Original Article

Six-Month Outcomes of Combined Phacoemulsification and Kahook Dual Blade Excisional Goniotomy Surgery in Various Glaucoma Subtypes

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Abstract

Objectives: To evaluate the efficacy and safety of the Kahook Dual Blade (KDB) excisional goniotomy procedure combined with phacoemulsification in patients with primary open-angle glaucoma (POAG), pseudoexfoliation glaucoma (PEXG), and primary angle-closure glaucoma (PACG).

Materials and Methods: This retrospective study included 25 eyes of 25 patients (13 males, 12 females) who underwent combined phacoemulsification and KDB excisional goniotomy for early- to moderate-stage glaucoma. Pre- and postoperative intraocular pressure (IOP), number of antiglaucoma medications, and best-corrected visual acuity (BCVA) were evaluated. Postoperative complications and surgical success rates were analyzed during a 6-month follow-up period. Surgical success was defined as a ≥20% reduction in IOP from baseline and IOP <18 mmHg, with or without medication.

Results: The patients' mean age was 67.0±11.9 years; 36% had POAG, 36% PEXG, and 28% PACG. The mean preoperative IOP was 22.7±6.0 mmHg, which significantly decreased to 12.8±2.2 mmHg at 6 months ($p<0.05$). The median number of medications decreased from 2 preoperatively to 0 postoperatively ($p<0.05$). There were no significant differences in 6-month IOP values ($p=0.96$) or IOP reduction rates ($p=0.61$) among glaucoma subtypes. BCVA improved from 0.5±0.4 to 0.1±0.1 logarithm of the minimum angle of resolution ($p=0.001$). The most common complications were transient hyphema (12%) and corneal edema (20%), all of which resolved with conservative/topical treatment. One patient required trabeculectomy at month 3, and 3 patients demonstrated less than 20% IOP reduction. The surgical success rate at month 6 was 84%.

Conclusion: The KDB procedure combined with cataract surgery provided significant reductions in both IOP and the need for IOP-lowering medications at 6 months of follow-up in patients with early and moderate POAG, PACG, and PEXG, while maintaining a very low rate of complications.

Keywords: Kahook Dual Blade goniotomy, combined KDB surgery, glaucoma, minimally invasive glaucoma surgery

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Introduction

Glaucoma is a progressive optic neuropathy characterized by retinal ganglion cell loss. The single most important and modifiable risk factor is elevated intraocular pressure (IOP). Glaucoma is the leading cause of irreversible yet preventable blindness worldwide.[1] The advent of minimally invasive glaucoma surgery (MIGS) has substantially expanded the available options in glaucoma surgery. MIGS procedures are advantageous in that they can be performed in the early stages of disease, potentially deferring the need for more invasive surgeries.[2,3]

Additional advantages are its low risk of complications, short operative time, and faster postoperative recovery.[3]

MIGS procedures are generally classified into three groups based on whether the aqueous outflow is directed into Schlemm's canal, the supraciliary space, or the subconjunctival space. The Kahook Dual Blade (KDB; New World Medical Inc. Rancho Cucamonga, CA, USA) is a bleb-free MIGS device designed to enhance conventional outflow by facilitating aqueous drainage through Schlemm's canal. The trabecular meshwork and inner wall of Schlemm's canal are the main sites of resistance to aqueous humor outflow. Trabeculotomy procedures aim to eliminate this resistance.[4] In contrast to ab externo approaches, KDB goniotomy is an ab interno trabeculotomy procedure. Ab interno methods do not scar the conjunctiva or sclera, thereby avoiding additional complications when trabeculectomy is required.[5]

KDB excisional goniotomy performed in combination with phacoemulsification was reported to yield greater IOP reduction than either procedure alone.[6,7] Reported IOP reductions after KDB surgery have ranged from 11% to 36%. Significant reductions in glaucoma medication burden have also been reported, with the proportion of patients requiring medical therapy decreasing from 92% to 15%. These findings provide compelling evidence supporting the efficacy of KDB surgery in the management of glaucoma.[8,9] The present study aimed to evaluate the surgical outcomes of KDB excisional goniotomy combined with phacoemulsification cataract surgery in patients with glaucoma.

Materials and Methods

The medical records of patients with early or moderate glaucoma who underwent combined KDB excisional goniotomy and cataract surgery in the glaucoma unit of our center between January 2020 and April 2024 were reviewed retrospectively. None of the patients included in the study had a history of prior glaucoma surgery. Data collected included glaucoma subtype, best-corrected visual acuity (BCVA), IOP, anterior segment findings, cup-to-disc (C/D) ratio, pre- and postoperative antiglaucoma medications, and postoperative complications. Surgical success was defined as an IOP reduction of more than 20% from the preoperative value and an IOP of less than 18 mmHg at the 6-month postoperative examination, with or without antiglaucoma medication. Surgical failure was defined as an IOP reduction of less than 20%, IOP ≥18 mmHg, or the need for additional glaucoma surgery. Glaucoma severity was staged according to the mean deviation (MD) on Humphrey visual field testing as mild (MD ≥-6.0 dB), moderate (-6.0> MD ≥-12.0 dB), and advanced (MD <-12.0 dB).

All surgeries were performed under sedation by two surgeons experienced in glaucoma surgery. In all cases, KDB excisional goniotomy was performed immediately after standard phacoemulsification surgery. Following standard phacoemulsification and in-the-bag intraocular lens implantation, intracameral carbachol (MioStat®, Alcon Laboratories Inc., Fort Worth, TX, USA) was applied to achieve intraoperative miosis. To optimize visualization of the nasal angle, the patient's head was rotated 30° nasally and the operating microscope was tilted 45° temporally. The anterior chamber was filled with dispersive viscoelastic (Viscoat®, Alcon Laboratories Inc., Fort Worth, TX, USA) through the temporal side port. The angle structures were visualized by direct gonioscopy using a single-mirror Swan-Jacob goniolens (Ocular Instruments Inc., Bellevue, WA, USA). In patients with open-angle glaucoma, the KDB tip was introduced into Schlemm's canal and advanced approximately 3 to 4 clock-hours clockwise and counterclockwise along the nasal angle to excise a total of approximately 8 clock-hours of trabecular meshwork. In patients with primary angle-closure glaucoma (PACG), goniosynechialysis was performed before excisional goniotomy. The sharp tip of the KDB was engaged at the peripheral iris and gentle, controlled force was applied centrally along the iris plane to release peripheral anterior synechiae (PAS) and expose the underlying trabecular meshwork for goniotomy. KDB excisional goniotomy was then performed along the exposed trabecular meshwork. At the end of the procedure, the viscoelastic material was carefully aspirated from the anterior chamber and intracameral cefuroxime (Aprokam®, Laboratoires Théa, Clermont-Ferrand, France) was administered.

To mitigate the risk of early postoperative IOP elevation attributable to residual ophthalmic viscosurgical material, all patients received oral acetazolamide (Diazomid®, Deva Holding A.Ş., İstanbul, Türkiye) at postoperative 2 and 4 hours. Postoperative topical therapy consisted of nepafenac 0.3% (Apfecto®, World Medicine, İstanbul, Türkiye) once daily, a fixed-combination containing moxifloxacin 0.5% and dexamethasone 0.1% (Moxidexa®, Abdi İbrahim İlaç, İstanbul, Türkiye) 4 times daily, and artificial tears containing sodium hyaluronate (Hyonat®, Vem İlaç, İstanbul, Türkiye) 4 times daily, all prescribed for 1 month. In patients with an IOP exceeding the target level at 12 hours postoperatively, additional antiglaucoma therapy was initiated. A postoperative IOP spike was defined as an increase of >10 mmHg over preoperative IOP at the 1-week postoperative follow-up.

Given the retrospective nature of the study, individual informed consent was not required. Ethics committee approval was obtained from the Marmara University Faculty of Medicine (protocol code: 09.2025.25-0294; decision date: 18.04.2025) and the study was carried out in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

All statistical analyses were performed using IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or median, and categorical variables as frequency and percentage. The normality of data distribution was assessed using the Shapiro-Wilk test. Preoperative and postoperative values were compared using the paired-samples t-test for normally distributed data and the Wilcoxon signed-rank test for non-normally distributed data. Variables reported as medians, such as medication count, were analyzed using appropriate non-parametric tests. Differences among the three glaucoma subgroups were assessed using one-way analysis of variance (ANOVA) for normally distributed variables and the Kruskal-Wallis test for non-normally distributed data. The durability of surgical success was assessed using Kaplan-Meier survival analysis. Between-group comparisons were performed using the log-rank test. A p value of <0.05 was regarded as statistically significant in all analyses.

Results

Twenty-five eyes of 25 patients (13 male, 12 female) who underwent KDB excisional goniotomy combined with phacoemulsification were included in the study. Of the included eyes, 71.4% were right eyes. The mean patient age was 67.0±11.9 years. Glaucoma subtype was primary open-angle glaucoma (POAG) in 36.0%, PACG in 28.0%, and pseudoexfoliation glaucoma (PEXG) in the remaining 36.0% of patients. All patients were using IOP-lowering drugs before the surgery. The mean BCVA was 0.5±0.4 logarithm of the minimum angle of resolution at baseline and improved to 0.1±0.1 at 6 months postoperatively (p=0.001). The mean preoperative IOP was 22.7±6.0 mmHg and the median C/D ratio was 0.7 (range, 0.6-0.9) (Table 1).

Postoperative complications included hyphema in 3 patients, corneal edema in 5 patients, IOP spike in 2 patients, cyclodialysis cleft in 1 patient, and vitreomacular traction in 1 patient (Table 2). All complications occurred in the early postoperative period. Corneal edema observed on postoperative day 1 resolved completely with standard postoperative topical therapy during follow-up. The patient who developed an intraoperative cyclodialysis cleft did not develop persistent hypotony during follow-up and did not require surgical intervention. The patient who developed vitreomacular traction at postoperative month 1 showed no functional or anatomical progression in regular follow-up examinations. Patients with hyphema noted on postoperative day 1 were managed conservatively with head elevation and reduced activity.

The mean IOP was 14.3±4.9 mmHg on postoperative day 1, 14.3±4.6 mmHg at week 1, 13.9±4.4 mmHg at 1 month, 13.6±3.6 mmHg at month 3, and 12.8±2.2 mmHg at month 6 (Table 2). The percentage IOP reduction across all patients was 33.3%, 33.9%, 33.7%, 35.9%, and 39.9% at day 1, week 1, month 1, month 3, and month 6, respectively (all p<0.01) (Table 3). The IOP reduction at month 6 was statistically significant within each glaucoma subgroup (POAG p=0.008, PEXG p=0.011, and PACG p=0.018) (Table 3).

Table 1. General characteristics of the patients

Eyes, n		**25**
Age (years), mean ± SD [range]		67.0±11.9 [41-85]
Sex, n (%)	Male	13 (52.0)
	Female	12 (48.0)
Laterality, n (%)	Right	14 (56.0)
	Left	11 (44.0)
Preoperative C/D ratio, median [95% CI]		0.7 [0.6-0.9]
Preoperative BCVA (logMAR)		0.5±0.4
Postoperative BCVA (logMAR)		0.1±0.1
Glaucoma subtype, n (%)	POAG	9 (36.0)
	PACG	7 (28.0)
	PEXG	9 (36.0)

SD: Standard deviation, C/D: Cup/disc, CI: Confidence interval, BCVA: Best-corrected visual acuity, logMAR: Logarithm of the minimum angle of resolution, POAG: Primary open-angle glaucoma, PACG: Primary angle-closure glaucoma, PEXG: Pseudoexfoliation glaucoma

Table 2. Frequency of postoperative complications

Complication	**n (%)**
Corneal edema	5 (20.0)
Transient hyphema	3 (12.0)
Intraocular pressure spike	2 (8.0)
Cyclodialysis cleft	1 (4.0)
Vitreomacular traction	1 (4.0)

Table 3. Mean intraocular pressure (IOP) values and percent change in IOP from baseline (%ΔIOP) at various time points in the overall cohort and by glaucoma subtype

Glaucoma subtype	Preop	Day 1 (%ΔIOP) p value	Week 1 (%ΔIOP) p value	Month 1 (%ΔIOP) p value	Month 3 (%ΔIOP) p value	Month 6 (%ΔIOP) p value
All patients	22.7±6.0 [12-40]	14.3±4.9 [7-25] (33.3%) **<0.001**	14.3±4.6 [9-32] (33.9%) **<0.001**	13.9±4.4 [8-30] (33.7%) **<0.001**	13.6±3.6 [9-27] (35.9%) **<0.001**	12.8±2.2 [9-17] (39.9%) **<0.001**
POAG	22.9±5.6 [17-34]	14.3±3.4 [10-19] (34.2%) **0.011**	15.1±3.5 [12-23] (29.3%) **0.021**	14.8±2.2 [10-18] (32.2%) **0.008**	13.4±1.9 [11-17] (38.1%) **0.012**	13.9±1.5 [12-16] (35.4%) **0.008**
PEXG	21.0±4.9 [12-27]	17.0±6.0 [7-25] (17.2%) 0.097	15.0±7.1 [9-32] (29.0%) 0.106	13.2±6.6 [8-30] (31.2%) 0.086	12.2±2.8 [9-18] (38.0%) **0.013**	11.7±2.5 [9-17] (40.7%) **0.011**
PACG	24.9±7.8 [17-42]	10.9±2.5 [7-15] (53.0%) **0.018**	12.6±1.6 [10-15] (45.5%) **0.018**	13.7±3.1 [9-19] (39.1%) **0.028**	15.4±5.4 [12-27] (30.2%) 0.075	12.9±2.0 [10-15] (44.5%) **0.018**

Data are presented as mean ± standard deviation [range]. Comparisons were made using Wilcoxon signed-rank test according to preoperative value. Bold values indicate statistical significance (p<0.05). POAG: Primary open-angle glaucoma, PEXG: Pseudoexfoliation glaucoma, PACG: Primary angle-closure glaucoma

At 6 months postoperatively, the mean IOP had decreased from 22.7±6.0 mmHg preoperatively to 12.8±2.2 mmHg, representing a mean reduction of 9.9 mmHg (39.9%). Analysis by glaucoma subtype showed that the mean IOP decreased from 22.9±5.6 mmHg to 13.9±1.5 mmHg in the POAG group, from 21.0±4.9 mmHg to 11.7±2.5 mmHg in the PEXG group, and from 24.9±7.8 mmHg to 12.9±2.0 mmHg in the PACG group (Table 2). The IOP reduction from baseline to month 6 was statistically significant in all groups (p<0.05) (Figure 1). However, the degree of IOP reduction did not differ significantly among the three groups (p=0.61). There was also no statistically significant difference in absolute IOP values between the glaucoma subgroups at 6 months (p=0.96).

The median number of antiglaucoma medications decreased from 2 preoperatively to 0 at the final postoperative visit (p<0.01). The mean number of antiglaucoma medications decreased from 3.24±1.01 preoperatively to 1.00±1.23 postoperatively, representing a 69.9% reduction.

One patient required trabeculectomy at month 3, and 3 patients achieved less than 20% IOP reduction from baseline. The overall surgical success rate at 6 months was 84.0%. Kaplan-Meier survival analysis demonstrated no statistically significant difference in the probability of sustained surgical success between the three glaucoma subtypes (log-rank test, p=0.773) (Figure 2).

Discussion

This study aimed to evaluate the effectiveness and safety of combined KDB excisional goniotomy and cataract surgery using clinical data. The KDB is a single-use ophthalmic blade developed specifically for ab interno excisional goniotomy. Several studies have reported on the early outcomes of KDB excisional goniotomy combined with cataract surgery.[7,10] In the present series, we retrospectively analyzed the 6-month outcomes of KDB excisional goniotomy combined with phacoemulsification.

In a multicenter study by Bravetti et al.[11] involving 40 eyes with severe or refractory open-angle glaucoma who underwent standalone or combined KDB goniotomy, surgical success was defined as an IOP reduction of at least 20% from baseline at 12 months with fewer medications than preoperatively. Mean IOP decreased from 18.1±5.0 mmHg at baseline to 14.8±3.7 mmHg at 12 months (18.2% reduction), and the mean number of medications was reduced by 32.0%.[11] A multicenter study of 71 patients with various glaucoma subtypes who underwent combined KDB and phacoemulsification reported a mean IOP decrease from 17.4 mmHg to 12.8 mmHg, with a significant reduction in antiglaucoma medication use.[7] A separate prospective study involving 51 patients demonstrated a 26.2% IOP reduction and 50% reduction in medication count.[10] Mechleb et al.[12] reported a 24.9% IOP reduction from baseline and a surgical success rate of 82.1%. In our cohort,

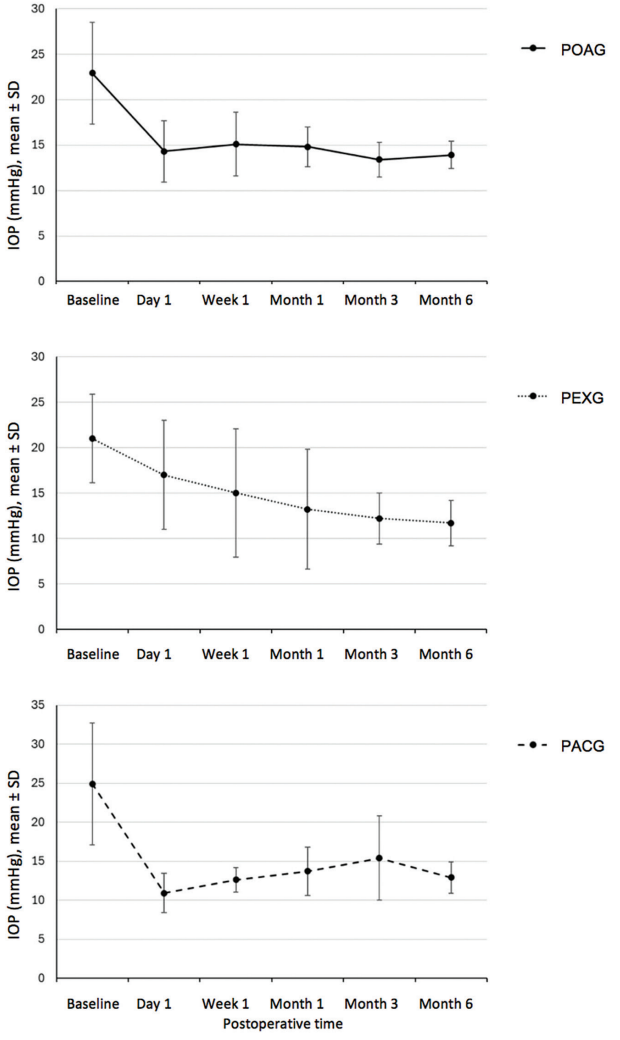

Figure 1. Changes in mean intraocular pressure (IOP ± standard deviation) over a 6-month follow-up period across different glaucoma subtypes
IOP: Intraocular pressure, POAG: Primary open-angle glaucoma, PEXG: Pseudoexfoliation glaucoma, PACG: Primary angle-closure glaucoma, SD: Standard deviation

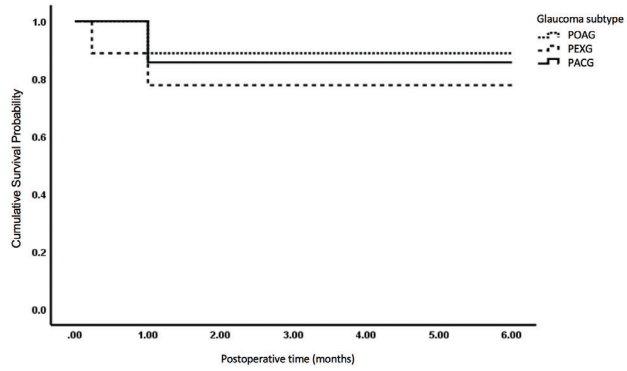

Figure 2. Kaplan-Meier survival analysis of surgical success over a 6-month follow-up period across different glaucoma subtypes
POAG: Primary open-angle glaucoma; PEXG: Pseudoexfoliation glaucoma, PACG: Primary angle-closure glaucoma

combined surgery yielded a mean absolute IOP reduction of 10 mmHg at 6-month follow-up, corresponding to a 39.9% decrease. In the literature, the mean IOP reduction following standalone KDB goniotomy has been reported as approximately 4 mmHg; the greater reduction observed in our series is likely attributable to the additive IOP-lowering effect of concurrent phacoemulsification.[7,10,12] In a study evaluating standalone KDB in 53 eyes of 42 patients with a mean baseline IOP of 23.5 mmHg, Berdahl et al.[8] reported mean IOP reductions ranging from 29.8% to 43.8% over a 6-month follow-up period, comparable to the reduction observed in our combined series. In our study, one patient required additional surgery and 3 patients failed to achieve at least 20% IOP reduction, yielding an overall surgical success rate of 84% for combined KDB. This is consistent with the 74.1%, 82.1%, and 86% success rates at postoperative 6 months reported in the literature.[6,12,13]

Non-adherence to medical therapy is a major problem that can arise in the long-term management of glaucoma. KDB excisional goniotomy helps address this challenge by reducing the patient's dependence on topical antiglaucoma medications.[3] The mean reduction in the medication count in our cohort (69.9%) was greater than the 46-50% reductions reported at 6 months in comparable studies.[10,12]

Reductions in both IOP and medication burden have been demonstrated in eyes with PEXG and POAG following KDB goniotomy.[14] In a study of 132 eyes, Pratte et al.[15] reported a 15.3% reduction in IOP (from 17.6±4.6 to 14.9±3.2 mmHg) and a 45% reduction in medication count (from 2±1.2 to 1.1±1.2) at 6 months postoperatively, noting that patients using more medications at baseline may derive greater benefit from combined surgery. Sieck et al.[6] reported a 12-month surgical success rate of 71.8% in 165 eyes undergoing combined KDB and phacoemulsification, with the mean IOP decreasing from 16.7 to 13.8 mmHg and a significant reduction in antiglaucoma medication use. The 39.9% IOP reduction observed at 6 months in our study is consistent with the literature. Our success

rate also seems comparable to those of other studies. One study conducted in China reported a 100% success rate at 6 months.[16] Bravetti et al.[11] emphasized that the efficacy of KDB excisional goniotomy tended to decrease over time based on their 12-month follow-up data, and Pratte et al.[15] reported differing success rates at 6 and 12 months, underscoring the importance of extended follow-up in evaluating the durability of surgical outcomes. In this context, the Kaplan-Meier analysis in our study complements the existing literature by demonstrating that combined surgery provides comparable and sustained surgical success across different glaucoma subtypes during the first 6 months, independent of early postoperative IOP fluctuations.

Although glaucoma subtypes have varying pathophysiological mechanisms, reduction of trabecular meshwork resistance, which is the primary mechanism of action of the KDB, is a common therapeutic target across all glaucoma forms. The EAGLE trial demonstrated that phacoemulsification in patients with early angle-closure glaucoma resulted in significantly greater IOP reduction and better quality of life compared with laser peripheral iridotomy alone.[17,18] Combined KDB surgery with phacoemulsification has been reported to be safe and effective in patients with PACG. This approach lowers IOP through a dual mechanism: lens extraction widens the anterior chamber angle, while goniotomy directly reduces trabecular resistance.[19,20] PAS permanently occlude the angle and chronically damage the underlying trabecular meshwork. Therefore, releasing the trabecular meshwork with goniosynechialysis alone often results in a dysfunctional outflow pathway.[21] In the combined procedure, the anatomical block is relieved by lens extraction, PAS are disrupted by goniosynechialysis, and the residual outflow resistance is addressed by KDB excisional goniotomy, which creates a functional bypass from the damaged trabecular meshwork into Schlemm's canal.[21] Studies have shown that KDB combined with phacoemulsification achieves significant reductions in both IOP and medication burden.[19,20] Combined cataract surgery, goniosynechialysis, and KDB excisional goniotomy in angle-closure glaucoma have been reported to reduce IOP by approximately 38-49% and decrease medication use by approximately 90-98% at 6-12 months.[20,21] The pronounced IOP reduction observed in our PACG cases suggests that the angle-widening effects of lens extraction and goniosynechialysis act synergistically with the trabecular-level mechanism of KDB excisional goniotomy. Consistent with the literature, these results support combined surgery as a safe and effective option for the treatment of PACG.

Several studies have demonstrated that combined KDB with cataract surgery has a favorable postoperative complication profile.[7,13,15] In cases where the IOP-lowering effect of KDB goniotomy decreases over time and additional surgical intervention is required, the preserved conjunctival integrity enables subsequent filtration surgery without compromise. As KDB goniotomy does not involve conjunctival incisions, future procedures are more likely to be successful. The combination of KDB with cataract surgery offers other additional benefits, particularly with respect to long-term glaucoma management. Given that trabeculectomy is known to accelerate cataract formation, performing concurrent cataract extraction at the time of KDB goniotomy preempts this complication in patients who may later require filtration surgery. Conversely, performing cataract surgery after filtration surgery risks compromising bleb function through increased postoperative inflammation and conjunctival scarring. Therefore, combining KDB with cataract surgery not only provides immediate IOP reduction but also preserves the surgical landscape for future interventions, optimizing conditions for subsequent glaucoma management. This approach highlights the value of strategic surgical sequencing in glaucoma management, securing both near-term efficacy and long-term therapeutic flexibility.

Early postoperative hyphema may occur due to blood reflux through Schlemm's canal during goniotomy. It is relatively common, typically developing within the first postoperative week, and is usually self-limiting.[10] The prevalence of transient hyphema in our series (21.4%) is consistent with the 35.1% and 39.4% rates reported in comparable studies.[7,13] Transient IOP spikes occurred in 14.3% of patients, also consistent with rates reported in the literature.[7,10] IOP spikes were managed successfully with topical antiglaucoma therapy, and hyphema resolved in all affected eyes with conservative observation. Cyclodialysis cleft is a rare complication following KDB goniotomy and has been reported in association with persistent hypotony.[22,23] Hypotony did not occur in any of our patients.

Study Limitations

Limitations of this study include its retrospective design, which precluded randomization, the inclusion of heterogeneous glaucoma subtypes within a single cohort, and the small sample size. Nevertheless, the available data provide promising early-stage evidence supporting the feasibility and safety of KDB excisional goniotomy across different glaucoma subtypes.

Conclusion

Combined KDB excisional goniotomy and phacoemulsification provided significant reductions in IOP and antiglaucoma medication use at 6 months in patients with early to moderate glaucoma, with a low rate of complications. KDB excisional goniotomy appears to be a promising and safe treatment option for both angle-closure glaucoma and various forms of open-angle glaucoma.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from the Marmara University Faculty of Medicine (protocol code: 09.2025.25-0294; decision date: 18.04.2025) and the study was carried out in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Given the retrospective nature of the study, individual informed consent was not required.

Declarations

Authorship Contributions

Surgical and Medical Practices: M.E., E.B.Ç., Concept: E.B.Ç., M.E., Ö.Ş., Design: E.B.Ç., M.E., Ö.Ş., Data Collection or Processing: E.B.Ç., H.H., Analysis or Interpretation: E.B.Ç., M.E., Ö.Ş., H.H., Literature Search: E.B.Ç., M.E., Writing: E.B.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

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