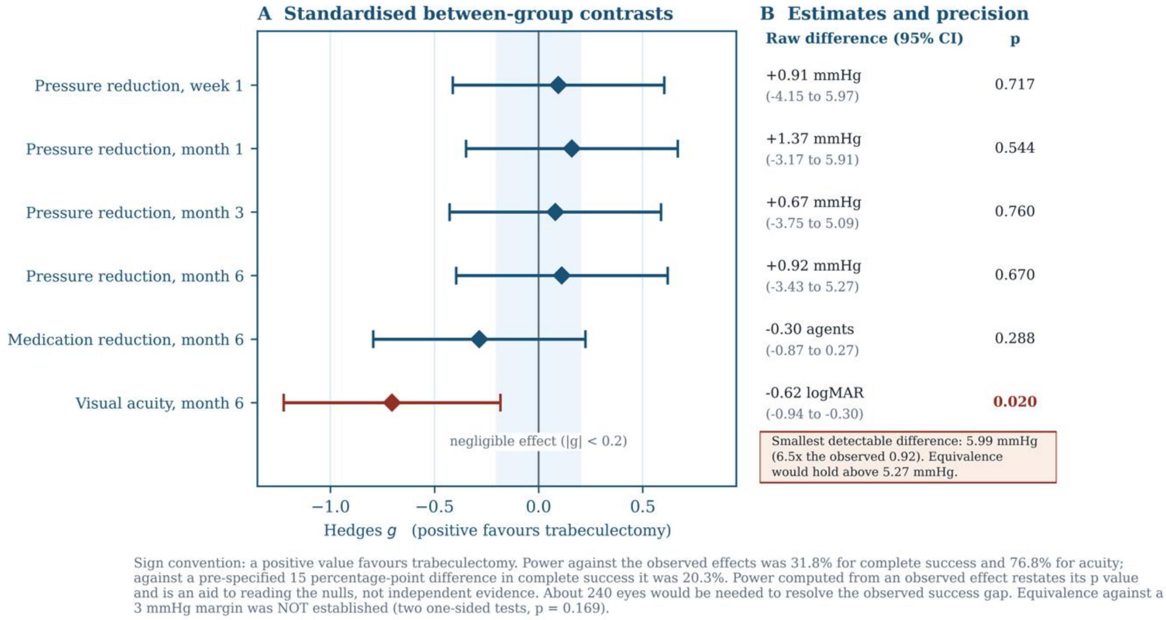


Figure 4. *Between-group contrasts on a common standardised scale, with raw differences and the precision the design could deliver. Positive values favour trabeculectomy. Only the visual acuity contrast excludes the null.*

4. Discussion

In this consecutive surgical series managed at the Department of Ophthalmology, Faculty of Medicine, Andalas University, Indonesia, both trabeculectomy alone and combined phacotrabeculectomy produced a large, early and durable fall in intraocular pressure — 46.9% and 47.1% from baseline at six months respectively — together with a reduction in topical therapy from an identical baseline of 2.00 agents per day to approximately one agent or none. Pressure was brought below the 21 mmHg threshold, with or without medication, in 91.89% of the whole cohort. The two procedures could not be separated on any pressure or medication endpoint, as Table 5 and Figure 4 make plain, but they were clearly separated on visual acuity, which favoured the combined procedure by 0.62 logMAR with a moderate-to-large standardised effect (Hedges g = 0.70).

The magnitude of pressure reduction achieved here is consistent with, and at the upper end of, the published surgical literature. Contemporary cohorts of primary trabeculectomy in advanced open-angle disease report end-pressures in the low teens with a substantial proportion of eyes medication-free[17,18], and device-assisted filtration has not bettered that[19]. What distinguishes the present series is where it started. Absolute pressure reduction after trabeculectomy scales with the preoperative pressure[39], and this cohort entered surgery at 27.79 mmHg on two agents, so a fall of 13.02 mmHg to a six-month mean of 14.77 mmHg is a larger absolute drop to a slightly higher end-point than series recruiting at lower baselines achieve, as the timepoint-by-timepoint values in Table 2 show. That is the signature of late presentation rather than of superior surgery, and it matches the Indonesian and regional epidemiology, in which under-diagnosis persists until substantial damage has accrued[3,5]. Preoperative pressure and medication burden are themselves established predictors of trabeculectomy success[40], which is why this cohort's baseline profile matters to the interpretation.

The null between-group result on pressure reproduces the weight of the existing evidence rather than contradicting it. A systematic review with meta-analysis of phacotrabeculectomy against trabeculectomy with or without later phacoemulsification found no significant pooled difference in pressure reduction[25]. A five-year cohort comparing synchronous with sequential surgery found no difference in the cumulative probability of success[29]. A randomised trial that isolated the filtration component found that adding it to lens extraction increased medication-free pressure control without improving final acuity[24]. Our point estimate of 0.92 mmHg, with a confidence interval of −5.27 to 3.43 mmHg, sits comfortably inside that literature. The finding that most closely parallels ours is the twelve-month comparison that reported equivalent pressure control with superior postoperative acuity after the combined procedure[28] — the same dissociation between pressure and vision that this series shows at six months. The trajectory in Figure 2 makes the point visually: the two curves separate by less than one millimetre of mercury at every visit.

Two considerations temper the reading of these success rates. The first is time: long-term cohorts of trabeculectomy in open-angle glaucoma show cumulative success declining steadily over years, driven mainly by the reintroduction of medication[18], and the two-year comparison of trabeculectomy with phacotrabeculectomy shows the two arms converging as follow-up lengthens[26]. The second is the bleb itself: early scarring is detectable within months, is the proximate mechanism of medication resumption, and often requires revision[21,41]; where revision fails, a repeat filtration procedure or a drainage device becomes the next step[42]. Both observations imply that a six-month complete-success rate — 55.56% and 75.00% in the present groups — is an optimistic estimate of durable success, and that the gradual reintroduction of adjunctive therapy already visible in Figure 3 between week 1 and month 6 is the leading edge of that process rather than a plateau. The apparent advantage of the combined procedure on complete success (odds ratio 2.40, 95% CI 0.76 to 7.55) should therefore not be read as established; it is an underpowered comparison at a timepoint known to flatter both arms, and the intervals in Table 4 are wide enough to accommodate a disadvantage as easily as a benefit.

The mechanistic account of these results is straightforward and has two independent strands. Filtration lowers pressure by creating a guarded fistula that bypasses trabecular outflow resistance, and the durability of that effect is governed almost entirely by the fibroblast response at the bleb wall. Chronic exposure to preserved topical medication primes conjunctival inflammation and is an established determinant of subsequent filtration failure[14,15]; preoperative medication number is an independent predictor of bleb failure in its own right[38]. That both groups here entered surgery on exactly 2.00 agents per day (p = 0.979) is therefore not a trivial baseline coincidence but the removal of the single most important prognostic imbalance available to confound a non-randomised surgical comparison. The second strand explains the acuity result without invoking any effect on outflow: lens extraction removes the opacity that was limiting acuity and simultaneously deepens the anterior chamber. The combined procedure thus delivers a visual benefit that trabeculectomy alone structurally cannot, which is exactly the dissociation observed — equivalent outflow surgery, unequal visual rehabilitation[24]. The converse is also documented: trabeculectomy alone is frequently followed by a measurable early decline in acuity, and the trajectory of that decline differs by filtration technique independently of the pressure achieved[43,44]. Two qualifications belong here. Refractive predictability is reduced when filtration is combined with lens extraction, and lens power calculation is less accurate in combined surgery than in cataract surgery alone[45,46], so the acuity advantage measured at six months may understate what an optimally refracted eye could achieve. And an acuity gain is not by itself a functional gain: adding a glaucoma procedure to cataract surgery has not been shown to alter the visual field trajectory[47].

For Indonesian practice the implications are practical. The Jaminan Kesehatan Nasional scheme has extended coverage to most of the population, but specialist and surgical capacity remain the binding constraint[32]. Where a patient with POAG and a visually significant cataract would otherwise require two separate theatre episodes, two pre-operative work-ups and two recovery periods, a single combined procedure that achieves the same pressure control and better acuity is the more efficient use of a scarce resource, and this series provides domestic evidence that it does so safely. The same logic applies upstream: insurance membership is a strong determinant of whether a patient receives eye surgery at all[33], so a pathway that resolves two problems in one funded episode widens access as well as saving theatre time. The pathway summarised in Figure 5 is offered as a locally grounded default, not as a substitute for national guidance. The reduction in medication burden carries a parallel benefit: each agent withdrawn is a recurring cost avoided and a reduction in preservative exposure that itself protects the ocular surface and future surgical prospects[15,48]. Patients themselves identify drop burden, treatment cost and visit frequency as the dominant burdens of glaucoma care[49], adherence falls as regimen complexity rises[50], and reducing topical therapy after surgery improves both ocular surface metrics and vision-related quality of life[51]. The scale of that saving is visible in Table 3: a reduction from two agents per day to approximately one, sustained to six months in both arms.

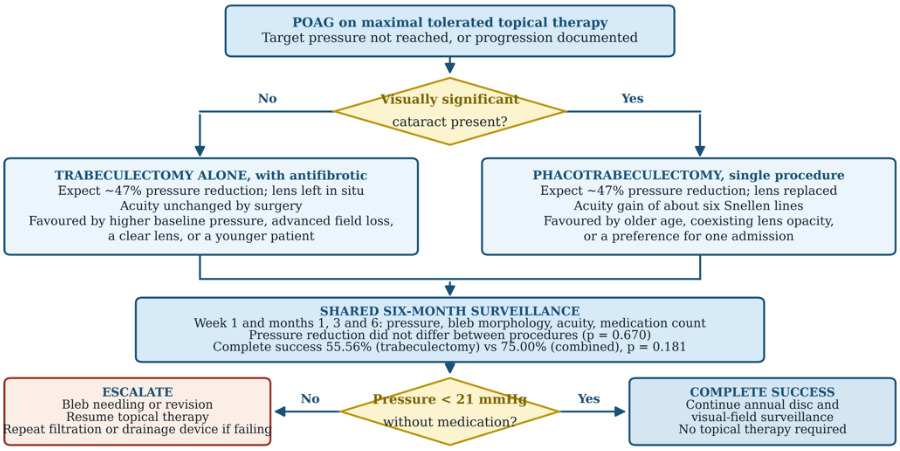


Figure 5. *Procedure-selection and six-month surveillance pathway derived from the present cohort, for use where a visually significant cataract coexists with primary open-angle glaucoma.*

The wider Indonesian context also explains what this series does not contain. Primary selective laser trabeculoplasty reduces the eventual need for incisional surgery[23], and minimally invasive procedures now occupy a defined niche in high-income practice; but the evidence for those procedures is of low certainty and none matches trabeculectomy for the magnitude of pressure reduction[22], while device cost and the absence of long-term regional data constrain their adoption across Asia-Pacific services[31]. In a department receiving patients at 27.79 mmHg on two agents, a procedure delivering a 47% reduction is not a conservative choice but the appropriate one, and trabeculectomy — alone or combined — remains the operation of record[16]. Among the combined options themselves, phacotrabeculectomy has outperformed phaco-viscocanalostomy for pressure reduction in open-angle disease[52], which is a further reason for a service with limited device access to standardise on it.

Three qualifications to the success figures deserve statement. First, success here is defined against a single conventional threshold of 21 mmHg without medication. In a cohort presenting at a mean of 27.79 mmHg, many eyes will have advanced damage for which most surgeons would target the low teens, and an eye at 20 mmHg off all drops counts here as a complete success while possibly still progressing. A stricter criterion — 18 mmHg, or a 30% reduction — would return lower success rates in both arms. The reassurance is that the mean pressures actually achieved, 14.77 and 13.60 mmHg, sit comfortably below the threshold used rather than just beneath it. Second, the shape of the medication curve in Figure 3 is itself a finding: both groups are at zero agents at week 1 and climb steadily through months 1, 3 and 6, and the slope has not flattened by the end of follow-up. That is the expected signature of progressive bleb fibrosis, and read together with the external evidence of success falling from about 88% at one year to about 62% at five[18], it indicates that the curve in Table 3 is the leading edge of a longer trajectory rather than a plateau. Third, these results come from a single university department with subspecialty-trained surgeons and a regular filtration caseload; they should not be read as what a general ophthalmologist performing a handful of trabeculectomies a year can expect. They are, however, more transferable to other late-presenting Indonesian and regional populations than European series are, precisely because the baseline pressures match.

Strengths

Four features strengthen the inference available from these data. First, the cohort is consecutive: every eligible eye operated within the accrual window was included, without pre-selection, which is the principal defence a retrospective design has against selection bias. Second, the groups were balanced at baseline on intraocular pressure ($p = 0.232$), sex ($p = 0.174$), visual acuity (p

= 0.680) and — exactly — on medication burden (p = 0.979), the last being the variable most strongly predictive of filtration failure[38]. Third, follow-up was complete: no eye was lost within the six-month window, so no imputation was required and the analysed sample equals the eligible sample, as Figure 1 shows. Fourth, the analysis reports interval estimates and standardised effect sizes for every comparison, tests equivalence explicitly rather than inferring it from a non-significant p value[37], and states the minimum detectable difference so that the null findings can be interpreted for what they are — an absence of resolution rather than a demonstration of sameness[36].

Limitations

Six limitations bound the conclusions. The first and most consequential is that allocation was not randomised: the operating surgeon chose the procedure, and the criterion that drove that choice — the presence of a visually significant cataract — is also a direct determinant of the endpoint on which the two groups differ. The acuity advantage of phacotrabeculectomy is therefore partly a consequence of the indication for it, and a randomised trial in eyes with coexisting cataract would be required to establish how much of the 0.62 logMAR difference is attributable to the operation rather than to the case-mix. The same mechanism generated the 6.0-year age difference between the groups (p = 0.008), which is the one baseline imbalance present. The direction of that bias can be bounded even without individual data, and it is informative to do so: older eyes mount a less vigorous fibroblast response and therefore tend to do better after filtration surgery, while older patients have worse acuity for reasons unrelated to the operation. The age imbalance therefore flatters the phacotrabeculectomy group on pressure and disadvantages it on acuity, which means the acuity finding is if anything conservative, while the null pressure finding could be masking a small true advantage for trabeculectomy. Lens status, the other structural imbalance, was not measured at all — it is the allocation criterion itself — and cannot be bounded in the same way.

Second, the study is underpowered for every comparison except acuity. With 54 and 20 eyes the smallest detectable difference in pressure reduction was 5.99 mmHg, some 6.5 times the observed 0.92 mmHg, and the achieved power for the complete-success contrast was only 31.8%; approximately 240 eyes would be needed to resolve a difference of the size observed. The equivalence test was correspondingly negative (p = 0.169). No claim that the two procedures give the same pressure control is supported by these data; the honest statement is that this series could not tell them apart.

Third, the follow-up horizon is short. Six months precedes the interval over which bleb failure and medication resumption principally occur, and the external evidence indicates that success rates measured at this point overstate durable success[18,26]. Fourth, the surgical record available for this analysis does not specify the antifibrotic protocol used, the tonometric method, or the bleb-management strategy, and it does not enumerate postoperative complications. Since hypotony, shallow anterior chamber and bleb leak dominate early morbidity after filtration surgery[20,53], and since the randomised evidence shows early complications to be more frequent after trabeculectomy than after tube shunt[20], the absence of a complication table means that no safety claim beyond the recorded absence of vision-threatening events can be made from this series. These variables should be captured prospectively in any successor study.

Fifth, group sizes are markedly unbalanced at approximately 2.7:1, which depresses precision for every between-group contrast; the confidence interval for the odds ratio on complete success spans 0.76 to 7.55 and is compatible with both a modest disadvantage and a large advantage for the combined procedure. Sixth, the analysis was conducted on summary statistics rather than individual records, which precluded multivariable adjustment for the confounding described above, precluded time-to-event analysis of failure, and precluded any threshold-based classification analysis. Each of these would have been informative and none could be performed honestly without the case-level data; they are stated here as gaps rather than being approximated.

5. Conclusion

Trabeculectomy and phacotrabeculectomy each produced a large, early and sustained reduction in intraocular pressure — 46.9% and 47.1% from baseline at six months — and each allowed topical therapy to be reduced from two agents per day to approximately one or none, with pressure controlled below 21 mmHg in 91.89% of the whole cohort. This series could not distinguish the two procedures on any pressure or medication endpoint, and because the smallest difference it could have detected was 5.99 mmHg, that null result should be read as a limit of resolution rather than as evidence of equivalence. The one reproducible difference was visual: acuity at six months was 0.62 logMAR better after the combined procedure, with the tail of very poor outcomes eliminated.

The procedure-selection and surveillance pathway set out in Figure 5 summarises what these findings support in practice. For an Indonesian service in which specialist and theatre capacity are the binding constraint, the practical implication is that where a visually significant cataract coexists with primary open-angle glaucoma requiring surgery, phacotrabeculectomy delivers comparable pressure control and better visual rehabilitation within a single admission. Confirmation now requires a prospective randomised comparison in eyes with coexisting cataract, powered on a pre-specified equivalence margin, following patients for at least two years, and recording the antifibrotic protocol and the full complication profile that the present record could not supply.

Ethical approval and consent. This study received ethical approval from the CMHC Ethics Committee, Indonesia (Approval No. 2026/0193). All records were de-identified before analysis and no individual patient can be identified from any table or figure presented here. The study was conducted in accordance with the Declaration of Helsinki.

Data availability. The summary dataset and the complete analysis script are available from the corresponding author on reasonable request.

Competing interests. The authors declare no conflict of interest.

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Generative artificial intelligence use. The authors did not use generative artificial intelligence to generate the scientific content, data extraction, or statistical analysis reported in this manuscript. The authors take full responsibility for the content of the published article.

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