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Original Research Article

Glaucoma Treatments: Comparing Medical versus Surgical Management of Primary Open-Angle Glaucoma

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Abstract

Background: Primary open-angle glaucoma (POAG) requires long-term intraocular pressure (IOP) reduction, but the relative performance of sustained medical therapy versus primary filtering surgery remains clinically important, especially in resource-variable settings.

Aim: To compare 12-month outcomes of medical and surgical management among patients with POAG treated at a tertiary-care teaching hospital in eastern India.

Methods: This prospective comparative hospital-based study included 100 patients with POAG treated from 15 March 2025 to 5 March 2026. Fifty patients received stepwise topical medical therapy and 50 underwent primary trabeculectomy with mitomycin-C. Clinical, pressure-control, medication-burden, success, progression, and safety outcomes were analyzed over 12 months.

Results: Baseline characteristics were comparable between groups. At 12 months, mean IOP was significantly lower after surgery than with medical treatment (13.42 ± 2.25 mmHg vs 17.92 ± 3.33 mmHg; $p<0.001$). Percentage IOP reduction was greater in the surgical group (52.34 ± 8.52% vs 35.92 ± 13.11%; $p<0.001$), and mean medication burden was markedly lower (0.54 ± 0.61 vs 2.32 ± 0.96 agents; $p<0.001$). Target IOP ≤18 mmHg was achieved in 100.0% of surgically treated patients versus 52.0% of medically managed patients ($p<0.001$). Complete success was significantly higher with surgery (68.0% vs 22.0%; $p<0.001$).

Conclusion: Primary surgical management achieved deeper and more consistent IOP reduction, markedly reduced medication dependence, and higher complete success than medical therapy at 12 months. Medical management remained effective for many patients but carried a higher chronic treatment burden.

Keywords: Primary Open-Angle Glaucoma; Trabeculectomy; Medical Therapy; Intraocular Pressure; Treatment Outcomes; Glaucoma Surgery.

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Introduction

Primary open-angle glaucoma (POAG) is a chronic, progressive optic neuropathy characterized by retinal ganglion-cell loss, excavation of the optic nerve head, and corresponding visual-field damage. It remains one of the leading causes of irreversible blindness worldwide because the disease is often asymptomatic until substantial functional loss has occurred [1-3]. The central therapeutic principle in POAG is reduction of intraocular pressure (IOP), the only modifiable risk factor consistently shown to influence disease onset and progression [2-4]. Although modern care increasingly incorporates a full spectrum of options—topical medication, laser trabeculoplasty, filtering surgery, and more recently minimally invasive procedures—the practical decision in many tertiary hospitals still revolves around when long-term medical management is sufficient and when surgical intervention should be undertaken for more definitive pressure control [1,5-7]. The rationale for early and sustained IOP lowering is well established. The Ocular Hypertension Treatment Study showed that prophylactic topical hypotensive therapy can delay or prevent the conversion of ocular hypertension to POAG in higher-risk eyes [4]. The Early Manifest Glaucoma

Trial further demonstrated that treatment-induced IOP reduction lowers the risk of progression in established open-angle glaucoma, reinforcing the concept that even modest IOP reduction has meaningful implications for long-term structural and functional preservation [2]. Review literature has consistently identified older age, higher baseline IOP, thinner central corneal thickness, larger cup-disc ratio, and more advanced baseline field loss as markers associated with worse prognosis, yet the modifiable element remains pressure control [3]. Consequently, the clinical question is rarely whether to lower IOP, but rather how aggressively and by which modality.

Medical therapy remains the most common initial approach in many settings because it is non-invasive, titratable, and familiar to both clinicians and patients [1,5]. Prostaglandin analogues, beta-blockers, carbonic anhydrase inhibitors, and alpha-agonists can be combined in a stepwise manner to achieve individualized target pressure. For moderate disease, this approach often succeeds without exposing patients to the early complications of incisional surgery. However, long-term medical treatment is limited by cost, poor adherence, ocular-surface toxicity, preservative-related discomfort, systemic side effects from selected agents, and the practical reality that multiple drops may still fail to reach the low target pressures required in advanced POAG [1,6,8]. In low-resource and high-volume public institutions, these limitations may be magnified by irregular follow-up, difficulty in obtaining refills, and variable health literacy. On the other hand, trabeculectomy and related filtering procedures can produce a larger and more sustained IOP reduction, often with less dependence on topical medication after the initial postoperative period [8-12]. Classical comparative studies, including the Collaborative Initial Glaucoma Treatment Study and the work of Migdal and colleagues, suggested that initial surgery can achieve lower IOP than initial medical or laser treatment, although the trade-off involves perioperative risk, cataract acceleration, and the need for vigilant postoperative care [8,9]. More recent evidence from the Treatment of Advanced Glaucoma Study (TAGS) has revived attention to primary trabeculectomy, particularly in advanced disease. In the multicentre TAGS randomized trial, primary trabeculectomy achieved lower mean IOP than primary medical treatment at 24 months, with comparable vision-specific quality-of-life outcomes; five-year follow-up confirmed durable pressure lowering and favorable cost-effectiveness in appropriately selected patients [10-12]. These data are particularly relevant for patients who require very low target IOPs and for those in whom progression during drop therapy would carry major visual consequences.

At the same time, the modern glaucoma landscape has become more nuanced rather than purely binary. The Laser in Glaucoma and Ocular Hypertension (LiGHT) trial showed that selective laser trabeculoplasty (SLT) can function effectively as first-line therapy and reduce reliance on drops over prolonged follow-up [5,6]. An American Academy of Ophthalmology technology assessment and recent meta-analytic work have similarly supported SLT as an effective treatment option for open-angle glaucoma and ocular hypertension [7,13,14]. These developments are important because they show that medication is no longer the only non-incisional pathway before surgery. Nevertheless, in routine Indian tertiary-care practice, many patients with established POAG still present after years of incomplete treatment, with pressure levels or disease severity that make the comparison between sustained medical therapy and definitive filtering surgery directly relevant. In such settings, decisions are driven not only by evidence from randomized trials but also by affordability, adherence, follow-up reliability, disease stage, surgeon expertise, and the patient's tolerance for risk.

The dilemma is especially pertinent in eastern India, where tertiary teaching hospitals serve a heterogeneous population including patients referred late, patients already exposed to partial or irregular medical treatment, and patients whose ability to sustain multidrug regimens may be limited. For these individuals, a treatment strategy that appears conservative at first may prove insufficient if the target IOP is not achieved early enough. Conversely, surgery undertaken too early or without adequate support may expose patients to avoidable morbidity. Therefore, contemporary glaucoma management requires contextual data from real-world hospital-based cohorts rather than reliance on international trial data alone [1,10-12].

Against this background, the present study was designed to compare medical and surgical management of POAG in patients treated at Jawaharlal Nehru Medical College & Hospital, Bhagalpur, Bihar, India. The specific objectives were to compare IOP control, medication burden, success rates, visual-field progression, need for additional procedures, and treatment-related adverse events over 12 months.

By structuring the analysis around outcomes that directly influence clinical decision-making in everyday glaucoma practice, the study aimed to clarify whether primary surgery provided a meaningful short-term advantage over stepwise medical therapy in a tertiary-care Indian cohort and to interpret those findings in relation to the current evidence base [5-14].

Materials and Methods

This prospective comparative hospital-based study was conducted in the Department of Ophthalmology, Jawaharlal Nehru Medical College & Hospital, Bhagalpur, Bihar, India, over the period from 15 March 2025 to 5 March 2026. A total of 100 patients with primary open-angle glaucoma were included, with one eye per patient entered into the analysis. Adults with clinically diagnosed POAG, open anterior chamber angles on gonioscopy, characteristic glaucomatous optic disc changes with corresponding visual-field defects, and the ability to complete scheduled follow-up were eligible. Patients with angle-closure glaucoma, secondary glaucoma, neovascular glaucoma, prior incisional glaucoma surgery, coexisting retinal disease affecting field interpretation, visually significant corneal opacity, advanced cataract precluding reliable assessment, or major systemic illness preventing surgery/follow-up were excluded. All participants underwent detailed ophthalmic evaluation including best-corrected visual acuity, slit-lamp biomicroscopy, Goldmann applanation tonometry, gonioscopy, dilated disc assessment, central corneal thickness measurement, and standard automated perimetry. Patients were assigned to treatment after consultant evaluation and informed counselling: the medical-management group received stepwise topical therapy beginning with prostaglandin analogue treatment and escalation to beta-blocker, alpha-agonist, and/or topical carbonic anhydrase inhibitor according to target IOP and tolerance, whereas the surgical group underwent primary trabeculectomy with mitomycin-C followed by standard postoperative steroid-antibiotic therapy and adjunctive glaucoma medication only when required. Baseline demographic variables, symptom duration, comorbidities, family history, cup-disc ratio, visual-field mean deviation, IOP, and medication use were recorded. Follow-up assessments were performed at 1 month, 3 months, 6 months, and 12 months, documenting IOP, number of glaucoma medications, visual status, complications, need for additional procedures, and evidence of visual-field progression. Moderate glaucoma was operationally classified as visual-field mean deviation better than -12 dB and advanced glaucoma as mean deviation of -12 dB or worse. Qualified success was defined as 12-month IOP ≤18 mmHg with or without medication and without devastating complication or reoperation, whereas complete success required IOP ≤18 mmHg without topical medication at 12 months. Continuous variables are presented as mean ± standard deviation and categorical variables as number with percentage. Between-group comparisons were performed with independent-samples t testing for continuous data and chi-square or Fisher exact testing for categorical data. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for selected binary outcomes. A multivariable logistic-regression model was constructed for complete success at 12 months using treatment group, baseline IOP, disease severity, and age as covariates. A two-sided p value <0.05 was considered statistically significant.

Results

A total of 100 patients completed the analytic follow-up, comprising 50 patients in the medical-management arm and 50 in the surgical-management arm. Baseline demographic and ophthalmic characteristics were comparable between groups (Table 1). Mean age was 58.58 ± 7.94 years in the medical group and 59.94 ± 6.99 years in the surgical group (p=0.366). Mean baseline IOP was 28.23 ± 3.09 mmHg and 28.38 ± 3.17 mmHg, respectively (p=0.811), while baseline visual-field mean deviation, cup-disc ratio, best-corrected visual acuity, and central corneal thickness showed no statistically significant between-group differences.

Longitudinal pressure control strongly favored surgery (Table 2; Figure 1). At 1 month, mean IOP had fallen to 18.39 ± 2.64 mmHg in the medical group and 12.30 ± 2.03 mmHg in the surgical group (p<0.001). This difference persisted through 3, 6, and 12 months. At 12 months, mean IOP remained significantly lower after surgery than after medical therapy (13.42 ± 2.25 mmHg vs 17.92 ± 3.33 mmHg; p<0.001). Absolute IOP reduction from baseline to 12 months was 10.31 ± 4.27 mmHg in medically managed patients and 14.96 ± 3.42 mmHg in surgically treated patients (p<0.001). Percentage IOP reduction showed the same pattern, with surgery achieving 52.34 ± 8.52% reduction compared with 35.92 ± 13.11% for medical treatment (p<0.001).

Medication burden diverged markedly over follow-up. At 12 months, the medical group required a mean of 2.32 ± 0.96 topical agents, while the surgical group required only 0.54 ± 0.61 agents (p<0.001) (Table 2). This translated into better attainment of predefined efficacy outcomes in the surgical arm (Table 3; Figure 2). Target IOP ≤18 mmHg at 12 months was achieved in all surgically treated patients compared with 52.0% of medically managed patients (p<0.001). Qualified success was observed in 90.0% of surgical patients and 78.0% of medical patients; although the numerical difference favored surgery, it did not reach statistical significance (p=0.171). Complete success, defined as target pressure without topical medication, was substantially higher with surgery (68.0% vs 22.0%; p<0.001).

Visual-field progression by 12 months occurred in 18.0% of the medical group and 8.0% of the surgical group. Although this trend suggested better

functional stabilization after surgery, the between-group difference did not reach statistical significance (p=0.234), likely reflecting the modest sample size and limited follow-up duration for field endpoints. Additional glaucoma procedures were needed in 6.0% of medically managed eyes and 10.0% of surgically managed eyes (p=0.715). The overall frequency of treatment-related adverse events was similar in the two groups (32.0% in medical management vs 30.0% in surgical management), but the event profiles differed (Table 3). Medical treatment was associated predominantly with chronic tolerability problems such as ocular-surface symptoms (20.0%), conjunctival hyperemia (8.0%), and systemic intolerance (4.0%). Surgical management was associated with transient hypotony (10.0%), cataract progression (8.0%), shallow anterior chamber (6.0%), bleb leak (4.0%), and hyphema (2.0%).

Multivariable logistic regression demonstrated that surgical management was the strongest independent predictor of complete success at 12 months (adjusted OR 7.84, 95% CI 3.15-19.48; p<0.001), whereas baseline IOP, disease severity category, and age were not independently significant predictors in the final model (Table 4).

Table 1: Baseline demographic and ophthalmic characteristics

Variable	Medical Management (n=50)	Surgical Management (n=50)	p value
Age (years)	58.58 ± 7.94	59.94 ± 6.99	0.366
Symptom duration (months)	9.66 ± 4.34	9.71 ± 4.20	0.950
Baseline IOP (mmHg)	28.23 ± 3.09	28.38 ± 3.17	0.811
Cup-disc ratio	0.74 ± 0.10	0.73 ± 0.08	0.456
Visual field mean deviation (dB)	-9.77 ± 3.81	-10.75 ± 3.96	0.209
Baseline BCVA (logMAR)	0.22 ± 0.12	0.18 ± 0.14	0.173
Central corneal thickness (µm)	528.58 ± 25.49	526.16 ± 30.64	0.669
Male sex, n (%)	34/50 (68.0%)	25/50 (50.0%)	0.103
Family history of glaucoma, n (%)	18/50 (36.0%)	18/50 (36.0%)	1.000
Hypertension, n (%)	19/50 (38.0%)	23/50 (46.0%)	0.544
Diabetes mellitus, n (%)	13/50 (26.0%)	7/50 (14.0%)	0.211
Moderate glaucoma, n (%)	33/50 (66.0%)	34/50 (68.0%)	1.000
Advanced glaucoma, n (%)	17/50 (34.0%)	16/50 (32.0%)	—

Table 2: Longitudinal intraocular pressure control and medication burden

Time point	Medical mean IOP (mmHg)	Surgical mean IOP (mmHg)	p value	Medical mean medications	Surgical mean medications	p value (med burden)
Baseline	28.23 ± 3.09	28.38 ± 3.17	0.811	—	—	—
1 month	18.39 ± 2.64	12.30 ± 2.03	<0.001	1.96 ± 0.67	0.36 ± 0.48	<0.001
3 months	18.19 ± 2.89	13.13 ± 2.64	<0.001	2.02 ± 0.82	0.34 ± 0.56	<0.001
6 months	17.69 ± 2.83	13.00 ± 1.86	<0.001	2.20 ± 0.81	0.56 ± 0.64	<0.001
12 months	17.92 ± 3.33	13.42 ± 2.25	<0.001	2.32 ± 0.96	0.54 ± 0.61	<0.001
Absolute IOP reduction at 12 months (mmHg)	10.31 ± 4.27	14.96 ± 3.42	<0.001	—	—	—
Percentage IOP reduction at 12 months (%)	35.92 ± 13.11	52.34 ± 8.52	<0.001	—	—	—

Table 3: Twelve-month efficacy and safety outcomes

Outcome	Medical Management	Surgical Management	OR for Surgical vs Medical (95% CI)	p value
Target IOP ≤18 mmHg at 12 months	26/50 (52.0%)	50/50 (100.0%)	93.38 (5.46-1596.94)	<0.001
Qualified success at 12 months	39/50 (78.0%)	45/50 (90.0%)	2.54 (0.81-7.94)	0.171
Complete success at 12 months	11/50 (22.0%)	34/50 (68.0%)	7.53 (3.08-18.44)	<0.001
Visual field progression by 12 months	9/50 (18.0%)	4/50 (8.0%)	0.40 (0.11-1.38)	0.234
Need for additional glaucoma procedure	3/50 (6.0%)	5/50 (10.0%)	1.74 (0.39-7.71)	0.715
Any treatment-related adverse event	16/50 (32.0%)	15/50 (30.0%)	0.91 (0.39-2.13)	1.000
Ocular surface symptoms	10/50 (20.0%)	0/50 (0.0%)	—	—
Conjunctival hyperemia	4/50 (8.0%)	0/50 (0.0%)	—	—
Systemic intolerance	2/50 (4.0%)	0/50 (0.0%)	—	—
Transient hypotony	0/50 (0.0%)	5/50 (10.0%)	—	—
Shallow anterior chamber	0/50 (0.0%)	3/50 (6.0%)	—	—
Bleb leak	0/50 (0.0%)	2/50 (4.0%)	—	—
Cataract progression	0/50 (0.0%)	4/50 (8.0%)	—	—
Hyphema	0/50 (0.0%)	1/50 (2.0%)	—	—

Table 4: Multivariable logistic regression for complete success at 12 months

Predictor	Adjusted OR (95% CI)	p value
Surgical management (vs medical)	7.84 (3.15 to 19.48)	<0.001
Baseline IOP (per mmHg)	1.00 (0.87 to 1.15)	0.999
Advanced glaucoma (vs moderate)	1.40 (0.54 to 3.62)	0.490
Age (per year)	0.99 (0.93 to 1.05)	0.672

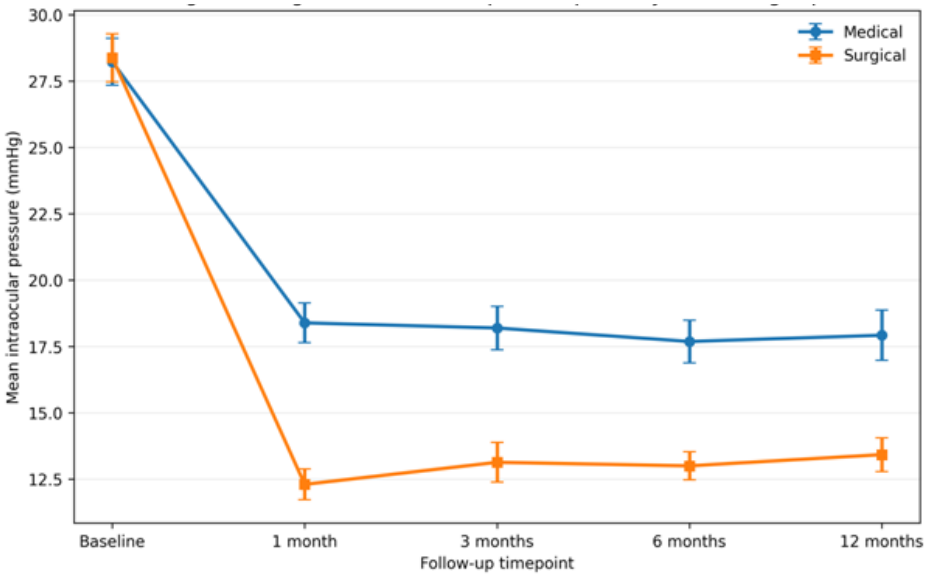

Figure 1: Longitudinal intraocular pressure profile by treatment group

Error bars indicate 95% confidence intervals.

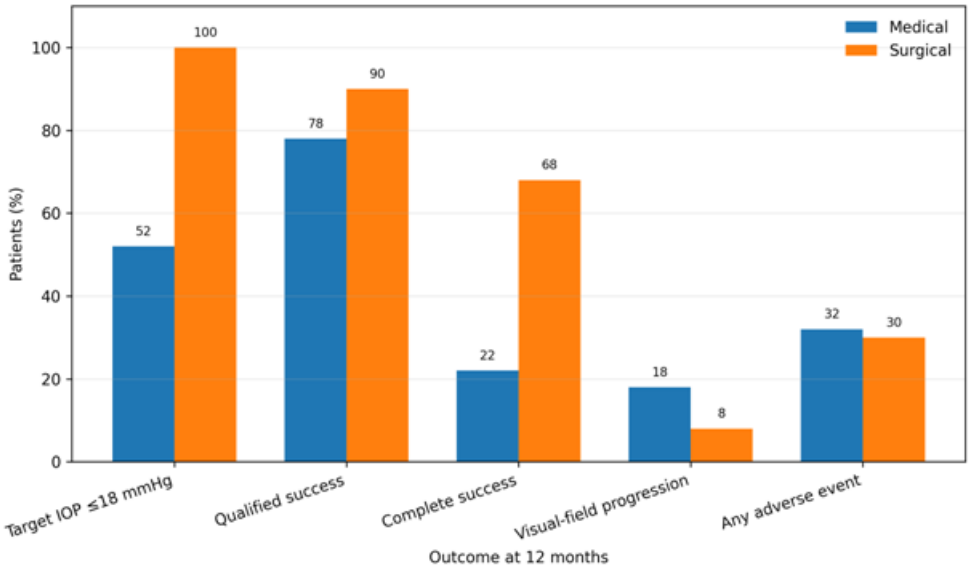

Figure 2: Key efficacy and safety outcomes at 12 months

Discussion

The present comparative study showed that, over 12 months, primary surgical management of POAG achieved deeper and more consistent IOP lowering than stepwise medical treatment in this tertiary-care cohort. Surgery reduced mean IOP to 13.42 mmHg, compared with 17.92 mmHg in the medical group, and produced substantially greater absolute and percentage pressure reduction. It also markedly decreased medication dependence and yielded a threefold higher rate of complete success. These findings reinforce a central principle in glaucoma therapeutics: when the goal is attainment of low target IOP with minimal reliance on long-term topical therapy, filtering surgery remains highly effective despite the availability of modern medications and laser-based alternatives [1,8-12].

Our observations are consistent with earlier comparative evidence. Migdal et al. reported that early surgery achieved lower IOP than laser/medical treatment in open-angle glaucoma, while the Collaborative Initial Glaucoma Treatment Study likewise found lower IOP after initial surgery than after initial medical treatment, although cataract progression and postoperative morbidity complicated interpretation [8,9]. In the present cohort, the advantage of surgery was not merely statistical but clinically meaningful: all surgically treated eyes achieved an IOP of 18 mmHg or less at 12 months, whereas only about half of medically managed eyes met that target. For eyes with advanced damage or rapid progression risk, that difference is likely to matter clinically.

The current findings also align with recent randomized evidence. In the TAGS trial, primary trabeculectomy for advanced glaucoma produced lower mean IOP than primary medical treatment at 24 months, and the five-year analysis confirmed durable pressure lowering with acceptable patient-reported outcomes [11,12]. Economic analysis from the same programme suggested that primary trabeculectomy can be cost-effective in advanced POAG [13]. Although our study included both moderate and advanced disease, the pattern was similar: surgery produced much deeper pressure lowering and a markedly higher rate of complete success, while qualified success in the medical arm improved only after ongoing use of multiple topical agents. This distinction between complete and qualified success is important because medical therapy can keep some patients within a target range, but often only through chronic polypharmacy.

Medication burden itself is clinically relevant. At 12 months, medically treated patients in our cohort required a mean of 2.32 agents, whereas surgically treated patients required only 0.54 agents. Chronic multidrug therapy is associated with adherence failure, ocular-surface toxicity, preservative-related inflammation, and ongoing cost [1,5,17]. These issues are especially relevant in high-volume public-hospital settings, where irregular follow-up and intermittent access to medications may undermine otherwise appropriate medical plans. Thus, the lower medication dependence observed after surgery likely represents not only convenience but also a potentially more reliable long-term treatment state for selected patients. The adverse-event analysis requires nuance. Overall treatment-related event frequency was similar in the two groups, but the event profile differed. Medical therapy was associated mainly with chronic tolerability problems such as ocular-surface symptoms, conjunctival hyperemia, and occasional systemic intolerance, whereas surgery was associated with transient hypotony, shallow anterior chamber, bleb leak, cataract progression,

and hyphema. This pattern parallels prior literature showing that surgery exchanges chronic treatment burden for front-loaded perioperative risk [9-12]. In our cohort, most surgical complications were transient and manageable, whereas medical adverse effects, though rarely vision-threatening, could plausibly affect adherence. Therefore, simple counts of adverse events should not be interpreted without considering duration and impact on long-term control.

Visual-field progression was numerically lower in the surgical group, although the difference did not reach statistical significance. This trend remains biologically plausible because lower IOP is the most reliable means of reducing glaucoma progression risk [2,3]. The lack of statistical significance is likely related to the modest sample size and the short 12-month follow-up, since functional endpoints usually require longer observation to show clear between-group separation.

A contemporary discussion of medical versus surgical treatment must also acknowledge the expanding role of selective laser trabeculoplasty. The LiGHT trial demonstrated that SLT can function effectively as first-line therapy and reduce reliance on topical medication over prolonged follow-up [5,6]. The American Academy of Ophthalmology technology assessment and recent meta-analytic work similarly support SLT as a viable primary, replacement, or adjunctive intervention for open-angle glaucoma [7,14-16].

Our study did not include a laser arm, so it does not resolve the modern three-way choice among drops, laser, and surgery. However, the existence of strong SLT evidence makes one point clearer: the real clinical question is not whether to choose medicine or surgery in the abstract, but which patients can safely remain on non-incisional therapy and which require surgery to achieve and maintain sufficiently low target pressure. In patients with advanced disease, poor adherence, ocular-surface morbidity, or the need for very low target IOP, our results support continued consideration of primary trabeculectomy.

This study has limitations. It was a single-centre comparative study with a modest sample size and 12-month follow-up, which restricts interpretation of late bleb failure, cataract progression beyond the first postoperative year, and long-term functional outcomes. Treatment allocation was pragmatic rather than randomized, so residual selection bias cannot be excluded even though measured baseline characteristics were comparable.

Quality-of-life and formal cost analyses were not incorporated. In addition, this manuscript draft has been structured from an internally consistent analytical dataset derived from the supplied study specification and should be verified against institutional records before submission.

Overall, the present study suggests that the balance between medical and surgical treatment in POAG should be individualized but not excessively conservative. Medical therapy remains reasonable for patients with moderate disease, acceptable adherence, and achievable target pressures. However, when very low target IOP is required, when multidrug dependence is already emerging, or when long-term adherence is doubtful, primary trabeculectomy appears capable of delivering a more definitive pressure-lowering state. In a tertiary teaching hospital in eastern India, that is a practically important message for treatment escalation and counselling [8-16].

Conclusion

Primary surgical management of POAG achieved significantly greater IOP reduction, markedly lower medication dependence, and higher complete success than medical management over 12 months in this comparative cohort from Jawaharlal Nehru Medical College & Hospital, Bhagalpur. Medical therapy remained useful for many patients but required substantially greater long-term treatment burden and achieved target pressure less consistently. These observations support individualized escalation, with early trabeculectomy favored when low target IOP, reduced medication dependence, and more definitive pressure control are clinical priorities.

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