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ORIGINAL PAPER

Effect of preoperative antiglaucoma medication duration on surgical outcomes of gonioscopy-assisted transluminal trabeculotomy in open-angle glaucoma

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Abstract

Purpose To evaluate the impact of preoperative antiglaucoma medication duration on the surgical outcomes of gonioscopy-assisted transluminal trabeculotomy (GATT) in patients with open-angle glaucoma (OAG).

Design Retrospective comparative study.

Patients and Methods This retrospective case series included 64 eyes from patients diagnosed with primary OAG or pseudoexfoliative glaucoma who underwent 360-degree GATT. Patients were categorized into three groups based on the duration of preoperative medication use: short-term (< 2 years), moderate-term (2–5 years), and long-term (> 5 years). Intraocular pressure (IOP) was measured using Goldmann applanation tonometry during follow-up visits, and surgical success was defined based on IOP reduction criteria. The number of glaucoma medications, best-corrected visual acuity, and postoperative complications were also recorded. Kaplan–Meier survival analysis was used to assess success rates.

Results The mean follow-up duration was 17.2 ± 6.8 months. The short-term, moderate-term, and long-term groups achieved significant IOP reductions ($p < 0.001$), with final mean IOPs of 13.2 ± 4.7 mmHg, 17.7 ± 6.4 mmHg, and 18.1 ± 6.9 mmHg, respectively ($p = 0.002$). The mean number of postoperative medications decreased significantly across all groups ($p = 0.032$). Qualified success rates were 92.3%, 77.2%, and 79.3% for the short-term, moderate-term, and long-term groups, respectively, while complete success rates were 76.9%, 63.6%, and 58.6%.

Conclusion GATT effectively lowers IOP in patients with OAG, though prolonged preoperative medication use is associated with reduced surgical success and higher postoperative medication dependence. Early surgical intervention may enhance long-term outcomes for patients with a history of escalating medication regimens.

Keywords Antiglaucoma medication · GATT · Gonioscopy-assisted transluminal trabeculotomy · Open-angle glaucoma

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Introduction

Gonioscopy-assisted transluminal trabeculotomy (GATT) has gained significant traction as an effective surgical intervention for open-angle glaucoma (OAG). Unlike traditional trabeculectomy, GATT

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bypasses the need for external bleb formation, preserving conjunctival integrity and reducing the risk of bleb-related complications. By targeting the trabecular meshwork circumferentially, GATT improves aqueous outflow through Schlemm's canal, resulting in substantial intraocular pressure (IOP) reduction without requiring implantable devices or extensive ocular incisions [1, 2]. This minimally invasive glaucoma surgery (MIGS) approach offers a safer postoperative profile and faster recovery, making it an appealing option for patients with primary or secondary OAG. [3]

However, many patients undergoing glaucoma surgery have a history of prolonged use of topical antiglaucoma medications. Long-term exposure to these medications, especially those containing preservatives, has been shown to induce structural and inflammatory changes in the conjunctiva and subconjunctival tissues [4–6]. Studies using in vivo confocal microscopy and anterior segment optical coherence tomography have demonstrated increased conjunctival fibrosis, decreased goblet cell density, and enhanced macrophage and lymphocyte infiltration following prolonged medical treatment. [7, 8] These adverse effects impair the conjunctival healing process and reduce the efficacy of filtration surgeries. Furthermore, the Glaucoma Medication Intensity Index has emerged as a valuable predictor, demonstrating that greater cumulative exposure to glaucoma medications correlates with lower surgical success rates [9]. Despite these findings, no studies have examined how preoperative medication history influences GATT outcomes.

To our knowledge, no prior study has stratified GATT outcomes based on the duration of preoperative topical antiglaucoma therapy. Although GATT addresses proximal outflow resistance effectively by bypassing the trabecular meshwork, it may not sufficiently resolve distal outflow obstruction in the collector channels or episcleral venous system. This limitation raises concerns about suboptimal long-term IOP control, particularly in patients with extensive preoperative medication use. To address this gap, our study aims to evaluate the outcomes of GATT in patients stratified by the duration of preoperative antiglaucoma medication use. By investigating IOP trends, medication dependence, and surgical success rates across different exposure groups, we aim to provide insights into the impact of preoperative treatment history on GATT efficacy and identify subgroups that may benefit from earlier surgical intervention.

Methods

This study was approved by the Ahi Evran University Faculty of Medicine Ethics Committee (Approval no: 2025–02/14). All procedures performed in this study adhered to the principles outlined in the Declaration of Helsinki, ensuring respect for individual rights, privacy, and safety. Written informed consent was obtained from all participants before their inclusion in the study.

Patient population

This retrospective case series included 64 eyes from 64 patients who underwent gonioscopy-assisted transluminal trabeculotomy (GATT) surgery for intractable glaucoma unresponsive to maximum tolerated medical therapy. All patients were on multiple classes of topical antiglaucoma medications prior to surgery, including prostaglandin analogs, beta-blockers (e.g., timolol or betaxolol), alpha agonists (e.g., brimonidine), and carbonic anhydrase inhibitors (CAIs; e.g., dorzolamide or brinzolamide). Patients were eligible for inclusion if they were diagnosed with primary open-angle glaucoma (POAG) or pseudoexfoliative glaucoma (PEXG), underwent a 360-degree GATT procedure, had no intraoperative complications, and had at least one year of postoperative follow-up data available. Exclusion criteria included patients with closed-angle glaucoma or neovascular glaucoma, the presence of peripheral anterior synechiae involving more than 90 degrees, the presence of ocular comorbidities other than cataract, and incomplete or insufficient follow-up data.

Surgical technique

All GATT procedures were performed under local anaesthesia by two experienced glaucoma surgeons (A.Y.U. and M.O.C.). A temporal clear corneal incision was created, followed by the instillation of a viscoelastic agent to maintain the anterior chamber and provide better visualization. A small goniotomy was performed using a microvitreoretinal blade at the nasal quadrant to access Schlemm's canal. A 5–0

polypropylene suture, prepared by bending its tip to aid in smooth navigation, was inserted into the canal and advanced circumferentially to achieve a complete 360-degree trabeculotomy. Upon completing the trabeculotomy, the suture was pulled through to unroof the entire trabecular meshwork. The anterior chamber was thoroughly irrigated to remove blood reflux and residual viscoelastic material. The procedure concluded with stromal hydration of the incision to ensure watertight closure.

Postoperatively, all patients received a standardized medication protocol to minimize variability in healing and inflammation. This included topical corticosteroids (dexamethasone 0.1%) administered every 2 h during the first postoperative week, then tapered gradually over 4–6 weeks based on anterior chamber inflammation. Topical antibiotics (moxifloxacin 0.5%) were prescribed seven times daily for 1 week. Anti-inflammatory and intraocular pressure (IOP)-lowering medications were adjusted based on each patient's IOP and clinical course during follow-up visits.

Main outcome measures

The primary outcome measure was the reduction in IOP following GATT. IOP was measured using Goldmann applanation tonometry at each follow-up visit. To minimize diurnal variations, all measurements were taken during morning hours (9:00 AM to 11:00 AM) to ensure consistency.

Surgical success was defined based on IOP levels and categorized as qualified or complete success. Qualified success was defined as achieving an IOP $\leq$ 21 mmHg with at least a 20% reduction from baseline, with or without the use of glaucoma medications. Complete success was defined as meeting the same IOP and percentage reduction criteria without the need for glaucoma medications. Failure was defined as an IOP > 21 mmHg, a reduction of less than 20% from baseline, or the need for further glaucoma surgery to control IOP. Patients were stratified into three groups based on the duration of preoperative antiglaucoma medication use: short-term use (< 2 years), moderate-term use (2–5 years), and long-term use (> 5 years).

Secondary outcome measures included the change in the number of antiglaucoma medications used postoperatively and the best-corrected visual acuity (BCVA), measured using the LogMAR scale preoperatively and during follow-up visits. Additionally, surgical complications, such as transient hyphema, hypotony (defined as IOP < 5 mmHg), endophthalmitis, or any other significant adverse events, were documented.

Statistical analysis

All statistical analyses were performed using SPSS software (version 22.0, IBM Corp., Armonk, NY). Continuous variables were presented as means ± standard deviations (SD), while categorical variables were summarized as frequencies and percentages. The normality of data distribution was assessed using the Kolmogorov–Smirnov test. For comparisons of continuous variables between the three groups, one-way analysis of variance (ANOVA) was used for normally distributed data, followed by Tukey's post-hoc test for pairwise comparisons. For non-normally distributed data, the Kruskal–Wallis test was applied, with pairwise comparisons using the Mann–Whitney U test.

Categorical variables, such as the proportion of patients requiring additional glaucoma surgery and the presence of postoperative complications, were analyzed using the chi-square test or Fisher's exact test where appropriate. Kaplan–Meier survival analysis was conducted to evaluate qualified and complete surgical success rates over the follow-up period, with Mantel-Cox log-rank tests used to compare survival curves between the groups. A p-value of less than 0.05 was considered statistically significant for all analyses.

Results

A total of 64 eyes from patients with POAG or PEXG were included in the study. The mean age of the patients was 65.1 ± 10.8 years (range: 45–81), with 45% of patients being female. The mean follow-up duration was 17.2 ± 6.8 months, with no significant difference between the groups ($p = 0.426$). The short-term group included 13 patients with less than two years of medication use, the moderate-term group included 22 patients with two to five years of use, and the long-term group included 29 patients with more

than five years of use. Table 1 shows the detailed baseline clinical and demographic characteristics.

At baseline, the mean IOP across all groups was 26.7 ± 6.0 mmHg, with no significant differences between the groups ($p = 0.684$). The average number of preoperative medications used was 3.2 ± 0.4 ($p = 0.523$). Postoperatively, IOP decreased significantly in all groups ($p < 0.001$). However, patients with longer preoperative medication use had higher postoperative IOP values at the final follow-up. The final IOP was 13.2 ± 4.7 mmHg in the short-term group, 17.7 ± 6.4 mmHg in the moderate-term group, and 18.1 ± 6.9 mmHg in the long-term group ($p = 0.002$, Table 2). Figure 1 illustrates the IOP trends across the follow-up period, showing that the short-term use group maintained lower IOP levels, while the other groups exhibited progressively higher values, particularly after 12 months. The mean number of medications at the final visit was 0.5 ± 0.3 in the short-term group, 0.9 ± 0.4 in the moderate-term group, and 1.1 ± 0.4 in the long-term group ($p = 0.032$), demonstrating

Table 1 Baseline demographical and clinical characteristics of patients

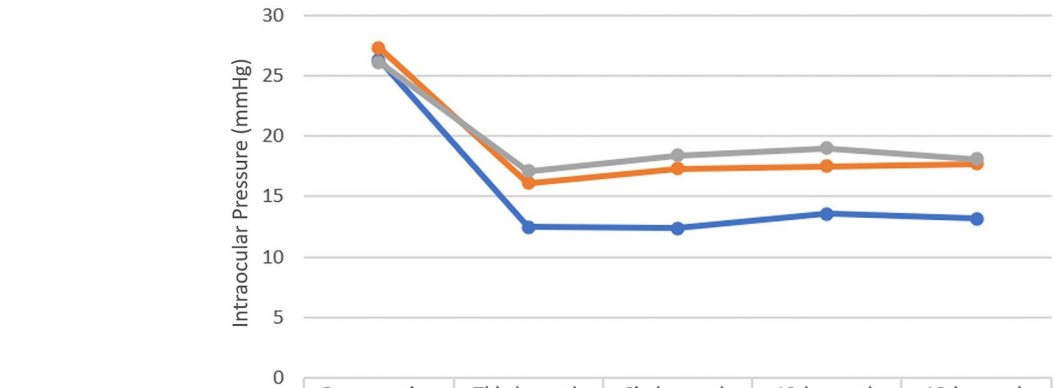
	< 2 years	2–5 years	> 5 years	Total	p
Number of patients	13	22	29	64	
Mean age (SD), yrs	61.2 ± 9.8	64.5 ± 11.2	67.8 ± 10.7	65.1 ± 10.8	0.180
Range, yrs	45–75	46–78	50–81	45–81	
Female (n, %)	5 (38%)	10 (45%)	14 (48%)	29 (45%)	0.752
Mean follow-up time (months) (SD)	18.4 ± 5.5	17.1 ± 6.7	16.2 ± 7.0	17.2 ± 6.8	0.426
Lens status					0.844
Phakic	8	12	13	33	
Pseudophakic	5	10	16	31	
Diagnosis (n)					0.532
POAG	9	15	21	45	
PEXG	4	7	8	19	
Type of preoperative medication					
Prostaglandin derivates	13 (100%)	21 (95.4%)	27 (93.1%)	61 (95.3%)	0.620
Brimonidine	10 (76.9%)	15 (68.2%)	16 (55.2%)	41 (64.1%)	0.351
CAI (Dorzolamide or Brinzolamide)	7 (53.8%)	12 (54.5%)	19 (65.5%)	38 (59.3%)	0.660
Beta blocker (Timolol or Betaxolol)	9 (69.2%)	16 (72.7%)	17 (58.6%)	42 (65.6%)	0.549

CAI carbonic anhydrase inhibitors, *POAG* primary open-angle glaucoma, *PEXG* pseudoexfoliative glaucoma

Table 2 Efficacy data based on preoperative antiglaucoma medication duration

	Short-term Use < 2 years (n = 13)	Moderate-term Use 2–5 years (n = 22)	Long-term Use > 5 years (n = 29)	Total (n = 64)	p
Visual acuity (Log MAR)					
Preoperative	0.28 ± 0.09	0.30 ± 0.10	0.35 ± 0.13	0.32 ± 0.11	0.356
Last visit	0.32 ± 0.12	0.35 ± 0.14	0.39 ± 0.17	0.36 ± 0.15	0.282
Further glaucoma surgery (n, %)	7.7% (1/13)	22.8% (5/22)	20.7% (6/29)	18.7%	0.511
Early IOP Spike	15.3%	13.6%	17.2%	15.6%	0.811
IOP (mm Hg)					
Preoperative	26.7 ± 5.8	26.4 ± 6.2	27.1 ± 5.9	26.7 ± 6.0	0.684
Final	13.2 ± 4.7	17.7 ± 6.4	18.1 ± 6.9	16.1 ± 5.9	**0.002**
Number of medication					
Preoperative	3.1 ± 0.3	3.2 ± 0.4	3.3 ± 0.4	3.2 ± 0.4	0.523
Final	0.5 ± 0.3	0.9 ± 0.4	1.1 ± 0.4	0.8 ± 0.4	**0.032**

IOP intraocular pressure



	Preoperative	Third month	Sixth month	12th month	18th month
Short-term(<2 years)	26,3	12,5	12,4	13,6	13,2
Moderate-term (2-5 years)	27,3	16,1	17,3	17,5	17,7
Long-term (>5 years)	26,1	17,1	18,4	19	18,1

Fig. 1 Graphical representation of intraocular pressure (IOP) changes over the postoperative follow-up period in three groups based on the duration of preoperative medication use: short-term (<2 years), moderate-term (2–5 years), and long-term (>5 years). Preoperative mean IOP values were 26.3 mmHg for the short-term group, 27.3 mmHg for the moderate-term group, and 26.1 mmHg for the long-term group. Postoperatively, the short-term group maintained the lowest mean IOP values, with 12.5 mmHg at the third month, 12.4 mmHg at the sixth month, 13.6 mmHg at the twelfth month, and 13.2 mmHg at the eighteenth month. The moderate-term group and long-term group exhibited progressively higher IOP values, reaching 17.7 mmHg and 18.1 mmHg, respectively, at the final follow-up

a significant reduction in medication dependence across all groups.

BCVA showed no significant changes postoperatively, with values of Log MAR 0.32 ± 0.11 at baseline and log MAR 0.36 ± 0.15 at the final visit ($p = 0.282$). The proportion of patients requiring further glaucoma surgery was 7.7% in the short-term group, 22.8% in the moderate-term group, and 20.7% in the long-term group, corresponding to an overall rate of 18.7% ($p = 0.511$).

The Kaplan–Meier survival analysis revealed that the qualified surgical success rate at the final follow-up was 92.3% for the short-term group, 77.2% for the moderate-term group, and 79.3% for the long-term group (Fig. 2A). The corresponding complete success rates were 76.9%, 63.6%, and 58.6%, respectively (Fig. 2B).

The most common complication was transient hyphema, observed in a similar proportion of all groups and resolving without further intervention. No cases of hypotony, endophthalmitis, or significant visual loss were observed.

Discussion

This study demonstrated that GATT effectively reduced IOP across all groups, with significant postoperative improvements observed at each follow-up point. However, patients with longer medication use showed relatively higher IOP levels at the final visit, despite the overall reduction. This suggests that prolonged exposure to antiglaucoma medications may adversely affect the long-term surgical outcomes, potentially due to the cumulative inflammatory and structural changes these treatments induce in the distal outflow pathways. In addition to IOP control, our study highlighted a significant reduction in the number of glaucoma medications used postoperatively. The short-term group required an average of 0.5 medications, while the moderate-term and long-term groups required 0.9 and 1.1 medications, respectively. Despite this improvement, the long-term group demonstrated a greater reliance on postoperative medications, indicating a potential link between preoperative medication burden and postoperative medication

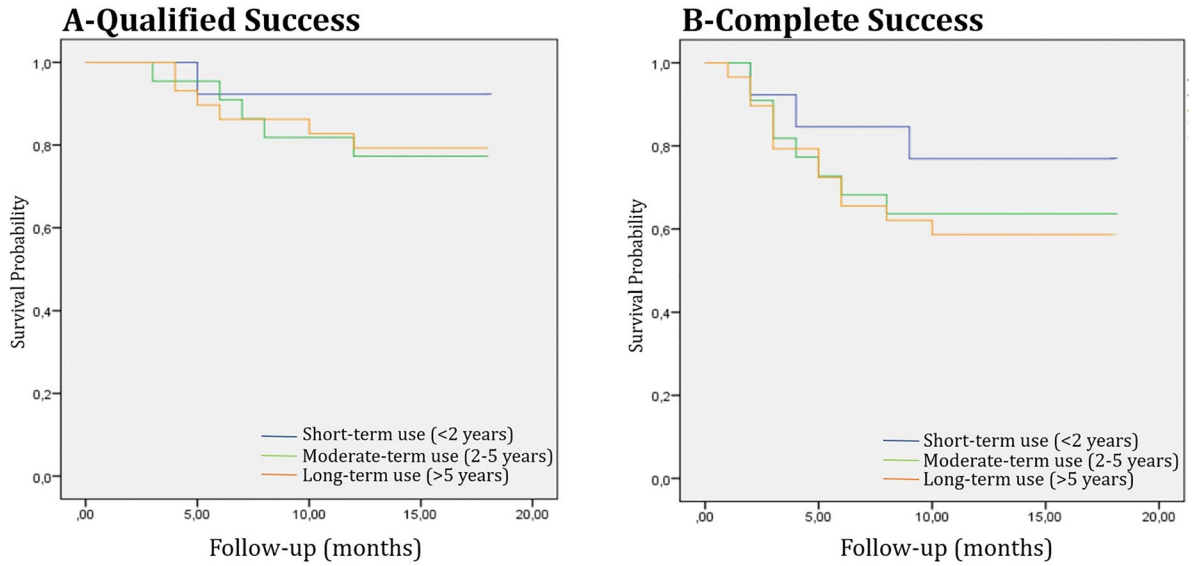


Fig. 2 Kaplan–Meier survival analysis depicting qualified surgical success **A** and complete surgical success **B** following GATT in patients categorized by the duration of preoperative antiglaucoma medication use: short-term (< 2 years), moderate-term (2–5 years), and long-term (> 5 years). At the final follow-up, the qualified success rates were 92.3%, 77.2%, and 79.3% for the short-term, moderate-term, and long-term groups, respectively. The corresponding complete success rates were 76.9%, 63.6%, and 58.6%, respectively. The analysis highlights the superior surgical outcomes in the short-term group compared to the moderate- and long-term groups

dependence. Moreover, the necessity for further glaucoma surgeries was also notably higher in the moderate- and long-term groups, reflecting the potential limitations of GATT in patients with advanced medication histories. Importantly, the absence of significant change in BCVA postoperatively reflects the minimally invasive nature of GATT, which preserves visual structures and is not typically associated with visual decline.

Several studies have demonstrated the influence of preoperative medication burden on surgical outcomes in glaucoma procedures. Okuda et al. [10] reported that patients using antiglaucoma medications for over 4.5 years had significantly lower surgical success rates at 12 months compared to those with shorter medication histories, with success rates of 52% versus 72% after ab interno microhook trabeculotomy. In our study, the long-term medication use group had a mean IOP of 18.1 mmHg at the final follow-up and a complete success rate of 58.6%, while the short-term group demonstrated a lower final IOP of 13.2 mmHg and a complete success rate of 76.9%. Additionally, Lee et al. [11] emphasized that patients undergoing trabeculectomy and exposed to more than three classes of antiglaucoma medications were at a higher risk of surgical failure.

The reduced efficacy of glaucoma surgery in patients with prolonged antiglaucoma medication use can be attributed to cumulative structural and inflammatory changes in the conjunctiva, sclera, and distal outflow pathways. Prolonged exposure to preservatives such as benzalkonium chloride has been shown to increase conjunctival fibrosis and goblet cell loss, leading to impaired mucin production and a compromised tear film [12]. Okuda et al. [10] reported a significant increase in inflammatory cell infiltration in the conjunctiva of patients with long-term medication use, which disrupts the normal tissue architecture and hinders postoperative healing. Similarly, Broadway et al. [13] observed that conjunctival biopsies from patients with extended antiglaucoma therapy revealed increased fibroblast activity and subepithelial collagen deposition, contributing to poor surgical outcomes.

This study provides valuable insights into the impact of preoperative antiglaucoma medication duration on the surgical outcomes of GATT. While previous studies have predominantly focused on

the efficacy of GATT in general glaucoma populations, our study uniquely stratifies patients based on their preoperative medication use and demonstrates a clear association between prolonged exposure and diminished postoperative success. By evaluating both IOP reduction and medication dependence across different exposure groups, this study addresses a critical gap in the literature concerning how long-term pharmacologic treatment influences trabecular outflow-targeting procedures.

Despite its valuable contributions, this study has several limitations. First, its retrospective design may introduce selection and reporting biases. Second, the sample size, particularly within the subgroups, may limit the generalizability of the findings to broader glaucoma populations. Third, the study did not include detailed evaluations of ocular surface changes or imaging of the distal outflow pathways, which could provide further insights into the mechanisms underlying reduced surgical efficacy. Moreover, while we considered regression analysis to identify independent predictors of success, subgroup sizes limited the statistical power for such an analysis. We acknowledge this as a limitation and suggest future studies incorporate larger sample sizes and regression-based designs to better understand predictive variables. Lastly, the follow-up duration, while sufficient for short- and medium-term outcomes, may not fully capture the long-term performance of GATT in patients with prolonged preoperative medication use.

In conclusion, GATT effectively lowers IOP, but prolonged preoperative antiglaucoma medication use is associated with reduced surgical success and higher postoperative medication dependence. These findings support early surgical intervention to improve long-term outcomes in glaucoma management.

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Author contributions RKU collected and analyzed data, and wrote the manuscript. MOC and AYU conducted the study, and performed all surgical procedures. All authors read and approved the final manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical approval Ahi Evran University Local Ethics Committee approved the study (Approval No: 2025–02/14).

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