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Posted Date: 24 September 2025

doi: 10.20944/preprints202509.2041.v1

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Article

Balancing Pressure and Pills: Short-Term Outcomes of Goniotomy vs Trabeculectomy in Adult Glaucoma

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Abstract

Glaucoma surgery aims to reduce intraocular pressure (IOP) and medication dependence while minimizing complications. This study compared short-term outcomes of goniotomy versus trabeculectomy ab externo in adult glaucoma. We conducted a retrospective review of 76 patients (100 eyes) who underwent either goniotomy (n = 50) or trabeculectomy (n = 50) at a tertiary center between May 2022 and June 2023, with a minimum of six months follow-up. Baseline and 6-month IOP, number of glaucoma medications, and postoperative complications (hyphema, infection, reoperation) were recorded. T-tests and Fisher's exact tests were used, with significance set at $p < 0.05$. Trabeculectomy resulted in a greater mean IOP reduction than goniotomy (8.78 ± 0.84 vs. 5.36 ± 0.81 mmHg, $p = 0.004$), while goniotomy achieved a larger decrease in medication use (1.47 ± 0.30 vs. 0.72 ± 0.20 , $p = 0.041$). Hyphema occurred more frequently after trabeculectomy ($p = 0.031$), whereas infection and reoperation rates were comparable between groups. Device type did not affect goniotomy outcomes. Over six months, trabeculectomy provided superior pressure lowering, while goniotomy offered greater medication reduction. These findings support individualized surgical planning based on baseline IOP, tolerance of medications, and complication risk, with longer-term studies warranted.

Keywords: goniotomy; trabeculectomy; glaucoma surgery; intraocular pressure; medication reduction; hyphema

1. Introduction

Glaucoma is a multifactorial eye disorder marked by progressive optic neuropathy, leading to irreversible vision loss if not adequately controlled due to elevated intraocular pressures (IOP). It stands as one of the leading causes of blindness in the United States, affecting over 4 million people as of 2022, and projected to increase further [1]. Typically, this disease is initially medically managed, using medication such as prostaglandins, adrenergic agents, beta-blockers, and carbonic anhydrase inhibitors. However, if the condition continues to progress or if the initial presentation is very acute, procedural therapy may be required. This most commonly involves laser procedures and surgery [2]. There are many types of surgery currently being used, among them, trabeculectomy, valve placement, and the minimally invasive glaucoma surgeries such as the goniotomy.

Globally, glaucoma management strategies continue to evolve in response to the increasing disease burden. With aging populations and improved life expectancy, clinicians are challenged to not only achieve adequate IOP control but also reduce the complexity of treatment and improve patient quality of life over decades of care. Medication adherence remains a critical issue and limitation of medical therapy, with some studies showing that up to 50% of patients discontinue one or more of their glaucoma medications within the first few months of treatment. [3]. This nonadherence can manifest as further disease progression and vision loss, underscoring the need for durable, effective surgical alternatives. This is especially the case for patient populations such as incarcerated patients where reliable access to medications can be difficult, thus further contributing

to worse outcomes where their intraocular pressures increase and visual field deficits become more pronounced.

Furthermore, it is important to note that medication nonadherence in glaucoma is multifactorial, encompassing both intentional and unintentional behaviors. Due to complex drop schedules often involving multiple medications, patients can struggle with forgetting to take one or more of their medications, as mentioned previously. Additionally, it can be a difficult burden for patients to consistently place these eyedrops into their eyes on a regular basis, especially if they require assistance to do so. This can result in worsening vision over time due to high intraocular pressures.

Beyond these challenges of medication schedule complexity and forgetfulness, several other burdens can further compromise adherence. Limited transportation to medical appointments or pharmacies may prevent timely prescription refills, particularly for elderly or socioeconomically disadvantaged patients. Medication availability can also be inconsistent, especially in rural areas or otherwise under-resourced healthcare systems, leading to interruptions in therapy despite the patient being motivated to continue their treatment regimens. Comorbidities should not be ignored as well. Physical issues with eye drop instillation, including poor vision, arthritis, or tremors, add another layer of complexity, as these patients may be unable to accurately administer drops even when they wish to comply. In addition, these medications have common side effects, such as ocular burning, hyperemia, altered taste, and even systemic effects such as bradycardia and hypotension due to the use of beta blockers [4]. These effects, compounded with systemic barriers to medication access, can discourage regular use over time.

In addition, adherence can decrease with chronic use of these medications, as asymptomatic patients may perceive fewer immediate benefits and become fatigued with treatment routines after many years of disease stability [5]. These patients may choose to completely discontinue medications when side effects seemingly outweigh perceived advantages. This gradual decline in adherence highlights the gap between that viewed in controlled clinical trials and real-world patterns, where long-term patient behavior often determines outcomes more than pharmacological effectiveness alone.

In light of medication adherence issues in certain patient populations, the treatment paradigm has shifted to procedures that can both achieve pressure reduction and reduce dependence on topical therapies, prompting interest in older procedures such as trabeculectomies and other, newer procedures that have risen in popularity.

Trabeculectomy has long been considered one of the most effective surgical procedures for lowering IOP in glaucoma, functioning by creating a fistula for aqueous humor in the eye to bypass the blocked trabecular meshwork into the subconjunctival space [6]. It has been associated with marked reductions in IOP [7]. Despite its efficacy, trabeculectomy has been previously seen in trials and multicenter studies to be associated with potential complications such as hypotony, bleb leaks, choroidal effusion, cataract, and a flat anterior chamber when compared to medical management or other noninvasive procedures [7,8].

Minimally-invasive glaucoma surgery (MIGS), also known as microinvasive glaucoma surgery, is a newer set of procedures, involving the lowering of IOP through a variety of different methods. These include increasing aqueous outflow from trabecular meshwork and Schlemm's canal, increasing uveoscleral outflow through suprachoroidal space, creating a shunt through the subconjunctival space, and decreasing aqueous production [9]. One of the procedures that falls under MIGS is the goniotomy, which involves excising the trabecular meshwork, thus providing an area of flow from the anterior chamber to Schlemm's canal without the formation of a bleb, resulting in lower complication rates [9,10].

Even though glaucoma surgeries such as MIGS often reduce both intraocular pressure and the need for topical medications, many patients ultimately remain on pharmacologic therapy long-term [10]. The primary goal of MIGS is frequently to decrease medication burden and improve quality of life rather than to completely eliminate the need for drops, particularly in patients with moderate to advanced disease where lifelong pressure control remains essential. Some patients may come to

surgery expecting to be medication-free afterward, so counseling before the procedure is critical to set realistic expectations and ensure satisfaction even when long-term therapy remains necessary. Outcomes can also vary considerably between individuals: while some eyes achieve excellent, sustained pressure control, others show a more limited or transient response due to factors such as postoperative scarring, baseline ocular anatomy, or the need for very low target pressures in advanced disease [11]. Patients with more severe glaucoma often require lower intraocular pressures than MIGS alone can reliably achieve, which explains why some eventually need to restart medications or undergo additional surgery despite initial improvement.

As time passes after MIGS, healing responses such as fibrosis or subconjunctival scarring can reduce aqueous outflow, leading to gradual increases in pressure and the need for adjunctive therapy [12]. In some cases, long-term disease progression occurs despite apparently adequate pressure lowering, reflecting the multifactorial nature of glaucoma damage. Repeat procedures or escalation to more invasive options like trabeculectomy or tube shunts may be required when intraocular pressure or visual field stability cannot be maintained. For these reasons, MIGS is increasingly viewed as part of a staged treatment algorithm rather than a one-time intervention, providing meaningful pressure and medication reduction while preserving future surgical options if the disease progresses. Patients and clinicians must therefore approach MIGS as one step in a long-term management strategy that often involves continued medications, close follow-up, and the possibility of additional procedures over time.

There is limited evidence in the literature directly comparing outcomes between trabeculectomies and goniotomies in similar patient populations. The purpose of this manuscript is to provide a comparative analysis of surgical outcomes, complication profiles, and IOP control between these two procedures at a single center. Our findings aim to add to the growing body of evidence on these glaucoma procedures and to help guide clinicians on selecting the most appropriate surgical procedure for patients who require operative intervention for glaucoma management. In particular, we sought to compare postoperative medication burden between the two surgeries, as this outcome has received less attention in prior studies despite its importance in long-term disease management. By addressing this gap, our study aims to provide data that may better inform treatment decisions and future research on glaucoma surgical care.

2. Materials and Methods

This retrospective comparative study included 76 patients who underwent either goniotomy or trabeculectomy ab externo between May 2022 and June 2023 at a single tertiary care center. Institutional review board approval was obtained. Patients were eligible if they had a diagnosis of glaucoma of any subtype, required surgical intervention to lower intraocular pressure (IOP), and completed at least six months of follow-up. Exclusion criteria included previous incisional glaucoma surgery on the same eye (other than cataract surgery), active ocular infection, and significant ocular comorbidities that could confound IOP measurements such as infection. Data collection was performed through a review of electronic medical records, and all patient information was de-identified to ensure confidentiality.

A total of 100 eyes (from 76 patients) met the study criteria: 50 eyes underwent goniotomy (using the Kahook Dual Blade, $n = 42$ or OMNI, $n = 8$ device, or another instrument) and 50 eyes underwent a standard trabeculectomy ab externo procedure. Baseline variables included patient demographics, ocular comorbidities, glaucoma subtype, and preoperative IOP. Each patient's IOP and glaucoma medication regimen were recorded at the preoperative visit and at the 6-month postoperative follow-up. Complications assessed included hyphema, infection, or need for additional operations within the 6-month postoperative period. Our primary endpoint was 6-month IOP change, while our secondary endpoints were medication reduction, hyphema and infection rates, and reoperation rate. Statistical analyses were performed using paired t-tests for within-group comparisons (preoperative vs. postoperative values) and independent t-tests for between-group comparisons (goniotomy vs. trabeculectomy). Statistical significance was set at $p < 0.05$.

3. Results

Data from 100 eyes (49 right eyes and 51 left eyes) were included. Of these, 66.8 years was the mean age of patients in the goniotomy group, and 67.6 years was the mean age in the trabeculectomy group. In the goniotomy group, 32% of the operated eyes were from male patients, whereas in the trabeculectomy group, 54% were from male patients. The most common associated comorbidities across all participants included cataracts (57%), type 2 diabetes mellitus (23%), and hypertension (12%). Open-angle glaucoma was the leading indication for surgical intervention in 72% of the cases (Table 1).

Table 1. Baseline Characteristics.

Variable	Goniotomy Group (<i>n</i> = 50 eyes)	Trabeculectomy Group (<i>n</i> = 50 eyes)
Age (mean ± SD)	66.8 ± 8.9	67.6 ± 13.4
Sex		
Male	16 (32.0%)	27 (54.0%)
Female	34 (68.0%)	23 (46.0%)
Race		
White	31 (62.0%)	25 (50.0%)
African American	17 (34.0%)	20 (40.0%)
Asian or Pacific Islander	1 (2.0%)	0 (0.0%)
Other/Multiracial	1 (2.0%)	5 (10.0%)
Primary Diagnosis		
Open Angle Glaucoma	38 (76.0%)	34 (68.0%)
Angle Closure Glaucoma	5 (10.0%)	6 (12.0%)
Other	7 (14.0%)	10 (20.0%)
Associated Medical Conditions		
Cataract	31 (62.0%)	26 (52.0%)
Type 2 Diabetes Mellitus	12 (24.0%)	11 (22.0%)
Hypertension	6 (12.0%)	6 (12.0%)
Hyperlipidemia	5 (10.0%)	6 (12.0%)
Atrial Fibrillation	3 (6.0%)	2 (4.0%)

Prior to surgery, the mean IOP was 19.12 ± 5.86 mmHg in the goniotomy group and 22.62 ± 7.71 mmHg in the trabeculectomy group. Six months after surgery, trabeculectomy ab externo demonstrated a significantly greater reduction in IOP compared to goniotomy (8.78 ± 0.84 vs. 5.36 ± 0.81 mmHg, *p* = 0.004). There was no significant difference in efficacy between Kahook Dual Blade

and OMNI for goniotomy. Regarding medication use, the goniotomy group experienced a more pronounced decrease in the number of glaucoma medications than the trabeculectomy group at the 6-month mark (mean 1.47 ± 0.30 vs. 0.72 ± 0.20 , $p = 0.041$). Postoperative hyphema occurred more frequently in the trabeculectomy group ($p = 0.031$), while infection and reoperation rates did not differ significantly between the two groups ($p = 1.00$ and $p = 0.249$, respectively) (Table 2).

No cases of vision-threatening complications such as endophthalmitis or persistent hypotony were observed during the study period. Furthermore, data collected from postoperative visits revealed that the majority of the IOP reduction occurred within the first month following surgery in both groups, with relative stability thereafter. The timing and magnitude of early IOP reduction were more pronounced in the trabeculectomy group, whereas goniotomy patients exhibited a more gradual decline. Furthermore, analysis of racial and demographic subgroups did not reveal any statistically significant differences in outcomes between patients of different races or sexes.

Table 2. Comparison of Goniotomy and Trabeculectomy Outcomes.

Variable	Goniotomy Group ($n = 50$ eyes)	Trabeculectomy Group ($n = 50$ eyes)
Mean Preoperative IOP (mean \pm SD)	19.12 ± 5.86	22.62 ± 7.71
Mean 6-Month Postoperative IOP (mean \pm SD)	13.76 ± 2.06	13.84 ± 5.59
Mean 6-Month IOP Reduction Difference (mean \pm SD)	5.36 ± 0.81	8.78 ± 0.84
Mean Decrease in Postoperative Medication Use	1.47 ± 0.30	0.72 ± 0.20
Postoperative Hyphema	1 (2.0%)	8 (16.0%)
Postoperative Ocular Infection	0 (0.0%)	0 (0.0%)
Postoperative Reoperation Rate	5 (10.0%)	9 (18.0%)

4. Discussion

This study compared goniotomy vs trabeculectomy outcomes at a single center. Our findings highlight key differences in surgical outcomes between goniotomy and trabeculectomy ab externo for patients with glaucoma. Although trabeculectomy achieved a greater lowering of IOP at the 6-month follow-up period, the goniotomy group surprisingly demonstrated a significantly greater reduction in medication burden. These results suggest that while trabeculectomy may be optimal for patients requiring a greater reduction in IOP, goniotomy may be useful in scenarios where reducing medication burden is advantageous, such as if a patient is less tolerant of multiple eye drops.

Although there is limited data in the literature comparing IOP reduction and medication burden between the two procedures in adults, our findings of reduced medication burden following goniotomy have been seen in a 2018 study by Berdahl et al., which focused on goniotomy outcomes with the Kahook Dual Blade [13]. We recorded a slightly greater decrease in medication use 6-months post-procedure with the Kahook Dual Blade. Other studies with longer-follow up times have reported similar decreases in medication use following goniotomy [14–16].

A possible explanation for the discrepancy in the medication burden reduction between the goniotomy and trabeculectomy procedures is that this is due to the underlying differences in surgical mechanism. In contrast to trabeculectomy, goniotomy modifies the native drainage pathway without creating a filtering bleb [13]. Therefore, there may be less of a postoperative need for adjunctive

medications to maintain that channel, particularly in patients whose baseline IOP is not extremely high. This is in contrast to trabeculectomy, which involves creating the fistula so that aqueous humor can exit the anterior chamber into the filtering bleb, leading to more scarring or leaking, often requiring more medications to control these potential complications [17,18]. However, it should not be ignored that this is also due to the severity of disease in the trabeculectomy group versus the goniotomy group, which could play a role in the medication reduction discrepancy. Furthermore, the mean IOP reduction was lower in the goniotomy group as compared to the trabeculectomy group, translating to a greater net reduction in the number of glaucoma drops required, especially in certain patients with milder disease.

The greater IOP reduction in the trabeculectomy group could be explained by the greater baseline preoperative IOP in the trabeculectomy group. Patients who present with higher preoperative IOP are often steered toward more aggressive procedures, such as trabeculectomy, because of the magnitude of pressure reduction needed [19]. Conversely, a lower preoperative IOP might make a MIGS procedure like goniotomy sufficiently effective at controlling IOP while also simplifying postoperative medical regimens. The variance in baseline IOP could partially explain why trabeculectomy patients achieved a greater net IOP decrease, as they started from a higher baseline.

Furthermore, there was no significant difference in outcomes between eyes undergoing goniotomy with the Kahook Dual Blade versus the OMNI device. This finding suggests that goniotomy with these two devices may have comparable efficacy, at least in the short to medium-term follow-up period. There is currently limited data in the literature comparing the efficacy of these two devices [20,21]. Additional studies with longer follow-up times are warranted to see if one device might yield more durable results than the other.

The observed differences in medication reduction and pressure control underscore the importance of individualizing surgical choices and adopting a sequenced treatment strategy rather than relying on a one-size-fits-all approach. In patients with advanced glaucoma, very high baseline IOPs, or rapidly progressing visual field loss, trabeculectomy may remain the preferred option because of its well-established ability to achieve profound and sustained pressure lowering, as mentioned previously. These patients often require the lowest possible target pressures to preserve vision, making the stronger efficacy of trabeculectomy clinically advantageous despite its higher risk profile and more demanding postoperative care. Conversely, goniotomy and other MIGS techniques may be especially suitable for individuals with mild to moderate disease, those with high IOPs undergoing cataract surgery, those who struggle with medication adherence, and patients who prefer a lower surgical risk. MIGS has been shown to meaningfully reduce IOP and medication burden while preserving tissue for future interventions down the road if disease progresses further [12]. This flexibility allows clinicians to integrate MIGS into a stepwise treatment algorithm in which less invasive procedures are performed earlier, reserving trabeculectomy or tube shunts for later stages if additional pressure lowering becomes necessary.

Beyond specific clinical outcomes, the decision between trabeculectomy and goniotomy has several implications for both healthcare resource utilization and patient quality of life. For example, trabeculectomy can require a more intensive postoperative regimen, including frequent clinic visits for bleb management, as well as possible needling procedures [22]. These additional visits and procedures can increase both patient burden and cost of care, thus contributing to more healthcare resource utilization. Conversely, goniotomy tends to have a more streamlined follow-up process, which can be a practical advantage in clinical settings with limited access to care, or even for patients with transportation or comorbid challenges. These factors, while not quantified in this study, remain essential considerations when translating surgical outcomes into real-world clinical decisions.

There are a few limitations to our study that should be considered. The retrospective design inherently carries limitations such as selection bias and inability to control for all confounding variables. Surgeon preference, patient comorbidities, and severity of visual field loss likely influenced the choice of procedure. Additionally, while we recorded multiple demographic factors, there may

be unmeasured confounders that could impact outcomes. Another limitation is the follow-up period of 6 months. Long-term bleb stability, risk of bleb-related infections, and maintenance of IOP control can evolve over a longer timeline; likewise, MIGS procedures may manifest a different performance profile beyond 6 months [23,24]. As a single-center study with 76 patients and 100 eyes, our sample size, although reasonable for an initial comparison, might limit the statistical power for less common complications. Future multicenter or larger-scale studies with longer follow-up time could help generalize these results.

5. Conclusions

Our results indicate that trabeculectomy ab externo is more effective for lowering IOP, but at the cost of a higher complication rate, particularly hyphema. Goniotomy offers a more moderate reduction in IOP with the added benefit of reducing dependence on glaucoma medications. These insights can help inform personalized surgical decision-making, ensuring that the choice of procedure aligns with each patient's individual clinical profile and treatment goals. Ultimately, the choice between trabeculectomy and goniotomy may depend on each patient's baseline IOP, disease severity, tolerance for certain topical medications and surgeon preference and experience.

Our study's results also reinforce the necessity for longitudinal research comparing these surgical options, especially in assessing the sustainability of both medication reduction and IOP control. This can help further clarify parameters and help identify certain characteristics that indicate a patient may benefit from a MIGS procedure over a trabeculectomy. Glaucoma's chronic, progressive nature means that the benefits of initial surgical management may wane over time, and the medication requirements of patients can continue to evolve. Multicenter, prospective studies with extended follow-up would help clarify whether early differences in medication burden translate into differences in visual field preservation, quality of life, and cost effectiveness. Incorporating patient-reported outcomes and economic analyses into future research would help further strengthen the evidence base, thus enabling more patient-centered discussions and informed surgical decisions.

Author Contributions: S.K. Methodology, Data Curation, Formal Analysis, Writing—original draft, Writing—review & editing; J.J. Conceptualization, Methodology, Project Administration, Writing—original draft, Writing—review & editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of the University of South Florida (STUDY006689 on 3/5/24).

Informed Consent Statement: Patient consent was waived by the IRB because the research involved minimal risk to participants and used de-identified data.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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