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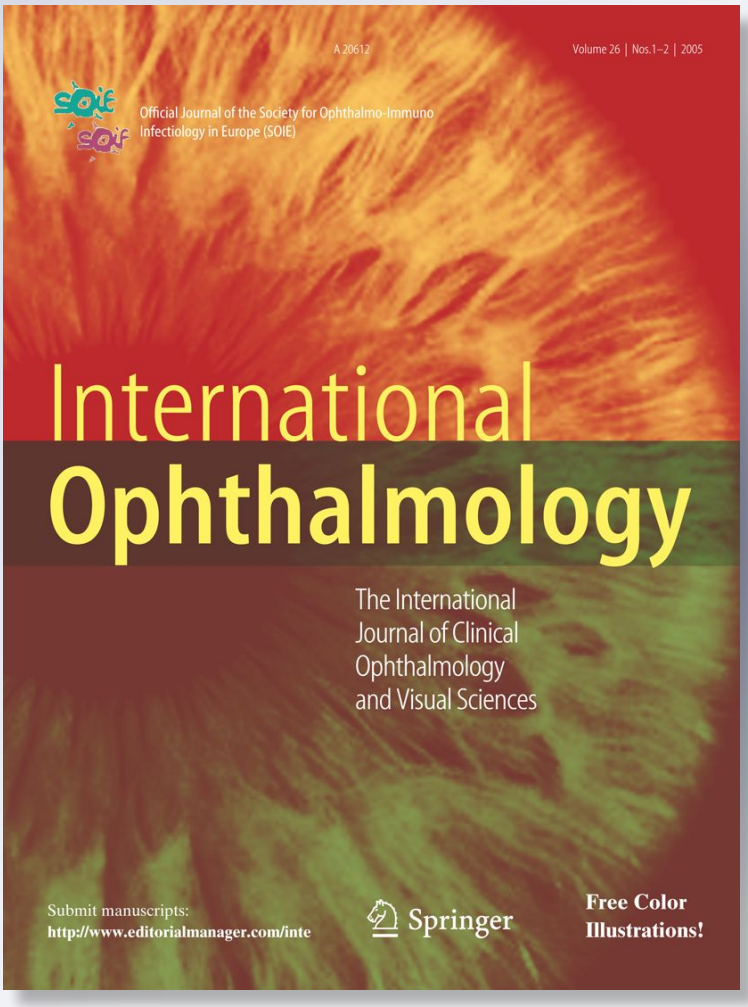

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ORIGINAL PAPER

Trabeculectomy for advanced glaucoma

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Abstract The objective of this study is to evaluate the visual prognosis and postoperative course in advanced glaucoma patients who underwent trabeculectomy. The records of 30 patients with advanced visual field (VF) defects undergoing trabeculectomy were retrospectively reviewed. Severe VF defects were defined as those with a sensitivity of ≤5 dB either in more than 85% of test points, excluding the central four points, or in >75% of test points, including three of the central four points with threshold automated perimetry. Main outcome measures were intraocular pressure (IOP), corrected visual acuity (VA) and mean deviation (MD) of VF tests. Mean preoperative IOP, VA and MD values were compared with their respective postoperative values. The latest examination of each patient was used to determine postoperative outcome measures. In addition, any complications encountered were recorded. A total of 34 trabeculectomies were performed. The mean age was 59.3 years (13–80 years). The mean follow-up time was 41.1 months (3–120 months). Preoperatively the mean IOP was 28.4 ± 13.1 mmHg, and the mean postoperative IOP was 14.8 ± 5.0 mmHg ($P = 0.001$). Preoperatively the mean VA was 0.87 ± 80, and the mean value of the MD was −24.5 ± 6.7 dB. At the latest follow-up there was no significant difference in VA (0.89 ± 79, $P = 0.699$) and MD (−23.9 ± 6.7, $P = 0.244$) values. Transient hypotony occured in five eyes while one eye with mitomycin C trabeculectomy experienced extended hypotony. Ten eyes showed reduction of VA between 1 and 5 lines due to cataracts and five eyes had late bleb failure with uncontrolled IOP. One patient had late endophthalmitis and one patient presented with blebitis, both of which were successfully treated. No patients experienced wipe-out phenomenon. In conclusion, our study of advanced glaucoma patients undergoing trabeculectomy, vision was preserved with no cases of unexplained loss of central vision. IOP was largely controllable, with cataract being the leading factor decreasing VA at late term.

Keywords Advanced glaucoma · Trabeculectomy · Vision · Wipe-out

The Study was performed in Celal Bayar University Faculty of Medicine, Manisa, Turkey.

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Introduction

Patients with advanced glaucoma usually require maximum medical therapy. Some of these patients will require additional surgical interventions, such as

laser trabeculoplasty or filtering surgery [1, 2]. Some studies have raised concerns about the risk of visual compromise after glaucoma surgery when operating on such patients [3–5]. Visual compromise in patients undergoing trabeculectomy may be attributable to cataract, cystoid macular edema, suprachoroidal or vitreous hemorrhage, retinal detachment and uncontrolled intraocular pressure (IOP) [6]. However loss of central vision can occur even after an otherwise uncomplicated operation, namely 'wipe-out' phenomenon [3, 5, 6]. The risk of wipe-out phenomenon after filtration surgery for advanced glaucoma has been debatable [4, 7–9]. It has been of concern to ophthalmologists that patients with small residual visual fields (VFs) may be at risk from sudden loss of central vision as a result of surgery [3, 5, 6].

Therefore, the decision to proceed with trabeculectomy in patients with advanced glaucoma may be controversial. The present study was undertaken to retrospectively review the results of trabeculectomy performed in patients with advanced glaucoma at a tertiary glaucoma referral center.

Study design/patients and methods

The records of patients with advanced glaucoma who underwent trabeculectomy over the past 10 years (1999–2008) in our institution were retrospectively reviewed. Patients with <3 months follow-up and insufficient hospital records were not included. Definition of advanced glaucoma was severe VF defects defined as those with a sensitivity of ≤5 dB either in >85% of test points, excluding the central four test points, or in >75% of test points, including three of the central four test points with threshold automated perimetry (Swedish Interactive Threshold Algorithm [SITA] standard 30-2 program of the Humphrey Field Analyzer-750; Carl Zeiss Meditec, Dublin, CA, USA), with consistent optic nerve head cupping [4]. Patients with neovascular glaucoma, uveitic glaucoma or with other ocular pathology contributing to VF loss were excluded. Aphakia or concurrent procedure with a trabeculectomy was not included.

Preoperative ophthalmic examinations included corrected visual acuity (VA), VF test results, anterior segment slit-lamp examination, IOP with Goldmann applanation tonometry, gonioscopy and dilated fundoscopy with assessment of vertical cup/disk ratio. Preoperative VA and IOP was recorded from the last visit before surgery. VA was measured with a Snellen chart and was converted to the logMAR VA scale for comparison.

Surgical technique

Either local anesthesia (peribulbar injection of a 1-to-1 mixture of 2% lidocaine hydrochloride and 0.75% bupivacaine hydrochloride) with monitored anesthesia care or general anesthesia was performed. General anesthesia was preferred only for young and very uncooperative patients. Special attention was given to lower IOP of patients with very high values utilizing intravenous mannitol 20% and oral acetazolamide before surgery.

Trabeculectomy was performed as follows: dissection of the conjunctiva was performed with either a fornix-based or limbus-based approach according to the preference of the surgeon. Light cautery was applied as needed and either a rectangular (3 mm × 4 mm) or a triangular (4 mm × 4 mm × 4 mm) half-thickness scleral flap was outlined with a surgical blade. The pre-outlined partial-thickness scleral flap was then dissected. Most of our patients underwent surgery without antimetabolites. Our preference is to use antimetabolites for relatively young patients, for reoperations and for coexisting pseudophakia. In eyes planned for antimetabolites, 50 mg/ml 5-fluorouracil (5-FU) was applied for 5 min or mitomycin C(MMC) 0.2 mg/ml was applied for 2 min over the scleral flap and under the conjunctival flap using pieces of soaked sponges. This area was then irrigated with balanced salt solution. After creating a paracentesis tract in the peripheral cornea, a block of trabecular section was removed anterior to the scleral spur with a trabeculectomy punch or microsurgical knife and Vannas scissors, followed by a peripheral iridectomy. The scleral flap was sutured with 1-3 interrupted 10-0 nylon sutures to ensure a slight egression of aqueous, and yet tight enough to maintain a deep anterior chamber. Conjunctival flap was closed with an 8-0 Vicryl suture. The operations were completed with a subconjunctival injection of gentamycin and dexamethasone. Postoperatively, patients received a 4- to 8-week tapering dose of 1% prednisolone acetate ophthalmic drops starting at 8 times daily.

All patients were examined at 1 day, 1 week, 1 month and 3 months postoperatively with documentation of VA, IOP, VF, optic disc status, and the number

of antiglaucoma medications required to achieve optimal IOP levels. Additional clinical visits were scheduled as clinically warranted. The incidence of intraoperative and also of any postoperative complications such as flat anterior chamber, hypotony, macular edema, choroidal detachment and status of bleb was recorded at all visits. Transient hypotony was defined as IOP of $\leq$5 mmHg during the first postoperative 2 weeks. Extended hypotony was defined as IOP of $\leq$8 mmHg after the first postoperative 2 weeks.

Main outcome measures of this study are IOP, VA and mean deviation (MD) of the VF at the latest examination after surgery compared with their corresponding preoperative values. The latest examination results were used for statistical analysis.

Statistical analysis was performed with SPSS statistical software, version 13.0, for Windows (SPSS Inc, Chicago, IL, USA). Since our study had normally distributed variables, we used the paired *t* test for comparing the mean IOPs, VA in logMAR values and the VF test results (MD) before and after surgery. Statistical significance was defined as $P < 0.05$.

Results

Records of 34 eyes of 30 recruited patients (15 males, 15 females) were reviewed in this study. Demographic and baseline clinical characteristics of patients are summarized in Table 1. Two eyes had previous trabeculectomy in the study eye. Three of the patients were blind in the fellow eye, two of them due to uncontrolled glaucoma.

Preoperative VA ranged between light perception to 20/20 (mean 0.87 $\pm$ 0.80 logMAR). Average MD of the preoperative VF was -24.53 ± 6.79 dB. Mean preoperative IOP was 28.4 $\pm$ 13.1 mmHg with maximal tolerated medical therapy. Preoperative fundus examination showed vertical cup/disc ratios between 0.8 and 1.0. Eleven eyes had split-fixation before surgery. Table 2 shows IOP, VA and VF results before and after filtration surgery in our patients.

Three eyes had 5-FU trabeculectomy, 7 had MMC trabeculectomy, 24 had trabeculectomy without antimetabolites. There were no intraoperative complications. Transient hypotony occured in 5 (14.7%) eyes, while 1 (2.9%) eye with MMC trabeculectomy experienced extended hypotony. Of these, two had bleb leaks and three had overfiltrating blebs, which were managed successfully by conventional medical means. There were no cases of postoperative flat anterior chamber, choroidal detachment or macular edema. One patient required argon laser suture lysis. Bleb revision with injection of 5-FU was required in one patient. No patient experienced wipe-out phenomenon.

One eye with MMC trabeculectomy experienced endophthalmitis at the third postoperative month and was treated with intravitreal antibiotics; however, cataract developed in this patient after endophthalmitis treatment but preoperative VA was salvaged after cataract extraction. Another patient with MMC trabeculectomy presented with blebitis at 3 years postoperatively; she was treated aggressively with topical

Table 1 Baseline clinical characteristics of patients undergoing trabeculectomy for advanced glaucoma

Age	
Range	13–80
Mean $\pm$ SD	59.3 $\pm$ 18.0
Gender	
Male	15 (50%)
Female	15 (50%)
Type of glaucoma	
Pseudoexfoliation glaucoma	15 (44.1%)
Primary open-angle	10 (29.4%)
Juvenile glaucoma	4 (11.8%)
Secondary glaucoma	2 (5.9%)
Normotensive glaucoma	2 (5.9%)
Chronic angle-closure glaucoma	1 (2.9%)
IOP (mmHg)	
Range	11–70
Mean $\pm$ SD	28.4 $\pm$ 13.1
C/D ratio	
Range	0.8–1.0
Mean $\pm$ SD	0.89 $\pm$ 0.02
VF mean deviation (dB)	
Range	-14.1 to -36.1
Mean $\pm$ SD	-24.5 ± 6.7
LogMAR visual acuity	
Range	0–2
Mean $\pm$ SD	0.87 $\pm$ 0.80
Number of antiglaucoma medications	
Range	2–4
Mean $\pm$ SD	3.1 $\pm$ 0.7

SD standard deviation, *C/D ratio* cup–disc ratio, *IOP* intraocular pressure, *dB* decibel

Table 2 IOP, visual acuity and VF results prior to and after trabeculectomy in patients with advanced glaucoma

	Gender	Age at surgery	Eye	Glaucoma type	VA		IOP		MD (dB)		Follow-up (months)
					Preop	Postop	Preop	Postop	Preop	Postop	
1	F	73	R	PXG	0.1	0.3	18	19	−19.45	−21.96	90
2	M	65	R	PXG	1.9	1.9	38	15	−17.44	−15.65	36
3	F	13	R	JG	0.1	0.1	17	10	−14.19	−12.83	36
4	M	65	L	PXG	0.3	0.4	30	15	−18.24	−13.11	3
5	F	72	R	PXG	0.1	0.3	32	15	−16.41	−16.9	11
6	M	72	L	POAG	1.9	1.9	20	13	−19.82	−18.32	15
7	M	70	R	POAG	0.2	0.2	11	15	−29.39	−29.22	3
8	M	60	R	POAG	2	2	70	10	−31.36	−31.29	6
9	M	58	L	PACG	0.2	0.2	38	11	−30.61	−28.20	28
10	F	60	L	PXG	0.1	0.2	31	12	−14.8	−13.50	108
11	M	70	L	POAG	0.1	0.4	44	14	−28.78	−26.93	120
12	F	72	R	POAG	0.2	0.3	26	15	−28.29	−27.60	108
13	M	80	R	PXG	2	2	36	20	−31.42	−29.14	96
14	M	74	L	PXG	0.4	1.9	17	10	−26.63	−29.85	96
15	M	74	R	PXG	0.1	0.1	13	12	−17.5	−16.24	84
16	F	65	R	POAG	2	2	30	32	−33.32	−34.16	48
17	F	65	L	PXG	1.8	2	15	20	−29.47	−29.32	24
18	F	51	R	POAG	0	0	26	15	−29.26	−27.39	24
19	F	48	L	NTG	0	0	12	9	−14.2	−13.95	72
20	F	48	L	NTG	0	0	15	12	−17.48	−16.13	60
21	F	62	L	PXG	1.3	0.5	16	14	−16.41	−20.51	60
22	M	72	L	PXG	1.9	2	35	18	−28.53	−32.12	60
23	M	67	R	POAG	1.8	1.3	30	23	−24.75	−28.08	48
24	F	27	R	JG	1.8	1.9	52	15	−34.64	−28.36	48
25	F	27	L	JG	1.5	1	50	13	−32.28	−23.08	48
26	F	73	L	PXG	1.9	1.9	27	16	−23.54	−23.45	12
27	F	67	L	PXG	0.1	0.1	24	14	−16.56	−15.85	8
28	F	18	R	JG	1.9	1.8	28	5	−36.12	−33.61	12
29	M	73	L	SG	0.7	1	30	20	−28.27	−29.12	3
30	M	60	L	POAG	0.4	0.4	19	22	−16.93	−16.87	8
31	F	21	L	SG	1	1	34	10	−32	−32.53	10
32	M	72	L	PXG	1.8	1.8	16	19	−25.9	−27.12	12
33	M	75	L	PXG	1	1	22	11	−21.54	−20.79	8
34	M	50	R	POAG	0.2	0.2	45	10	−28.66	−26.32	3

PXG pseudoexfoliative glaucoma; *POAG* primary open-angle glaucoma; *NTG* normotensive glaucoma; *JG* juvenile glaucoma; *SG* secondary glaucoma; *PACG* primary angle-closure glaucoma; *dB* decibel; *MD* mean deviation; *VA* visual acuity (logMAR)

antibiotics and the inflammation regressed without further complications.

After a mean follow-up of 41.4 months (3 months–10 years), a significant reduction of IOP was achieved (from 28.4 ± 13.1 with maximal therapy preoperatively to 14.8 ± 5.0 mmHg postoperatively, $P = 0.001$, paired t test). Twenty-four eyes (70.5%) had IOP < 16 mmHg at the last examination (with or without medications). Thirteen eyes (38.2%) had optimal IOP values and did not require any additional medical therapy. Twenty-one eyes required additional medication due to unacceptable IOP levels. Of these, four eyes had still IOP ≥ 21 mmHg with medication. Three eyes with seemingly good IOP control were still

prescribed with one medication, in order to achieve very low pressures.

Five eyes were considered to have late bleb failures with flat blebs and bleb fibrosis. The rest of the eyes had functioning blebs but still required additional medication, either due to worsening of glaucoma or the clinical decision of the ophthalmologist based on optic disc examinations and perimetry.

At the last follow-up visit the mean VA was 0.89 ± 0.79 logMAR ($P = 0.699$, paired t test). Ten eyes (29.4%) showed a reduction of VA between 1 and 5 lines due to cataracts. Of these patients, one had lost 5 lines after 8 years follow-up with good control of IOP, but refused cataract surgery due to old age and good vision in the other eye. One patient with sufficient control of IOP developed cataract and lost 3 lines after 10 years follow-up, however, he was satisfied with his current vision.

The mean postoperative MD was −23.9 ± 6.7 dB at the last visit. No statistically significant differences were found between MD values before and after trabeculectomy ($P = 0.244$, paired t test).

Discussion

The goal of trabeculectomy is to preserve or enhance the patient's quality of life by preserving VF without introducing troublesome side-effects and complications. When a patient presents with advanced VF loss and high IOP despite medical therapy, it is usually foreseen that the patient will experience further loss of vision from glaucoma, unless the IOP is lowered surgically to a level below that at which the damage occurred; however, the decision to proceed with filtering surgery in such patients has been controversial. Some authors have stressed the dangers of performing trabeculectomy in patients with advanced glaucoma, while others suggested that the dangers are minimal [3–12].

Despite the development of non-penetrating glaucoma surgery, trabeculectomy is still the most favored and the golden standard surgical procedure for glaucoma [13]. Trabeculectomy has known complications that may occur in any glaucoma patient, but the 'wipe-out' phenomenon is typically described for advanced glaucoma patients. Wipe-out refers to an idiopathic, irreversible loss of central vision after surgery in glaucoma patients with advanced disease [8].

Table 3 presents the results of the various studies that evaluated the rate of wipe-out phenomenon after trabeculectomy, including our study. In these studies, the rate ranged from 0 to 7.7% [3, 4, 6, 7, 9, 10, 12]. The variability of the rate of wipe-out phenomenon among studies may have resulted from different study designs, different sample sizes and inclusion criteria. We did not experience any sudden loss of vision possibly due to a younger patient population, and perhaps due to a small study sample.

The exact mechanism of the 'wipe-out' phenomenon is unknown. It has been suggested that wipe-out may be associated with the occurrence of sudden, intraoperative ocular hypotony during glaucoma surgery. This may result in optic nerve hemorrhage and decreased perfusion pressure to an already compromised optic nerve blood supply. It may also induce a microembolic episode that could damage the remaining nerve fibers [7, 9].

Hypotony, either transient or extended, might cause loss of central vision, possibly by vascular changes in the optic nerve head. In our study, transient hypotony occurred in five (14.7%) eyes. In the study by Law et al. [4] MMC trabeculectomy resulted in 6% central vision loss with hypotony being the leading cause. Topouzis et al. [9] reported transient hypotony in three eyes and more extended hypotony in one eye, with no cases of wipe-out phenomenon after a 3 month follow-up.

Some studies have stressed the importance of older age as a risk factor for loss of VA after trabeculectomy [6]. The mean age of our patients was relatively younger (59 ± 18 years) than other published studies dealing with the results of trabeculectomy for advanced glaucoma. In our retrospective study, we could not find data about systemic comorbidities, such as systemic hypertension, atherosclerosis and cardiovascular diseases, which could be related with decreased optic nerve head perfusion.

In a major study Costa et al. [6] analyzed 440 trabeculectomies and reported that lens opacification was the main cause of VA loss followed by hypotony maculopathy; wipe out was rare and older patients with advanced VF defects were found to be at increased risk. Although our study included a relatively younger patient population, we also found that cataract was the main cause of VA loss.

Topouzis et al. [9] prospectively studied 21 patients with end-stage glaucoma followed for 3 months after

Table 3 Existing studies on the incidence of wipe-out phenomenon after glaucoma procedure

Source	No. of eyes (no. of patients)	Mean age (years)	Diagnosis	Study design	Procedures studied	% of wipe-out
Aggarwal and Hendeles [3]	26 (26)	68.5	POAG	Prospective	Trabeculectomy (26 eyes)	7.7
Langerhorst et al. [10]	50 (42)	65.4	POAG, PACG, Pig glc, PXG, ICE syndrome	Retrospective	Filtering procedure (37 eyes), cataract surgery (13 eyes)	2.0
Martinez et al. [7]	54 (44)	N/A	N/A	Retrospective	Trabeculectomy (limbus based)	0
Costa et al. [6]	508 (440) (4 cases of VA wipe-out compared with 75 controls)	N/A	N/A	Retrospective	Trabeculectomy (fluorouracil used in 24 eyes), trabeculectomy with anterior vitrectomy (3 eyes), trabeculectomy with Molteno implantation (6 eyes)	0.95
Topouzis et al. [9]	21 (21)	64.0	POAG, PACG, PXG, Uveitic glc	Prospective	Trabeculectomy with mitomycin C (19 eyes), trabeculectomy with mitomycin C and cataract operation (2 eyes)	0
Law et al. [4]	117 (117)	74.4	POAG, Non-POAG	Retrospective	Trabeculectomy with mitomycin C	0
Awai et al. [12]	49 (49)	66.5	POAG, PACG, PXG	Retrospective	Trabeculectomy with mitomycin C and postoperative suture lysis	0
Current study	34 (30)	59.3	POAG, PACG, PXG, NTG, Sec glc, Juv glc	Retrospective	Trabeculectomy (mitomycin C used in 7 eyes and 5-fluorouracil used in 24 eyes)	0

VA visual acuity; *POAG* primary open-angle glaucoma; *PACG* primary angle-closure glaucoma; *PXG* pseudoexfoliative glaucoma; *Pig glc* pigmentary glaucoma; *Sec glc* secondary glaucoma; *Juv glc* juvenile glaucoma; *N/A* not applicable

filtration surgery. Vision was preserved with no occurrences of wipe-out of the central field, which led to their conclusion that sudden unexplained loss of vision in patients with end-stage glaucoma undergoing filtrating surgery is, at most, a rare complication. In another prospective study, Aggarwal and Hendeles [3] reported central VF loss in 4 out of 26 (15.4%) patients undergoing trabeculectomy for advanced glaucoma. The reasons for loss of central vision were shallow anterior chamber and cystoid macular edema; one patient had no identifiable cause. The authors recommended that these operations be performed only on those with inadequate control of IOP and certain evidence of progression [3].

More recently Law et al. [4] reported that severe loss of vision after MMC trabeculectomy occurred in 6% of their patients with marked VF loss, specifically in those with high preoperative IOPs and intraoperative complications. The reasons for central vision loss were hypotony maculopathy, uncontrolled elevated IOPs, cataract, and inflammatory reaction, in decreasing order.

Cataract is a well-known possible consequence of trabeculectomy, associated especially with marked postoperative inflammation and flat anterior chamber [14]. The cases we present either had clear lenses or only mild lens opacities before trabeculectomy. After surgery 11 patients were followed for >60 months and 15 patients for >48 months. Ten eyes (29.4%) showed reduction of VA between 1 and 5 Snellen lines due to cataracts. Since we did not encounter any flat anterior chambers requiring intervention, cataracts did not develop in the early years, but appeared usually after 5 years.

Optimizing IOP before trabeculectomy and meticulous surgery for preventing postoperative hypotony is essential in avoidance of complications in all glaucoma patients. In patients with very high preoperative IOP values, consideration can be given to stabilize the eye to mid- to low-normal range. Performing a paracentesis tract in the temporal quadrant during surgery will be beneficial by providing slow decompression during the surgery. Planned argon laser suture lysis and releasable sutures to allow gradual reduction of IOP can also be considered [8, 12]. Postoperative flat anterior chambers should be aggressively treated by forceful dilation of the pupil and reformation with the aid of viscoelastic [8].

There are some limitations of our retrospective study such as the small sample size, varying age groups, nonstandardized surgical technique and follow-up length. Some of our patients had triangular and some had rectangular scleral flaps due to surgeon preference at the time of operation; however, to our knowledge, there is no evidence that one is superior to the other. In our study, eyes with either juvenile glaucoma, secondary glaucoma or previous filtration surgery had trabeculectomy with antimetabolites since bleb failure was possible due to strong fibrosis tendency in such eyes. We used limbus-based conjunctival flaps for our earlier patients requiring antimetabolites. Later we preferred the more convenient fornix-based conjunctival flaps in all surgeries (irrespective of antimetabolite use) since it has been shown that fornix-based flaps led to a reduction in cystic blebs and consequently less incidence of hypotony and bleb-related infections [15].

In conclusion, in our retrospective review of 34 eyes with advanced glaucoma, followed for a mean period of 41 months after trabeculectomy, vision was preserved with no cases of wipe-out. IOP was largely controllable, with cataract being the leading factor decreasing VA at late term. In view of our results, we conclude that trabeculectomy has beneficial effects in the majority of patients with advanced glaucoma.

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Conflict of interest None.

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