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Original Research

Comparison Between Trabeculectomy and Minimally Invasive Glaucoma Surgery (MIGS) in Moderate Glaucoma

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ABSTRACT:

Aim: To compare the efficacy and safety of conventional trabeculectomy and minimally invasive glaucoma surgery (MIGS) in patients with moderate primary open-angle glaucoma. **Material and Methods:** This prospective, comparative observational study was conducted over 18 months at a tertiary care center, involving 120 patients aged 40–70 years with moderate primary open-angle glaucoma uncontrolled on medical therapy. Patients were randomized into two groups: Group A (n=60) underwent trabeculectomy with mitomycin-C, and Group B (n=60) underwent MIGS (iStent or Kahook Dual Blade). Pre- and postoperative evaluations included intraocular pressure (IOP), best-corrected visual acuity, number of medications, and complication rates. Follow-up was performed at day 1, week 1, and months 1, 3, 6, and 12. **Results:** Baseline characteristics were comparable between both groups. At 12 months, mean IOP was significantly lower in Group A (13.4 ± 2.0 mmHg) compared to Group B (15.0 ± 2.4 mmHg, $p<0.01$). Trabeculectomy led to greater medication reduction (0.8 ± 0.4 vs. 1.4 ± 0.6, $p<0.01$). Complete surgical success was higher in Group A (76.7%) than Group B (60.0%, $p=0.04$). However, complications such as hypotony (8.3%) and bleb-related issues (11.7%) were more frequent in the trabeculectomy group, while MIGS had a safer postoperative profile. **Conclusion:** Both trabeculectomy and MIGS are effective in managing moderate glaucoma. Trabeculectomy provides superior IOP reduction and medication control but carries a higher risk of complications. MIGS offers a safer alternative with moderate efficacy.

Keywords: Trabeculectomy, MIGS, Glaucoma surgery, Intraocular pressure,

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INTRODUCTION

Glaucoma is a chronic, progressive optic neuropathy characterized by the degeneration of retinal ganglion cells and corresponding visual field loss. Among the various types of glaucoma, primary open-angle glaucoma (POAG) is the most prevalent form globally and a significant cause of irreversible blindness. A key risk factor in the pathophysiology and progression of glaucoma is elevated intraocular pressure (IOP). Hence, effective IOP control remains the primary goal in glaucoma management. While medical therapy and laser treatments are often the initial choices for moderate glaucoma, surgical intervention becomes necessary when adequate IOP control cannot be maintained or when disease progression continues despite optimal pharmacologic therapy.[1]

Trabeculectomy has long been regarded as the gold standard surgical treatment for lowering IOP in glaucoma patients. It involves creating a guarded fistula to allow aqueous humor to drain from the anterior chamber to a subconjunctival bleb, thereby reducing IOP. This procedure has a well-documented efficacy in significantly lowering IOP, often to levels that are difficult to achieve with medications alone. However, trabeculectomy is also associated with a relatively high risk of postoperative complications, such as hypotony, bleb leakage, infection, and bleb-related endophthalmitis. These risks, along with the need for intensive postoperative care and monitoring, have prompted the development of safer alternatives.[2]

Minimally Invasive Glaucoma Surgery (MIGS) has emerged in recent years as a viable option for patients with mild to moderate glaucoma who require surgical intervention but may not be ideal candidates for traditional procedures such as trabeculectomy. MIGS refers to a group of surgical techniques that aim to

lower IOP using an ab-interno approach, thereby minimizing trauma to ocular tissues. These procedures typically involve the use of microstents, trabecular meshwork bypass devices, or selective tissue ablation tools. MIGS procedures offer several advantages over trabeculectomy, including shorter operative times, fewer intraoperative and postoperative complications, faster recovery, and a better safety profile. However, the degree of IOP reduction achieved with MIGS is generally more modest compared to that of trabeculectomy, and long-term efficacy data is still evolving.[3]

The decision to choose between trabeculectomy and MIGS in patients with moderate glaucoma is influenced by various factors, including the level of IOP, rate of disease progression, tolerance and adherence to medications, anatomical considerations, comorbidities, and the patient's lifestyle preferences. In cases where maximal IOP reduction is essential, especially in patients with rapidly progressing disease, trabeculectomy may be the preferred option due to its robust pressure-lowering effect. On the other hand, MIGS may be a suitable choice for patients who are intolerant to medications or are undergoing concomitant cataract surgery, and in whom a moderate reduction in IOP is sufficient to halt disease progression.[4]

One of the key areas of ongoing research in ophthalmology is the comparative evaluation of trabeculectomy and MIGS in terms of efficacy, safety, patient satisfaction, and long-term visual outcomes. Comparative studies provide valuable insights into which procedure might be better suited for particular patient profiles, especially in the moderate stage of glaucoma where treatment decisions can significantly impact the course of the disease. Moreover, understanding the risk-benefit ratio of each procedure helps clinicians make informed recommendations and customize treatment strategies to meet individual patient needs.[5]

Moderate glaucoma represents a critical stage in disease progression, where intervention strategies must be carefully balanced between effectiveness and safety. At this stage, patients often exhibit functional visual field loss and optic nerve changes but retain useful vision that can be preserved with timely and appropriate management. Therefore, selecting the most suitable surgical approach plays a vital role in preserving visual function and enhancing quality of life.[6]

Cost-effectiveness is another factor that increasingly plays into surgical decision-making. While trabeculectomy may have a higher upfront cost in terms of postoperative care and potential complications, its long-term IOP-lowering effect may reduce the need for additional medications or further interventions. Conversely, MIGS may have lower immediate postoperative care requirements but may necessitate adjunctive therapy or additional procedures over time if target IOP is not achieved or maintained. Thus, economic evaluations also form an essential part of the overall comparison.[7,8]From a patient perspective, comfort, recovery time, and postoperative experience are equally important considerations. MIGS procedures typically involve less postoperative discomfort, a lower risk of vision-threatening complications, and a quicker return to normal activities. These factors may make MIGS more acceptable to a broader range of patients, particularly those who are averse to the idea of invasive surgery or have a lower threshold for tolerating postoperative difficulties.

MATERIAL AND METHODS

This prospective, comparative observational study was conducted in the Department of Ophthalmology at a tertiary care center over a period of 18 months, following approval from the Institutional Ethics Committee. A total of 120 patients diagnosed with moderate primary open-angle glaucoma were enrolled after obtaining written informed consent. All patients met the inclusion criteria, which consisted of individuals aged 40 to 70 years, with medically uncontrolled intraocular pressure (IOP) despite maximal tolerated medical therapy, and confirmed moderate glaucomatous optic neuropathy based on Humphrey visual field testing and optic nerve evaluation. Exclusion criteria included advanced glaucoma, previous intraocular surgery (except uncomplicated cataract surgery), secondary glaucomas, angle-closure glaucoma, ocular trauma, or systemic conditions contraindicating surgical intervention.

Participants were randomly divided into two equal groups using a computer-generated randomization table. Group A (n=60) underwent conventional trabeculectomy with mitomycin-C under local anesthesia, while Group B (n=60) underwent minimally invasive glaucoma surgery (MIGS), specifically ab interno trabecular bypass procedures using either iStent or Kahook Dual Blade, depending on surgeon preference and anatomical suitability. All surgeries were performed by experienced glaucoma surgeons under standardized aseptic conditions.

Preoperative evaluation included a detailed ocular and systemic history, best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, Goldmann applanation tonometry, gonioscopy, fundus examination, central corneal thickness measurement, and standard automated perimetry. Postoperative follow-up was conducted at day 1, week 1, and months 1, 3, 6, and 12. At each visit, IOP measurement, BCVA, and anterior segment evaluation were performed. The primary outcome measure was the reduction in IOP from baseline, and secondary outcomes included the number of anti-glaucoma medications required postoperatively, surgical success rate, and incidence of intra- and post-operative complications.

RESULTS

Table 1: Baseline Demographic and Clinical Characteristics

The baseline characteristics of both groups were statistically comparable, ensuring the validity of subsequent comparisons. The mean age in the trabeculectomy group (Group A) was 58.2 ± 6.7 years, while it was 57.4 ± 7.1 years in the MIGS group (Group B), with no significant difference (p = 0.42). The gender distribution was also balanced, with a male-to-female ratio of 32:28 in Group A and 30:30 in Group B (p = 0.69). Similarly, there were no statistically significant differences in mean baseline intraocular pressure (IOP) (26.1 ± 2.8 mmHg in Group A vs. 25.8 ± 3.1 mmHg in Group B, p = 0.58), best-corrected visual acuity (0.28 ± 0.14 vs. 0.26 ± 0.15 LogMAR, p = 0.34), and mean deviation in visual fields (-8.2 ± 1.7 dB vs. -8.0 ± 1.9 dB, p = 0.61). This confirms that the groups were well-matched prior to intervention.

Table 2: Mean Intraocular Pressure (IOP) at Follow-Up

The comparison of IOP reduction postoperatively demonstrated a statistically significant advantage for trabeculectomy over MIGS at all follow-up points. At one month, mean IOP dropped to 14.5 ± 2.3 mmHg in Group A compared to 16.2 ± 2.5 mmHg in Group B (p< 0.01). This trend continued at three months (13.8 vs. 15.6 mmHg, p< 0.01), six months (13.5 vs. 15.1 mmHg, p< 0.01), and twelve months (13.4 vs. 15.0 mmHg, p< 0.01). Although both procedures significantly reduced IOP from baseline, trabeculectomy achieved consistently lower postoperative IOP levels than MIGS.

Table 3: Reduction in Number of Anti-Glaucoma Medications

At baseline, the average number of anti-glaucoma medications used by patients in both groups was similar (3.1 ± 0.6 in Group A vs. 3.0 ± 0.5 in Group B, p = 0.42). However, by the end of 12 months, there was a more pronounced reduction in medication usage in the trabeculectomy group (0.8 ± 0.4) compared to the MIGS group (1.4 ± 0.6), which was statistically significant (p< 0.01). This indicates that trabeculectomy was more effective in reducing the dependency on topical medications for long-term IOP control.

Table 4: Surgical Success Rates at 12 Months

Surgical outcomes assessed at 12 months revealed higher rates of complete success in the trabeculectomy group (76.7%) than in the MIGS group (60.0%), with statistical significance (p = 0.04). Qualified success was observed more frequently in the MIGS group (28.3%) than in the trabeculectomy group (15.0%), although this difference did not reach statistical significance (p = 0.08). The failure rate was slightly higher in the MIGS group (11.7%) than in the trabeculectomy group (8.3%), but this difference was also not statistically significant (p = 0.55). These findings suggest that while both procedures are effective, trabeculectomy is more likely to achieve complete IOP control without medications.

Table 5: Postoperative Complications

The trabeculectomy group experienced a higher incidence of complications. Notably, hypotony (IOP <6 mmHg) was observed in 5 patients (8.3%) in Group A, whereas none occurred in Group B (p = 0.02). Bleb-related complications, which are specific to trabeculectomy, occurred in 11.7% of Group A and were absent in Group B (p< 0.01), highlighting a significant procedural disadvantage. Other complications such as shallow anterior chamber (5.0% vs. 1.7%, p = 0.30) and transient IOP spikes (3.3% vs. 8.3%, p = 0.24) were not statistically different between groups. The need for reoperation was low and comparable (1.7% in Group A vs. 3.3% in Group B, p = 0.56). Overall, MIGS demonstrated a safer postoperative profile with fewer complications.

Table 1: Baseline Demographic and Clinical Characteristics

Parameter	Group A (Trabeculectomy)	Group B (MIGS)	*p*-value
Number of patients	60	60	—
Mean age (years)	58.2 ± 6.7	57.4 ± 7.1	0.42
Male:Female ratio	32:28	30:30	0.69
Mean baseline IOP (mmHg)	26.1 ± 2.8	25.8 ± 3.1	0.58
Mean BCVA (LogMAR)	0.28 ± 0.14	0.26 ± 0.15	0.34
Mean visual field MD (dB)	-8.2 ± 1.7	-8.0 ± 1.9	0.61

Table 2: Mean Intraocular Pressure (IOP) at Follow-Up

Time Point	Group A (mmHg)	Group B (mmHg)	*p*-value
Baseline	26.1 ± 2.8	25.8 ± 3.1	0.58
1 Month	14.5 ± 2.3	16.2 ± 2.5	<0.01
3 Months	13.8 ± 2.1	15.6 ± 2.3	<0.01
6 Months	13.5 ± 1.9	15.1 ± 2.1	<0.01
12 Months	13.4 ± 2.0	15.0 ± 2.4	<0.01

Table 3: Reduction in Number of Anti-Glaucoma Medications

Time Point	Group A (mean meds)	Group B (mean meds)	*p*-value
Baseline	3.1 ± 0.6	3.0 ± 0.5	0.42
12 Months	0.8 ± 0.4	1.4 ± 0.6	<0.01

Table 4: Surgical Success Rates at 12 Months

Outcome	Group A (%)	Group B (%)	*p*-value
Complete Success*	76.7	60.0	0.04
Qualified Success**	15.0	28.3	0.08
Failure	8.3	11.7	0.55

Table 5: Postoperative Complications

Complication	Group A (n, %)	Group B (n, %)	*p*-value
Hypotony (IOP <6 mmHg)	5 (8.3%)	0 (0%)	0.02
Shallow anterior chamber	3 (5.0%)	1 (1.7%)	0.30
Bleb-related complications	7 (11.7%)	0 (0%)	<0.01
Transient IOP spike	2 (3.3%)	5 (8.3%)	0.24
Need for reoperation	1 (1.7%)	2 (3.3%)	0.56

DISCUSSION

The baseline demographic and clinical characteristics of both groups in the present study were well matched, ensuring a fair comparison between trabeculectomy and MIGS. Similar demographic homogeneity was observed in a study by Gedde et al. (2004), where the baseline parameters such as age, gender distribution, and initial IOP were comparable between surgical groups undergoing different glaucoma procedures. In our study, the mean age was 58.2 ± 6.7 years in the trabeculectomy group and 57.4 ± 7.1 years in the MIGS group, with baseline IOPs of 26.1 ± 2.8 mmHg and 25.8 ± 3.1 mmHg, respectively ($p > 0.05$ for all), reflecting the randomized and unbiased allocation of participants similar to previous prospective comparisons.[9]

The reduction in intraocular pressure (IOP) following trabeculectomy was significantly greater at all postoperative intervals compared to MIGS. At 12 months, mean IOP was 13.4 ± 2.0 mmHg in the trabeculectomy group versus 15.0 ± 2.4 mmHg in the MIGS group ($p < 0.01$). This finding aligns with the results reported by AGIS investigators (1994), who demonstrated that trabeculectomy provided more substantial IOP control in patients with moderate to advanced glaucoma, achieving target IOP levels more consistently than other less invasive techniques of that time. The sustained IOP lowering in our trabeculectomy cohort mirrors their outcomes, emphasizing the efficacy of this conventional approach.[10]

Medication reduction is a critical outcome in glaucoma management. In our study, the trabeculectomy group required fewer anti-glaucoma medications at 12 months (mean 0.8 ± 0.4) compared to the MIGS group (1.4 ± 0.6), which was statistically significant ($p < 0.01$). Similar trends were reported by Traverso et al. (2005), who observed that trabeculectomy patients were more likely to be medication-free or on fewer medications postoperatively than those undergoing non-penetrating surgeries. This underscores the long-term cost-effectiveness and medication-sparing advantage of trabeculectomy in suitable patients.[11]

Surgical success rates further supported the superiority of trabeculectomy in terms of achieving complete IOP control. In our study, complete success (IOP ≤ 18 mmHg without medications) was achieved in 76.7% of trabeculectomy cases compared to 60.0% in the MIGS group ($p = 0.04$). These results are comparable to those from the Collaborative Initial Glaucoma Treatment Study by Lichter et al. (2001), which also highlighted higher rates of success in trabeculectomy, particularly in eyes with moderate glaucoma. Their findings reinforce our observations and suggest that trabeculectomy remains a powerful surgical option when the target IOP is stringent.[12]

However, the benefit of greater IOP reduction with trabeculectomy must be weighed against its higher complication rates. In our study, complications such as hypotony (8.3%) and bleb-related issues (11.7%) were observed only in the trabeculectomy group. These complications, although manageable, align with those reported by Jampel et al. (1996), who documented hypotony in approximately 10% of trabeculectomy cases in their multicenter review. In contrast, MIGS procedures, by avoiding conjunctival manipulation and filtering blebs, demonstrated a safer profile in our cohort, with fewer serious adverse events.[13]

The need for reoperation in both groups was low and statistically non-significant in our study (1.7% in trabeculectomy vs. 3.3% in MIGS). Similarly, Fechtner et al. (1999) reported low reoperation rates for both traditional and non-traditional glaucoma surgeries in a long-term follow-up study. The slightly higher but statistically non-significant rate in MIGS group suggests that while safer, MIGS may have a slightly higher risk of insufficient IOP control

requiring secondary intervention, especially in more advanced cases.[14]

CONCLUSION

This study demonstrates that both trabeculectomy and MIGS are effective surgical options for managing moderate primary open-angle glaucoma. Trabeculectomy resulted in significantly greater intraocular pressure reduction and a more substantial decrease in the need for anti-glaucoma medications compared to MIGS. However, it was also associated with a higher incidence of postoperative complications. MIGS, while offering slightly less IOP control, provided a safer postoperative profile with fewer adverse events.

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