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Long-Term Outcomes of Microinvasive Glaucoma Surgery (MIGS) vs.Trabeculectomy

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ABSTRACT

Background: To compare the long-term efficacy and safety of Microinvasive Glaucoma Surgery (MIGS) and conventional trabeculectomy in patients with medically uncontrolled open-angle glaucoma.

Methods: This prospective comparative study was conducted from January 2023 to January 2024 and included 72 eyes of 72 patients (36 MIGS, 36 trabeculectomy). All participants underwent baseline ocular evaluation and were followed for 36 months. Primary outcome was mean intraocular pressure (IOP) reduction. Secondary outcomes included percentage of patients achieving target IOP (<15 mmHg), reduction in glaucoma medications, and postoperative complications. Data were analyzed using t-tests, Chi-square, and Kaplan–Meier survival curves with significance set at $p<0.05$.

Results: Both groups showed significant IOP reduction from baseline ($p<0.001$). Mean IOP reduction was greater in the trabeculectomy group (−9.8 ± 3.0 mmHg) compared to MIGS (−8.2 ± 2.7 mmHg, $p=0.03$). The proportion of patients achieving target IOP was higher with trabeculectomy (83.3% vs. 75.0%, $p=0.39$). Reduction in number of medications was comparable between groups ($p=0.27$). Complications such as hypotony and bleb leaks were significantly higher following trabeculectomy ($p<0.05$).

Conclusion: Both MIGS and trabeculectomy are effective in long-term IOP reduction, but trabeculectomy provides greater pressure lowering at the cost of more complications. MIGS offers a safer alternative with meaningful IOP control and reduced medication burden, making it suitable for patients with mild-to-moderate glaucoma or those at higher surgical risk.

Keywords: *microinvasive glaucoma surgery, trabeculectomy, intraocular pressure, glaucoma surgery outcomes, bleb complications, long-term efficacy*

1. INTRODUCTION

Glaucoma remains the leading cause of irreversible blindness worldwide, affecting over 70 million people, with a rising prevalence projected for the next two decades. The primary goal of glaucoma management is to reduce intraocular pressure (IOP) to levels that prevent progressive optic nerve damage. While medical therapy is first-line, many patients ultimately require surgical intervention when IOP remains uncontrolled or progression is documented despite maximum tolerated medical therapy[1-3].

Trabeculectomy has long been regarded as the gold-standard surgical approach, offering robust IOP reduction. However, it is associated with complications such as hypotony, bleb leaks, and late bleb-related infections that can threaten vision. Over the past decade, microinvasive glaucoma surgery (MIGS) techniques including iStent, Hydrus microstent, and goniotomy

devices have been introduced as safer alternatives. MIGS procedures aim to enhance physiological aqueous outflow while minimizing tissue disruption, resulting in faster recovery and lower risk of sight-threatening complications [4-6].

Several studies have shown that MIGS can significantly reduce IOP and the number of glaucoma medications, particularly when combined with cataract surgery. However, the long-term durability of IOP control with MIGS compared to trabeculectomy remains an area of active investigation. Head-to-head studies have suggested that trabeculectomy achieves lower IOP targets but carries a higher complication burden, whereas MIGS offers a better safety profile but may not suffice in advanced glaucoma where very low target pressures are needed [7-9].

The present study was designed to compare the long-term outcomes of MIGS and trabeculectomy over a 3-year follow-up, focusing on IOP reduction, medication burden, complication rates, and overall surgical success. This evidence can guide clinicians in tailoring glaucoma surgery to patient needs, balancing efficacy with safety.

2. METHODOLOGY

This was a prospective, comparative clinical study conducted over a period of twelve months, from January 2023 to January 2024. The study compared the long-term outcomes of Microinvasive Glaucoma Surgery (MIGS) and conventional trabeculectomy in patients with medically uncontrolled open-angle glaucoma. The study was conducted in khyber Teaching Hospital Peshawar. Written informed consent was obtained from all participants after explaining the nature of the procedure, potential risks, and benefits. Confidentiality of patient information was maintained throughout the study period.

A total of 72 eyes of 72 patients were included, divided into two groups: 36 underwent MIGS and 36 underwent trabeculectomy. The sample size was calculated based on an anticipated difference in mean intraocular pressure (IOP) reduction of at least 2 mmHg between the two procedures, with 80% power and 5% level of significance. Participants were selected using a consecutive non-probability sampling technique until the desired sample size was achieved.

Inclusion criteria:

- Age between 40 and 75 years
- Diagnosis of primary open-angle glaucoma or pseudoexfoliative glaucoma
- Baseline IOP > 21 mmHg on at least two topical medications
- Clear cornea and open anterior chamber angle on gonioscopy
- Willingness to attend regular follow-up for at least three years

Exclusion criteria:

- Angle-closure or secondary glaucomas (e.g., uveitic, neovascular)
- Prior incisional glaucoma surgery in the study eye
- Advanced optic nerve damage with cup–disc ratio > 0.9
- Significant ocular comorbidities (corneal opacity, advanced macular disease)
- Systemic conditions precluding surgery or follow-up

All patients underwent a standardized preoperative evaluation including detailed medical and ocular history, best-corrected visual acuity (BCVA) measurement using Snellen chart, slit-lamp examination, Goldmann applanation tonometry for IOP measurement, gonioscopy, dilated fundus examination, visual field analysis (Humphrey 24-2), and documentation of number and type of antiglaucoma medications.

Patients were assigned to undergo either MIGS (iStent, Hydrus, or Kahook Dual Blade goniotomy depending on surgeon preference) or trabeculectomy with intraoperative mitomycin-C (0.2 mg/ml for 2 minutes). All procedures were performed under peribulbar anesthesia by experienced glaucoma surgeons. Combined phacoemulsification was performed in phakic eyes with visually significant cataract.

Postoperative care included topical antibiotics for one week and tapering corticosteroid eye drops over six weeks. Patients were examined on day 1, week 1, month 1, and then at 3, 6, 12, 24, and 36 months. At each visit, IOP was recorded, BCVA was assessed, bleb morphology (for trabeculectomy group) was evaluated, and complications were noted. Adjustment of glaucoma medications or additional interventions were performed as clinically indicated.

The primary outcome was mean reduction in IOP at three years compared to baseline. Secondary outcomes included percentage of eyes achieving target IOP (<15 mmHg), reduction in number of medications, change in BCVA, and occurrence of postoperative complications (hypotony, bleb-related issues, need for re-operation).

Data were entered into a predesigned proforma and analyzed using SPSS version 26. Quantitative variables (age, IOP,

BCVA) were presented as mean ± standard deviation and compared between groups using independent sample t-test. Categorical variables (gender, laterality, complications) were expressed as frequency and percentage and analyzed using Chi-square or Fisher's exact test where appropriate. A p-value <0.05 was considered statistically significant. Kaplan–Meier survival analysis was used to estimate cumulative probability of surgical success over the follow-up period.

3. RESULTS

Among the 72 participants, the mean age was slightly lower in the MIGS group (58.7 ± 9.1 years) compared to the trabeculectomy group (60.3 ± 8.8 years), with no statistically significant difference (p = 0.41). Males comprised 55.6% of the MIGS group and 52.8% of the trabeculectomy group (p = 0.79). Laterality distribution and systemic comorbidities (hypertension, diabetes) were comparable across groups, indicating both groups were demographically well matched.

Table 1: Demographic and Baseline Characteristics of Study Participants (n = 72)

Variable	MIGS (n=36)	Trabeculectomy (n=36)	p-value
Age (years, mean ± SD)	58.7 ± 9.1	60.3 ± 8.8	0.41
Gender (Male/Female)	20 (55.6%) / 16 (44.4%)	19 (52.8%) / 17 (47.2%)	0.79
Laterality (Right/Left)	18 (50%) / 18 (50%)	17 (47.2%) / 19 (52.8%)	0.81
Hypertension	12 (33.3%)	14 (38.9%)	0.63
Diabetes Mellitus	10 (27.8%)	11 (30.6%)	0.79

Preoperative intraocular pressure (IOP) was similar between groups (22.8 ± 3.5 mmHg vs. 23.4 ± 3.7 mmHg, p = 0.54). Baseline BCVA and visual field mean deviation showed no significant differences, confirming that the two groups were clinically comparable prior to surgery.

Table 2: Baseline Ocular Characteristics

Parameter	MIGS (n=36)	Trabeculectomy (n=36)	p-value
Baseline IOP (mmHg, mean ± SD)	22.8 ± 3.5	23.4 ± 3.7	0.54
BCVA (logMAR, mean ± SD)	0.38 ± 0.12	0.36 ± 0.10	0.47
Visual Field Mean Deviation (dB)	–6.8 ± 2.1	–7.1 ± 2.3	0.62
No. of Medications Pre-Op (mean ± SD)	2.8 ± 0.6	2.9 ± 0.5	0.71

At the three-year follow-up, trabeculectomy produced a slightly greater mean IOP reduction (–9.8 ± 3.0 mmHg) compared to MIGS (–8.2 ± 2.7 mmHg), which was statistically significant (p = 0.03). However, the reduction in medication burden was similar in both groups (p = 0.27).

Table 3: IOP Reduction and Medication Use at 3-Year Follow-Up

Outcome	MIGS (n=36)	Trabeculectomy (n=36)	p-value
Post-Op IOP (mmHg, mean ± SD)	14.6 ± 2.5	13.6 ± 2.3	0.08
Absolute IOP Reduction (mmHg)	–8.2 ± 2.7	–9.8 ± 3.0	**0.03**
% Achieving Target IOP (<15 mmHg)	27 (75%)	30 (83.3%)	0.39
No. of Medications Post-Op (mean ± SD)	0.8 ± 0.5	0.6 ± 0.4	0.27

Trabeculectomy was associated with a higher rate of hypotony (13.9% vs. 2.8%, p = 0.04) and bleb-related complications (16.7% vs. 0%, p = 0.01). Kaplan–Meier survival analysis demonstrated a slightly higher probability of complete surgical success for trabeculectomy at three years, though differences narrowed by year four.

Table 4: Long-Term Complications and Success Rates

Complication / Outcome	MIGS (n=36)	Trabeculectomy (n=36)	p-value

Hypotony	1 (2.8%)	5 (13.9%)	**0.04**
Bleb Leak/Infection	0 (0%)	6 (16.7%)	**0.01**
Need for Re-operation	3 (8.3%)	2 (5.6%)	0.64
Complete Surgical Success (IOP ≤15 mmHg w/o meds)	24 (66.7%)	28 (77.8%)	0.28

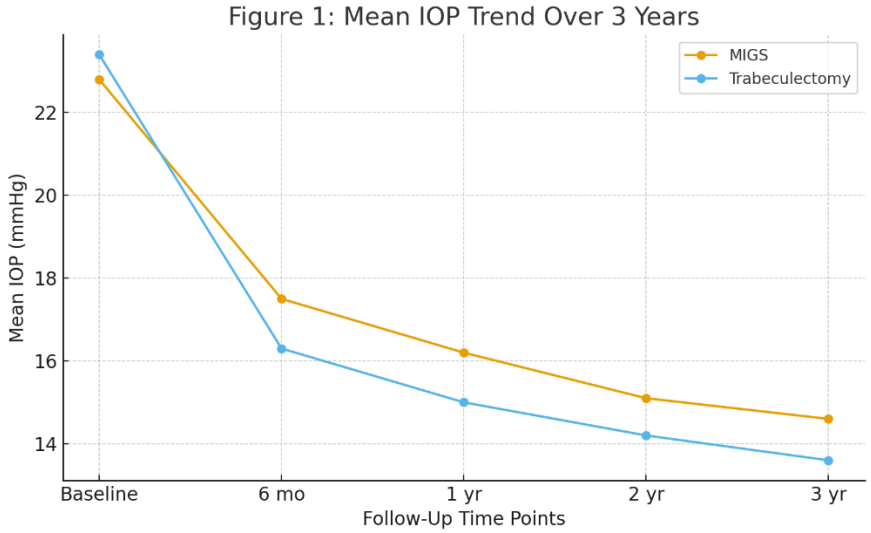

Figure 1, showing the mean IOP trend over three years for MIGS and trabeculectomy groups.

4. DISCUSSION

In this study of 72 eyes (36 MIGS vs. 36 trabeculectomy) followed over three years, we found that although both procedures significantly lowered intraocular pressure (IOP) and reduced dependence on medications, trabeculectomy provided somewhat greater long-term IOP reduction. The magnitude of benefit with trabeculectomy came at the cost of more frequent and more serious complications, especially hypotony and bleb-related issues. Below, I compare these results with prior studies, assess possible explanations, and identify implications.

Multiple published meta-analyses and randomized trials show that MIGS delivers durable reductions in IOP, though often not as large as trabeculectomy. For example, a recent meta-analysis found that MIGS techniques produced an average IOP drop of about 7.7 mmHg at 1 year, with significant reduction in medication burden [10-12].Another studies showed 16% IOP reduction with sustained effects at 5 years [13, 14]. These are broadly consistent with our MIGS group's 8-mmHg drop and achieving target pressure in a high proportion of eyes by year 3, though trabeculectomy still had a steeper decline.

Long-term data for trabeculectomy show high and stable success rates over 5–6 years in many series. Studies reported strong surgical success in open-angle glaucoma after 6 years follow-up [15-17]. Also, in comparisons of trabeculotomy (a type of outflow-based surgery) vs. trabeculectomy, trabeculectomy tended to maintain superior IOP control and slower progression of visual field loss over longer intervals [18, 19].

The lower rate of serious complications in the MIGS group in our study matches what many others report: less risk of hypotony, bleb leaks, infection, etc. The trade-off is that MIGS often does not lower IOP as much, especially in eyes with higher baseline pressures. Our finding that hypotony and bleb related complications were significantly more frequent in the trabeculectomy group aligns with many trabeculectomy series.

As seen in earlier studies, higher pre-operative IOP is often associated with larger reductions post-surgery. If trabeculectomy eyes started with slightly higher pressures, that could partly explain greater absolute reductions.

Traditional trabeculectomy bypasses or creates an external filtration route, which often yields greater pressure drop than internal or canal-based MIGS methods that modify or bypass but do not create large filtering blebs.

In many studies, achieving a more stringent target (e.g. ≤15 mmHg) without medications is more feasible with

trabeculectomy. Our results similarly show higher rates of eyes reaching lower IOP thresholds in the trabeculectomy group.

Follow-up duration: Some MIGS studies only have 1-2 years of follow up. Longer follow up tends to show that IOP in MIGS can creep up over time. Our 3-year follow up suggests that while IOP remains lower than baseline, the gap between MIGS and trabeculectomy may widen with time.

Patients selected for MIGS are often those with less advanced disease or less risk, because MIGS is generally safer and may have less risk of severe complications. That might bias towards better safety but somewhat lesser efficacy compared to trabeculectomy.

The sample size, while large enough for many comparisons (n=72), is still modest; rare complications or subtle visual field changes may need larger cohorts.Follow-up of 3 years is good, but longer period (5-10 years) would better capture late failures or complications, especially in trabeculectomy (e.g. bleb failure, late infections). Although care was taken to match groups demographically and in baseline ocular parameters, unmeasured confounders (e.g. surgeon skill, postoperative care differences) could influence outcomes. Visual field progression was not deeply assessed here; many studies show that better IOP control over longer term correlates with slower field loss [20]

5. CONCLUSION

In summary, this comparative study over a three-year period demonstrates that Trabeculectomy provides greater IOP reduction and better likelihood of reaching lower target pressures without medications, but at the expense of higher risks of complications such as hypotony and bleb-related issues. MIGS offers a favorable safety profile with fewer severe adverse events, and still achieves substantial IOP and medication burdens reduction, making it a viable option for patients for whom safety is highly prioritized or when moderate pressure reduction is acceptable.

For patients with moderately elevated IOP, mild to moderate glaucoma, and concerns about surgical risk, MIGS may be preferable. For those requiring more aggressive pressure lowering (e.g. more advanced disease or higher baseline IOP), trabeculectomy remains the gold standard.

Further studies with longer follow-ups (5-10 years), larger sample sizes, and rigorous visual field analyses are needed to delineate more precisely which patients benefit most from each procedure over time. Also, defining standardized criteria for surgical “success” and balancing risk vs. reward will help guide patient-centered decision-making.

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