

LONG-TERM OUTCOMES OF INTRAOCULAR PRESSURE CONTROL AFTER TRABECULECTOMY

Kamran Waheed¹, Yousaf Jamal Mahsood¹, Bakht Danyal Khan¹

ABSTRACT

Objective: To determine the long-term effect of trabeculectomy on intraocular pressure (IOP).

Methods: It was a cross-sectional study conducted at Department of Ophthalmology Hayatabad Medical Complex, Peshawar from May 2025 to October 2025. Eligible participants with at least nine months of follow-up were included in this study. Intraocular pressure (IOP) was measured using Goldmann applanation tonometry before and after the trabeculectomy. Intraocular pressure control of ≤ 18 mmHg with or without medications was termed as success. Baseline and postoperative IOP values at final follow-up were compared using paired t-test. Number of postoperative antiglaucoma medications and complications of the surgery were also noted.

Results: A total of 81 eyes of 75 patients, with a mean age of 37.09 ± 14.25 years, were included in this study. The mean follow-up duration of the whole study group was 30.53 ± 11.9 months. Out of total participants, 43 (57.3%) were females contributing 46 eyes (56.8%). Mean preoperative IOP was 32.65 ± 9.2 mmHg, which decreased to 14.6 ± 6.6 mmHg at the study endpoint, reflecting a mean reduction of 17.9 ± 8.2 mmHg ($p < 0.001$). Successful IOP levels were achieved in 59 (72.8%) of the eyes; 41 (69.5%) achieved successful IOP levels without medications. Postoperative complications were observed in 23 (28.4%) of the eyes. No vision-threatening events were observed.

Conclusions: Trabeculectomy provided significant, sustained IOP reduction in the majority of the eyes over a mean follow-up of nearly three years, with an acceptable safety profile.

Keywords: Trabeculectomy, Glaucoma, Intraocular pressure, Postoperative complications, Treatment Outcome

INTRODUCTION

Glaucoma is a progressive optic neuropathy with characteristic field defects and raised intraocular pressure (IOP) is an important risk factor. The link between optic disc changes and visual field losses has been well documented.¹ Treatment options include medications, laser therapy and surgery. The next option in our settings when maximum medical management does not achieve the target IOP is filtration surgery with trabeculectomy being the most common procedure.² Worldwide, trabeculectomy is considered as the gold standard surgery in patients with uncontrolled glaucoma.³

The technique consists of making a new pathway for the aqueous fluid to flow i.e. through a hole in the trabecular meshwork into a bleb fashioned from the sclera.⁴ There have been many innovations leading to safer trabeculectomy techniques.⁵ International literature on the IOP control after trabeculectomy shows success rate of 54.1% to 93.9%.^{6,7} While local literature has published and verified the IOP lowering effect of trabeculectomy, very few studies demonstrate the long-term success through defined parameters. A study by Shahid et al. conducted in 2020, followed patients for one year after surgery, reported a surgical success in 28 (53.8%) out of 52 patients.⁸

The rationale for this study is to highlight the gaps in understanding the sustainability of trabeculectomy outcomes over extended periods. By analyzing the long-term IOP control and the postoperative complications of patients undergoing trabeculectomy, this study aims to provide valuable insight into the effectiveness of trabeculectomy for the long-term control of IOP in the adult population. There is a lack of data on this area in our region, and this study will fill this gap.

¹ Department of Ophthalmology, MTI - Hayatabad Medical Complex, Peshawar, Pakistan

.....
Address for Correspondence

Dr. Yousaf Jamal Mahsood

Associate Professor,
Department of Ophthalmology,
MTI - Hayatabad Medical Complex, Peshawar,
Pakistan.
yousaf82@hotmail.com

MATERIALS AND METHODS

This cross-sectional study was conducted at the Department of Ophthalmology, Hayatabad Medical Complex, Peshawar from May 2025 to October 2025. The sample size of 81 eyes of 75 patients was calculated using the WHO sample calculator, based on qualified success rate at 1 year of 94.9%⁹ and absolute precision of 5%. Patients were recruited through non-probability consecutive sampling. Ethical approval was obtained from the Institutional Review Ethical Board (Ref No. IREB HMC/1944). The study was conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from all the included patients.

The inclusion criteria were patients between 18–60 years diagnosed with glaucoma who had undergone trabeculectomy by consultant ophthalmologists with at least 9 months of follow-up and without any additional procedures. Patients with previous intraocular surgeries, laser procedures for glaucoma or retinal pathology, active uveitis, neovascular glaucoma, or history of penetrating open-globe injuries were excluded. Patients were recruited on their follow-up visits and their IOP was measured using Goldmann applanation tonometry (GAT). The success of IOP control was defined as ≤ 18 mmHg with or without

topical antiglaucoma medications. Comprehensive ophthalmic examination was conducted for all the patients, and complications were noted. Data was analyzed using SPSS version 26. Results were recorded and displayed as charts and figures while IOP analysis was done by paired t-test and p value of < 0.05 was considered statistically significant.

RESULTS

Fulfilling the inclusion criteria, a total of 75 patients contributing 81 eyes that had undergone trabeculectomy were included in the study. Of the 75 patients included in the study, 43 (57.3%) were females, contributing 46 eyes (56.8%). The mean age of the study population was 37.09 ± 14.25 years. Trabeculectomy was performed in only the right eye in 35 (46.7%) of the patients, left eye in 34 (45.3%) while 6 patients (8%) had surgery in both eyes.

The mean duration since trabeculectomy at the time of assessment was 30.53 ± 11.9 months. The mean follow-up duration was slightly longer in males (32.2 ± 13.4 months) compared to females (29.3 ± 10.7 months). The mean preoperative intraocular pressure (IOP) was 32.65 ± 9.2 mmHg. The reduction in IOP from baseline was 17.9 ± 8.2 mmHg which was statistically significant ($p < 0.001$). Table 1 presents a comparison between preoperative intraocular pressure and values at study endpoint.

Table 1 : Comparison of Preoperative and Postoperative Intraocular Pressure Following Trabeculectomy

Group	n	Preoperative IOP (mmHg) Mean \pm SD	IOP (mmHg) at study end point Mean \pm SD	Mean IOP (mmHg) Reduction Mean \pm SD	p-value*
Male eyes	35	34.8 \pm 7.3	14.5 \pm 6.6	20.3 \pm 9.4	< 0.001
Female eyes	46	31.1 \pm 10.2	14.8 \pm 6.7	16.3 \pm 9.2	
Total eyes	81	32.65 \pm 9.2	14.6 \pm 6.6	17.9 \pm 8.2	

n=number of eyes, IOP=intraocular pressure, SD=standard deviation, mmHg=millimeters of mercury

*Paired t-test was applied

Successful long-term IOP control was achieved in 59 (72.8%) eyes. Out of these 59 eyes, 41 (69.5%) did so without using any medications while 18 (30.5%) achieved with medications. Out of 22 (27.2%) eyes which did not achieve successful IOP lowering, only 15 (68.2%) were using antiglaucoma medications and 7 (31.8%) were not using any antiglaucoma medications. This data is summarized in table 2.

Table 2: Antiglaucoma Medication Use in Relation to Target Intraocular Pressure Achievement

Successful IOP ≤18 mmHg achieved	Frequency (n)	Without antiglaucoma medications	With antiglaucoma medications		
			OD	BID	TDS
Yes	59	41	9	9	0
No	22	7	3	10	2

n=number of eyes, IOP=intraocular pressure, OD=once daily, BID=twice daily, TDS=three times daily, mmHg=millimeters of mercury.

Clinically, postoperative complications were observed in 23 eyes (28.4%) while 58 eyes (71.6%) had no recorded complications. Postoperative complications included first postoperative day hypotony in 8 eyes (9.9%), long-term bleb scarring in 4 eyes (4.9%), and vision-related complaints in 6 eyes (7.4%). Other minor postoperative events were observed in 5 eyes (6.2%). No cases of severe vision-threatening complications such as endophthalmitis or suprachoroidal hemorrhage were observed. Figure 1 shows a graphical representation of complication frequencies.

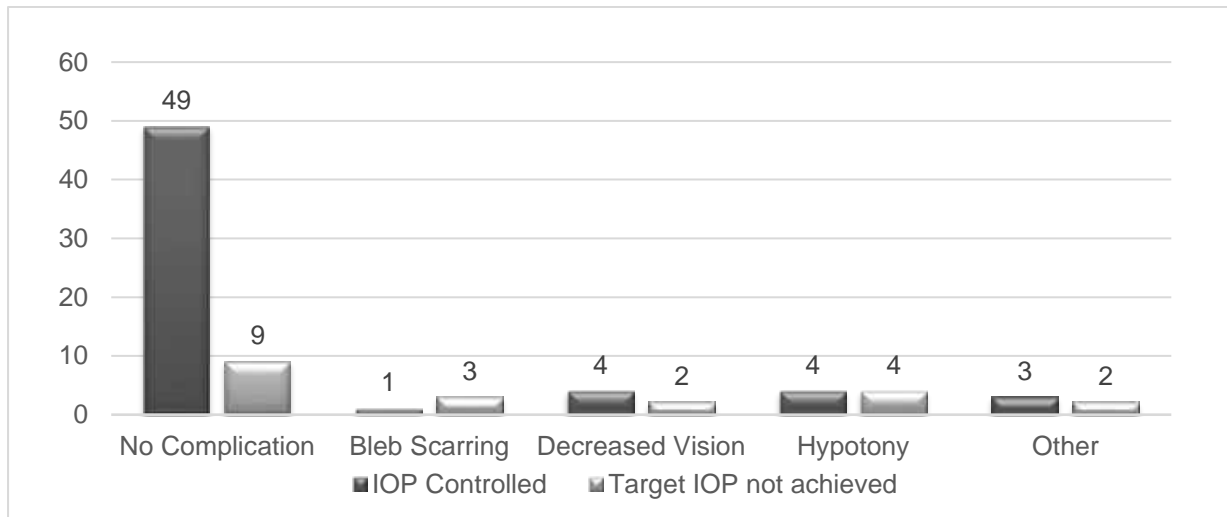


Figure 1 Post Operative Complications Frequencies

The follow-up patterns of the patients were that 5 (6.7%) patients followed up monthly while 35 (46.7%) patients visited every 3 months, 24 (32%) visited every 6 months and 11 (14.7%) had irregular follow-ups.

DISCUSSION

This study looked at long-term intraocular pressure control following trabeculectomy in patients with glaucoma. We achieved successful IOP control in the majority of eyes. We noted a success rate of 72.8% with more than half of the eyes not on any glaucoma medications which highlights the effectiveness of trabeculectomy at maintaining IOP.

These findings align with prior reports of procedure success. A study done by Shahid et al. showed a success rate of 73.6%-80.7% in 71 patients¹⁰ Despite a longer mean follow-up duration of approximately 30 months in our study, the success rate of 72.8% remains comparable, suggesting sustained long-term efficacy of trabeculectomy. The magnitude of

intraocular pressure reduction observed in our study (17.9 mmHg) is also consistent with their findings. Our findings are also consistent with long-term outcomes reported by Ehrnrooth et al.¹¹, who demonstrated a progressive decline in surgical success from 82% at year 1 to 52% at year 4 following trabeculectomy. In their study, the success rate at approximately 2-3 years was reported to be around 70% which closely corresponds to the 72.8% success rate observed in our study at a mean follow-up of 30 months. This similarity reinforces the reliability and external validity of our results in the context of long-term intraocular pressure control. However, the magnitude of reduction in our study (17.9 mmHg) was greater than that reported by Ehrnrooth et al., where reductions ranged between 8-10mmHg. Their difference

may be attributed to higher baseline intraocular pressures or differences in disease severity and patients' demographics.

Large randomized control trials have proven the effectiveness of primary trabeculectomy. For instance, the 5-year TAGS study in the UK shows a 12 mmHg decrease in mean IOP^{12,13} and our study showed 17.9 mmHg reduction. The marked pressure reduction in our sample cohort is clinically significant because even minor reductions in IOP are reported to slow down glaucoma progression.¹⁴ Furthermore, literature suggests that quality-of-life GQL-15 scores improved significantly after trabeculectomy (32.1 ± 10.3) compared to scores while on maximal medical therapy (36.3 ± 11 ; $P < 0.001$).¹⁵

In the context of newer surgical modalities, minimally invasive glaucoma surgeries (MIGS) have emerged to treat mild to moderate glaucoma and offer a better safety profile at the cost of less IOP reduction.¹⁶ Our sample predominantly consisted of advanced cases which required significant IOP reduction and hence trabeculectomy was the procedure of choice. A 36-month comparative study done in Pakistan showed that both procedures reduce IOP significantly but trabeculectomy yielded a slightly greater mean reduction (-9.8 vs -8.2 mmHg).¹⁷ This, however, came at the cost of more post-operative hypotony and bleb complications. The consensus is that MIGS is generally a better option for patients who require moderate IOP reduction or for those who are not suitable candidates for incisional surgery, whereas trabeculectomy remains the preferred option when a lower target IOP is needed.¹⁸

For drainage devices like tube shunts, results are comparable. Tubes are reserved for refractory or previously failed trabeculectomies, but recent studies show that primary surgery with drainage devices can also give similar results.¹⁹ However, literature reports that trabeculectomy patients need fewer post-operative glaucoma medications and have a better immediate post-operative success rate.^{20,21}

In our study, 28.4% of the eyes experienced complications, however these were mostly benign and transient with no serious permanent consequences. According to the literature, the most common early postoperative complications include hypotony, transient intraocular pressure elevation and bleb leakage.²² This is consistent with our study where the similar complications in plausible

ratios were observed. It is worth noting that complication rates are significantly lower in newer less invasive MIGS procedures.²³

It is apparent that trabeculectomy is likely to maintain its central role in glaucoma management in developing countries such as Pakistan due to its substantial sustained cost-effective IOP control. While newer modalities are evolving and offer advantages in select cases, their limited accessibility remains a major hurdle. Strengthening surgical training, developing follow-up protocols and integrating cost-effective innovations can go a long way in helping our patients.

Strengths: The strengths of our study were that it employed clearly defined and clinically relevant success criteria (IOP ≤ 18 with or without medications), allowing objective assessment of long-term surgical outcomes and comparison with international data such as the Treatment of Advanced Glaucoma Study¹¹. The mean follow-up duration of approximately 31 months provides meaningful insight into sustained intraocular pressure control beyond the early postoperative phase. Intraocular pressure was measured using Goldmann applanation tonometry, the gold standard technique, ensuring reliability and accuracy of measurements. Additionally, the study reflects real-world outcomes from a tertiary care center in Pakistan, enhancing its contextual relevance and external validity for similar resource-limited settings. The inclusion of medication dependence and postoperative complication rates further strengthens the study by providing a comprehensive evaluation of both efficacy and safety.

Limitations: Our study has certain limitations, including the absence of a comparison group and reliance on clinical outcome measures alone. Although the mean follow-up of approximately 31 months provides useful information on mid-term outcomes, longer follow-up would further clarify the long-term durability of trabeculectomy success. Glaucoma surgeries can fail at any time with the success rates declining gradually beyond the first year. Long-term studies show an increase in failure probabilities with each passing year.²² Our reported success rate may overestimate long-term results and some eyes could require supplemental medications or even repeat surgery. Our study lacked a control group as we did not compare directly to MIGS or only medications. Our outcomes were primarily clinical, and we did not employ formal quality of life instruments. Moreover, economic outcomes were not directly assessed in our study. Cost

and cost-effectiveness are crucial considerations in our setting which is a limitation we acknowledge given their importance. However, we have inferred from literature that trabeculectomy can be cost effective for longer durations of time.²⁴

CONCLUSION

In this study, a significant reduction in IOP was observed with three-quarters of eyes achieved and maintained target intraocular pressures with an acceptable safety profile.

DECLARATIONS

Authors' contributions:

1. Kamran Waheed: Idea, Background, Ethical Approval, Study Design, Database search, Data Collection, Result compilation, Interpretation of data, devising conclusions, agrees to be accountable.
2. Yousaf Jamal Mahsood: Refining the idea, data interpretation, proofreading the manuscript, agrees to be accountable.
3. Bakht Danyal Khan: Study Design, Data analysis, Manuscript refinement, Discussion, proofreading the manuscript, agrees to be accountable.

Conflict of interest: The authors confirm that no conflict of interest exists regarding this research

Funding: This research did not receive any funding at any stage of this study.

Acknowledgements: None.

REFERENCES

1. Geevarghese A, Wollstein G, Ishikawa H, Schuman JS. Optical Coherence Tomography and Glaucoma. *Annu Rev Vis Sci.* 2021;7:693–726. doi:10.1146/annurev-vision-100419-111350
2. Nasir AH, Bano M, Mahsood YJ. Outcomes of Trabeculectomy at a Newly Established Glaucoma Clinic in Khyber Pakhtunkhwa. *Pak J Ophthalmol.* 2021;38(1):48–51. doi:10.36351/pjo.v38i1.1306
3. Kratz A, Goldberg I, Koren T, Hadad A, Knyazer B, Lim R. Flow-Adjusted Trabeculectomy. *J Clin Med.* 2024;13(21):6609. doi:10.3390/jcm13216609
4. Singh K. Innovations to Make Glaucoma Surgery Safer. *Delhi J Ophthalmol.* 2022;32:78–81. doi:10.4103/dljo.dljo_85_23
5. Maheshwari D, Kanduri S, Rengappa R, Kadar M. Intraoperative injection versus sponge-applied mitomycin C during trabeculectomy: One-year study. *Indian J Ophthalmol.* 2020;68(4):615–9. doi:10.4103/ijo.IJO_963_19
6. Zweifel LAB, Storp JJ, Vietmeier FE, Danzer MF, Merté RL, Eter N, et al. Preserflo MicroShunt versus Trabeculectomy: Efficacy and Surgical Success within a Heterogenous Patient Cohort. *Life (Basel).* 2024;14:1171. doi:10.3390/life14091171
7. Jiang L, Eaves S, Dhillon N, Ranjit P. Postoperative outcomes following trabeculectomy and nonpenetrating surgical procedures: a 5-year longitudinal study. *Clin Ophthalmol.* 2018;12:995–1002. doi:10.2147/opth.s163247
8. Shahid E, Fasih U, Shaikh A. Outcome of Conventional Trabeculectomy in Terms of Intraocular Pressure and Visual Acuity in Primary Open Angle Glaucoma. *Pak J Ophthalmol.* 2020;36(4):386–390. doi:10.36351/pjo.v36i4.1086
9. Yuasa Y, Sugimoto Y, Hirooka K, Ohkubo S, Higashide T, Sugiyama K, et al. Effectiveness of trabeculectomy with mitomycin C for glaucomatous eyes with low intraocular pressure on treatment eye drops. *Acta Ophthalmol.* 2019;98(1):81–87. doi:10.1111/aos.14195
10. Shahid E, Fasih U, Shaikh A. Postoperative Complications of Trabeculectomy in Primary Open Angle Glaucoma Versus Primary Angle Closure Glaucoma. *Pak J Ophthalmol.* 2022;38(2):97–102. doi:10.36351/pjo.v38i2.1360
11. Ehrnrooth P, Lehto I, Puska P, Laatikainen L. Long-term outcome of trabeculectomy in terms of intraocular pressure. *Acta Ophthalmol Scand.* 2002;80(3):267–271. doi:10.1034/j.1600-0420.2002.800307.x
12. King AJ, Hudson J, Azuara-Blanco A, Burr J, Kernohan A, Homer T, et al. Evaluating primary treatment for people presenting with advanced glaucoma: 5-year results of the Treatment of Advanced Glaucoma Study. *Ophthalmology.* 2024;131:759–770. doi:10.1016/j.ophtha.2024.01.007
13. King AJ, Hudson J, Fernie G, Kernohan A, Azuara-Blanco A, Burr J, et al. Primary trabeculectomy for advanced glaucoma: pragmatic multicentre randomised controlled trial (TAGS). *BMJ.* 2021;373:n1014. doi:10.1136/bmj.n1014
14. Asrani SG, McGlumphy EJ, Al-Aswad LA, Chaya CJ, Lin S, Musch DC, et al. The relationship between intraocular pressure and glaucoma: An evolving concept. *Prog*

- Retin Eye Res. 2024;103:101303.
doi:10.1016/j.preteyeres.2024.101303
15. Muralidharan S, Kumar S, Ichhpujani P, Dhillon HK. Quality of life in glaucoma patients: Comparison of medical therapy, trabeculectomy, and glaucoma drainage device surgery. *Indian J Ophthalmol.* 2022;70:4206–4211.
doi:10.4103/ijoo.IJO_667_22
 16. Verma-Fuehring R, Matlach J, Klink T, Hillenkamp J, Grehn F. Long-term outcomes of trabeculectomy versus canaloplasty in open-angle glaucoma - an 11-year follow-up of the TVC study cohort. *BMC Ophthalmol.* 2025;25:340.
doi:10.1186/s12886-025-04183-9
 17. Jahangir K, Awan LCAH, Farooq N, Rahman J ur, Zainab M, Aamir Khan M, et al. Long-Term Outcomes of Microinvasive Glaucoma Surgery (MIGS) vs. Trabeculectomy. *J Neonatal Surg.* 2024;13:1322–1327.
doi:10.63682/jns.v13i1.9236
 18. Ahmed IIK, Fea A, Au L, Ang RE, Harasymowycz P, Jampel HD, et al. A Prospective Randomized Trial Comparing Hydrus and iStent Microinvasive Glaucoma Surgery Implants for Standalone Treatment of Open-Angle Glaucoma. *Ophthalmology.* 2020;127:52–61.
doi:10.1016/j.ophtha.2019.04.034
 19. Luo N, Liu M, Hao M, Xu R, Wang F, Zhang W. Comparison of tube shunt implantation and trabeculectomy for glaucoma: a systematic review and meta-analysis. *BMJ Open.* 2023;13:e065921.
doi:10.1136/bmjopen-2022-065921
 20. Sun CQ, McSoley MJ, Lum F, Chang TC, Gedde SJ, Vanner EA. Tube Versus Trabeculectomy IRIS Registry Study: 1-Year Secondary Treatment Outcomes. *Am J Ophthalmol.* 2023;256:97–107.
doi:10.1016/j.ajo.2023.08.011
 21. Gedde SJ, Vinod K, Prum BE; Primary Tube Versus Trabeculectomy Study Group. Results from the Primary Tube Versus Trabeculectomy Study and translation to clinical practice. *Curr Opin Ophthalmol.* 2023;34:129–137.
doi:10.1097/ICU.0000000000000928
 22. Mazidah Zulfa MZ, Puspasari D, Rahmi FL. Early Postoperative Complication Following Filtration Surgery In Dr. Kariadi General Hospital Semarang 2020–2022. *Ophthalmol Indones.* 2024;49:177–183.
doi:10.35749/49p4dc89
 23. Chiu HI, Su HI, Ko YC, Liu CJL. Outcomes and risk factors for failure after trabeculectomy in Taiwanese patients: medical chart reviews from 2006 to 2017. *Br J Ophthalmol.* 2022;106:362–367.
doi:10.1136/bjophthalmol-2020-317303
 24. Shabaninejad H, Homer T, Kernohan A, King AJ, Burr J, Azuara-Blanco A, et al. Is primary trabeculectomy cost-effective for patients with advanced primary open angle glaucoma? Results from the Treatment of Advanced Glaucoma Study economic model. *Br J Ophthalmol.* 2024;108:1210–1215. doi:10.1136/bjo-2023-323390