HAYDARPAŞA NUMUNE MEDICAL JOURNAL

DOI: 10.14744/hnhj.2022.06926
Haydarpasa Numune Med J 2023;63(4):428–437


ORIGINAL ARTICLE

# Post-Trabeculectomy Hypotony: Clinical Outcomes and Effect on Post-Operative Antiglaucoma Medication Use

**Raziye Dönmez Gün, Burcu Yelmi, Ayşegül Penbe, Aysu Arsan, Şaban Şimşek**

**Department of Ophthalmology, Istanbul Kartal Dr. Lütfi Kırdar City Hospital, Istanbul, Türkiye**

## Abstract

**Introduction:** The aim of this study was to evaluate the clinical outcomes of post-trabeculectomy hypotony and the effect of hypotony on the final number of glaucoma medications used.

**Methods:** Data pertaining to 34 patients (34 eyes) who developed hypotony after trabeculectomy were analyzed retrospectively and compared with the data of 35 patients (35 eyes) without hypotony after trabeculectomy. We compared pre-operative, intraoperative, and post-operative data between the groups and evaluated hypotony recovery time and the effects of hypotony on visual acuity, final intraocular pressure (IOP), and number of glaucoma medications used.

**Results:** The mean follow-up times were 30±18 and 29±18 months in the hypotony and control groups, respectively. There were no significant differences in pre-operative or intraoperative data between the groups ($p>0.05$). IOP values at post-operative 1 day, 1 week, 1 month, and 3 months were lower in the hypotony group compared to the control group ($p<0.05$), while 6-month and final IOP values were similar ($p>0.05$). Hypotony resolved at a mean of 4±2 (1–11) weeks. There was no difference between the groups in terms of post-operative vision loss ($p>0.05$). The number of glaucoma medications used postoperatively was lower in the hypotony group ($p=0.009$) and was significantly reduced in both groups compared to preoperatively ($p<0.001$). The decrease in the number of glaucoma medications used was higher in the hypotony group ($p<0.05$). At the last follow-up, 11.8% of patients in the hypotony group and 42.9% of the control group used glaucoma medication ($p<0.001$).

**Discussion and Conclusion:** According to our study, post-operative 6 month and final IOP levels were similar in eyes with and without post-trabeculectomy hypotony. Hypotony resolved within 1 month on average and had no significant effect on future vision loss. Patients with hypotony were less likely to need glaucoma medication postoperatively and used fewer glaucoma medications than patients without hypotony.

**Keywords:** Complication; hypotony; medication; trabeculectomy.

Glaucoma is a progressive form of optic neuropathy and can result in blindness if not treated appropriately. Although conservative therapies such as topical medication and laser trabeculoplasty may slow or stop progression, surgical treatment is required in many advanced or unresponsive patients[1]. Trabeculectomy has traditionally been regarded as the gold standard filtration surgery[2,3]. However, although trabeculectomy remains one of the most effective incisional methods for lowering intraocular pressure (IOP), it is also associated with a number of post-operative complications[1]. Among these is hypotony, or very low IOP[4,5]. One of the most common complications after trabeculectomy,[6-8] hypotony can result in loss of vision due to choroidal effusion, maculopathy, optic neu-

**Correspondence:** Raziye Dönmez Gün, M.D. Department of Ophthalmology, Istanbul Kartal Dr. Lütfi Kırdar City Hospital, Istanbul, Türkiye
**Phone:** +90 537 025 37 70 **E-mail:** rdmstf84@gmail.com
**Submitted Date:** 11.04.2022 **Revised Date:** 31.05.2022 **Accepted Date:** 02.06.2022
Haydarpaşa Numune Medical Journal

ropathy, and cataract[9]. Unfortunately, there is no standard definition of hypotony due to differences in the numerical definitions used in the literature, definitions of its onset and duration, and definitions related to whether or not it is associated with clinical symptoms[10]. The numerical definition of ocular hypotony proposed by the World Glaucoma Association is an IOP of 5 mmHg or lower measured by tonometer[11]. Low IOP may occur without abnormal signs or symptoms or may be associated with clinically apparent choroidal detachment and shallow anterior chamber. Low IOP leads to retinal and choroidal folds (hypotony maculopathy) in some eyes and both choroidal detachment and hypotony maculopathy in others[12]. Persistent hypotony may result in central vision loss[13].

Ocular surface disease is common in glaucoma patients receiving medical therapy and causes symptoms that can affect the patient's quality of life[14]. Approximately half of medically treated glaucoma patients have ocular surface disease, with severity increasing with the number of medications used[15]. The number of drugs used can be significantly reduced by performing trabeculectomy[16]. In fact, while some authors have considered being medication-free after trabeculectomy as complete success and needing medication as a partial success;[16] in one study, the initiation of medication after trabeculectomy was classified as failure[17]. Based on these points of view, we believe that we as ophthalmologists hope to enable our patients to use no glaucoma medications or as few glaucoma medications as possible after trabeculectomy.

Our aim in this study was to investigate the clinical implications of post-trabeculectomy hypotony by evaluating its relationship with patients' final IOP values, best-corrected visual acuity, and final number of glaucoma medications used. We also aimed to evaluate the resolution time of post-trabeculectomy hypotony.

## Materials and Methods

We retrospectively reviewed data pertaining to 156 eyes that underwent trabeculectomy in our clinic between January 2016 and December 2020. Of these, 34 eyes of 34 patients with IOP of 5 mmHg or lower at any post-operative examination were included in the hypotony group and 35 eyes of 35 patients randomly selected from among those who did not develop hypotony after trabeculectomy performed during the same period were included in the control group. Patients with a post-operative follow-up period of 6 months or longer were included in the study. The study was approved by the Ethics Committee of Kartal Doctor Lutfi Kırdar City Hospital (clinical trial protocol number: 2021/514/210/14) and was carried out in accordance with the principles of the Declaration of Helsinki.

Not all patients in the groups had primary trabeculectomy. In the hypotony group, two patients had previous trabeculectomy and three patients had previous XEN® gel stent implantation, while in the control group, four patients had previous trabeculectomy, and two patients had previous XEN® gel stent implantation. The patients included in the study had stage 3, 4, or 5 glaucoma according to the optical coherence tomography Glaucoma Staging System[18].

All surgical procedures were performed using same protocol by two experienced surgeons (A.K.A., Ş.Ş.). Trabeculectomy was performed using a modification of the technique developed by Cairns[19]. In all patients, trabeculectomy was performed under local anesthesia. After administering local anesthesia, a conjunctival incision was made and a limbal-based rectangular scleral flap was raised. According to the pre-operative plan, sponges soaked with mitomycin C (MMC, 0.1 mg/mL) were applied beneath the scleral flap, on the posterior surface of the conjunctiva, Tenon's capsule, and adjacent tissue for 3 min in selected patients. The area was, then, irrigated with a balanced salt solution. Anterior chamber puncture was performed after creating the scleral flap in eyes that did not receive MMC and after irrigation in eyes that received MMC. After removing a $2 \times 1$ mm trabecular block immediately anterior to the scleral spur, peripheral iridectomy was performed. The scleral flap was sutured to the scleral bed using 10/0 nylon sutures. Outflow was checked by injecting balanced salt solution into the anterior chamber through the paracentesis site. After observing the anterior chamber remained formed with a visible leak around the scleral flap at equilibrium, Tenon's capsule and the conjunctival flap were closed with continuous suturing with 7/0 and 8/0 Vicryl, respectively. Postoperatively, patients received topical prednisolone acetate 6 times a day for 1 week and then tapered over 4–6 weeks, topical ofloxacin drops 5 times a day for 2 weeks or longer if necessary, and cyclopentolate twice daily for 1–2 weeks as needed. Topical prednisolone acetate application was decreased to four times daily for patients with hypotony and flat anterior chamber. All antiglaucoma medications were discontinued after surgery.

In both the hypotony and control groups, we analyzed the patients' sex, age at time of surgery, history of diabetes mellitus or hypertension, glaucoma subtype, history of previous glaucoma surgery, and if present, the type of glau-

coma surgery, and their central corneal thickness (CCT), best-corrected visual acuity, IOP, number of antiglaucomatous agents used, and cup to disk ratio recorded at the last pre-operative visit. Pre-operative lens status (phakic, pseudophakic, and aphakic) and intraoperative use of antifibrotic agents were noted. We also recorded the patients' post-operative follow-up time (if additional glaucoma surgery other than revision was performed, follow-up period until additional surgery); IOP values at post-operative 1 week, 1 month, 3 months, 6 months, and final examination; post-operative hypotonic complications (shallow anterior chamber, anterior chamber loss, choroidal detachment, and hypotony maculopathy); post-operative cataract progression or new cataract development; post-operative vision loss (defined as decrease in two lines or more on Snellen chart); best-corrected visual acuity at final post-operative examination; number of antiglaucomatous agents used; hypotony resolution time; time until surgical revision if required; and whether the eye required additional glaucoma surgery other than revision during follow-up.

### Statistical Analysis

Descriptive statistics (mean, standard deviation, median, minimum, and maximum) were used for continuous variables (age, BCVA, IOP levels, CCT, number of glaucoma medications and decrease in number of glaucoma medications, pre-operative cup-to-disc ratio, post-operative follow-up time, time to hypotony resolution, and time to revision). Comparisons of normally distributed variables were performed using Student's t-test and non-normally distributed variables were analyzed using Mann–Whitney U-test to evaluate differences between the hypotony and control groups. Comparisons of two dependent and non-normally distributed variables were analyzed using Wilcoxon test to evaluate differences between pre- and post-operative number of glaucoma medications. Relationships between categorical variables (sex, glaucoma stages, systemic comorbidities, glaucoma subtype, history of glaucoma surgery, CCT, lens status, and intraoperative MMC use) were analyzed using Fisher's exact test. The statistical significance level was set at $p<0.05$. Analyses were performed using IBM SPSS Statistics version 24 package software.

## Results

In total, hypotony occurred in 34 (21.79%) of 156 eyes that underwent trabeculectomy. The mean age of the 34 patients in the hypotony group was 54.76±18.03 years. The mean age of the 35 patients in the control group was 58.09±15.19 years. The demographic data of the groups are shown in Table 1.

In the hypotony group, 16 patients (47.1%) had stage three glaucoma, 7 (20.6%) had stage four glaucoma, and 11 (32.4%) had stage five glaucoma. In the control group, 16 patients (45.7%) had stage three glaucoma, 7 (20%) had stage four glaucoma, and 12 (34.3%) had stage five glaucoma. There was no significant difference in glaucoma stages between the groups (p=1.000).

In both the hypotony and control group, MMC was preferred as the antifibrotic agent for eyes treated with an antifibrotic agent intraoperatively. Fourteen eyes (41.2%) in the hypotony group and 19 (54.3%) eyes in the control group received intraoperative MMC. There were no significant differences in pre-operative and intraoperative parameters between the hypotony and control groups ($p>0.05$; Table 1).

When the post-operative data were examined, we observed similar mean 6 month and final IOP values and post-operative vision levels ($p>0.05$) but lower mean IOP values in the hypotony group compared to the control group at post-operative 1 day, 1 week, 1 month, and 3 months ($p<0.05$) (Fig. 1). The number of glaucoma medications used during post-operative follow-up was significantly lower in the hypotonia group ($p<0.05$). The mean resolution time in the hypotony group was 4±2 (1–11) weeks. Hypotony was not detected in any eyes after post-operative 3-month follow-up. Three eyes (8.8%) in the hypotony group underwent surgical revision. We determined in our retrospective chart review that these eyes had no post-trabeculectomy bleb leakage and underwent revision (scleral flap resuturation). In the eyes requiring post-operative surgical revision, the mean time to revision was 5±3 (3–8) weeks. When the data of the eyes with choroidal detachment were analyzed, it was found that

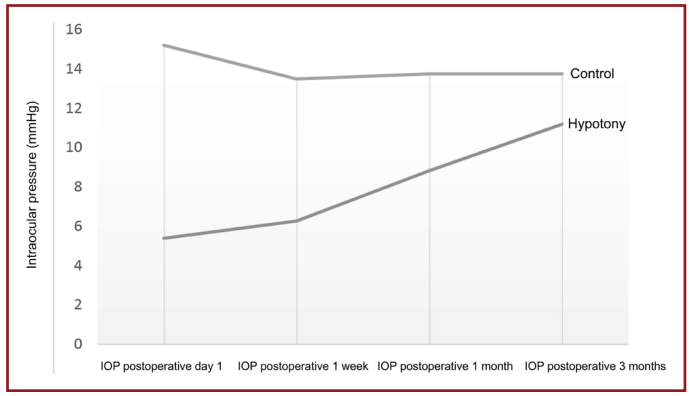


**Figure 1.** Mean post-operative intraocular pressure levels in both groups.

**Table 1.** Pre-operative and intraoperative data

| | Hypotony | | Control | | p |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Age (years) | | | | | |
| Mean±SD | 54.76±18.03 | | 58.09±15.19 | | 0.460[1] |
| Med. (Min.-Max.) | 59 (22–83) | | 61 (25–78) | | |
| Sex | | | | | |
| Female | 12 | 35.3 | 14 | 40.0 | 0.805[2] |
| Male | 22 | 64.7 | 21 | 60.0 | |
| Systemic comorbidities | | | | | |
| Hypertension | 13 | 38.2 | 8 | 22.9 | 0.527[2] |
| Diabetes | 1 | 2.9 | 2 | 5.7 | |
| Hypertension and Diabetes | 4 | 11.8 | 7 | 20.0 | |
| Glaucoma subtype | | | | | |
| Primary open-angle glaucoma | 9 | 26.5 | 18 | 51.4 | 0.271[2] |
| Pseudoexfoliation glaucoma | 11 | 32.4 | 5 | 14.3 | |
| Post-penetrating keratoplasty glaucoma | 4 | 11.8 | 1 | 2.9 | |
| Angle-closure glaucoma | 2 | 5.9 | 2 | 5.7 | |
| Glaucoma secondary to eye trauma | 1 | 2.9 | 1 | 2.9 | |
| Pigmentary glaucoma | 1 | 2.9 | 0 | 0.0 | |
| Neovascular glaucoma | 2 | 5.9 | 3 | 8.6 | |
| Steroid-induced glaucoma | 3 | 8.8 | 2 | 5.7 | |
| Uveitic glaucoma | 1 | 2.9 | 3 | 8.6 | |
| History of Glaucoma Surgery | | | | | |
| Trabeculectomy | 2 | 5.9 | 4 | 11.5 | 0.648[2] |
| XEN® gel implant | 3 | 8.8 | 2 | 5.7 | |
| BCVA (logMAR) | | | | | |
| Mean±SD | 0.7±0.5 | | 0.9±0.5 | | 0.275[1] |
| Med. (Min.-Max.) | 0.5 (0–1.5) | | 1 (0–1.5) | | |
| IOP (mmHg) | | | | | |
| Mean±SD | 35±7 | | 35±7 | | 0.634[1] |
| Med. (Min.-Max.) | 36 (23–54) | | 35 (25–50) | | |
| CCT (µm) | | | | | |
| Mean±SD | 541±38 | | 551±32 | | 0.230[3] |
| Med. (Min.-Max.) | 545 (430–610) | | 542 (475–610) | | |
| No. of glaucoma medications preoperatively | | | | | |
| Mean±SD | 4±0 | | 4±0 | | |
| Med. (Min.-Max.) | 4 (2–4) | | 4 (3–4) | | 0.363[1] |
| Lens status | | | | | |
| Phakic | 17 | 50.0 | 15 | 42.9 | 0.632[2] |
| Pseudophakic | 17 | 50.0 | 20 | 57.1 | |
| Pre-operative cup-to-disc ratio | | | | | |
| Mean±SD | 0.8±0.2 | | 1.1±1.6 | | 0.430[1] |
| Med. (Min.-Max.) | 0.9 (0.2–1) | | 0.9 (0.4–10) | | |
| Intraoperative use of mitomycin-C | 14 | 41.2 | 19 | 54.3 | 0.338[2] |

Mann–Whitney U-test[1]; Fisher's Exact test[2]; Student's t test[3]; SD: Standard deviation; Med.: Median; Min: Minimum; Max: Maximum; BCVA: Best-corrected visual acuity; IOP: Intraocular pressure; CCT: Central corneal thickness.

detachments were small and healed spontaneously without intervention. Post-operative vision loss was noted in 5 eyes (4.7%) in the hypotony group and in 1 eye (2.9%) in the control group, but this difference was not statistically significant (p>0.05). There were no significant differences in pre-operative and post-operative vision within or between the groups (p>0.05). Of the 5 eyes (14.7%) in the hypotony group with decreased vision, it was attributed to hypotony maculopathy in three patients and cataract progression in two patients. Of the eight eyes that developed hypotony maculopathy in our study, only three did not exhibit visual recovery. We determined that these eyes had received medical treatment in the follow-ups after hypotony and IOP recovered at post-operative 4 weeks in two patients and ten weeks in one patient, but vision loss occurred even though hypotony did not persist into the late post-operative period. Vision loss in the control patient was determined to be a result of cataract progression. The post-operative data of the groups are shown in Table 2.

Evaluation of number of glaucoma medications used showed that both groups used a comparable number of glaucoma medications preoperatively (p>0.05), while the hypotony group used significantly fewer medications postoperatively than the control group (p=0.009). Comparisons of pre-operative and post-operative glaucoma medication use revealed a significant reduction in the number of glaucoma medications used in both groups (p<0.001) (Fig. 2). The mean reduction in number of glaucoma medications postoperatively compared to preoperatively was 3.47±1.2

**Table 2.** Post-operative data

| | Hypotony | | Control | | |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Hypotony-related complications | | | | | |
| Anterior chamber loss + Hypotony maculopathy | 1 | 2.9 | - | | |
| Flat anterior chamber | 2 | 5.9 | - | | |
| Flat anterior chamber + Hypotony maculopathy | 1 | 2.9 | - | | |
| Flat anterior chamber + Choroidal detachment | 1 | 2.9 | - | | |
| Choroidal detachment | 3 | 8.8 | - | | |
| Choroidal detachment + Hypotony maculopathy | 1 | 2.9 | - | | |
| Hypotony maculopathy | 5 | 14.7 | - | | |
| Cataract progression | 2 | 5.9 | 1 | 2.9 | |
| Cause of post-operative vision loss | | | | | |
| Hypotony maculopathy | 3 | 8.8 | 0 | 0.0 | |
| Cataract progression | 2 | 5.9 | 1 | 2.9 | |
| Revision for hypotony | 3 | 8.8 | - | | |
| Need for additional glaucoma surgery | | | | | |
| Trabeculectomy | 2 | 5.9 | 1 | 2.9 | |
| Ahmed's glaucoma valve implantation | 1 | 2.9 | | | |
| | **Mean±SD Med. (Min.-Max.)** | | **Mean±SD Med. (Min.-Max.)** | | **p** |
| Post-operative follow-up time (month) | 30±18 28 (6–66) | | 29±18 29 (6–65) | | 0.791[1] |
| IOP post-operative day 1 (mmHg) | 5±3 5 (2–19) | | 15±3 15 (10–21) | | <0.001[1] |
| IOP post-operative 1 week (mmHg) | 6±4 5 (2–26) | | 13±5 12 (7–26) | | <0.001[1] |
| IOP post-operative 1 month (mmHg) | 9±6 7 (4–35) | | 14±5 13 (7–28) | | <0.001[1] |
| IOP post-operative 3 months (mmHg) | 11±4 11 (6–27) | | 14±5 13 (8–26) | | 0.011[1] |
| IOP post-operative 6 months (mmHg) | 12±4 11 (7–23) | | 13±4 12 (7–23) | | 0.672[1] |
| Final IOP (mmHg) | 13±4 12 (7–24) | | 13±5 13 (6–34) | | 0.704[1] |
| Post-operative BCVA (logMAR) | 0.7±0.5 0.5 (0–1.5) | | 0.8±0.5 0.7 (0–1.5) | | 0.480[1] |
| No. of glaucoma medications at the last post-operative followup | 0.38±1.1 0 (0–4) | | 1±1.4 0 (0–4) | | 0.009[1] |

Mann–Whitney U-test[1]; SD: Standard deviation; Med.: Median; Min: Minimum; Max: Maximum; IOP: Intraocular pressure; BCVA: Best-corrected visual acuity.

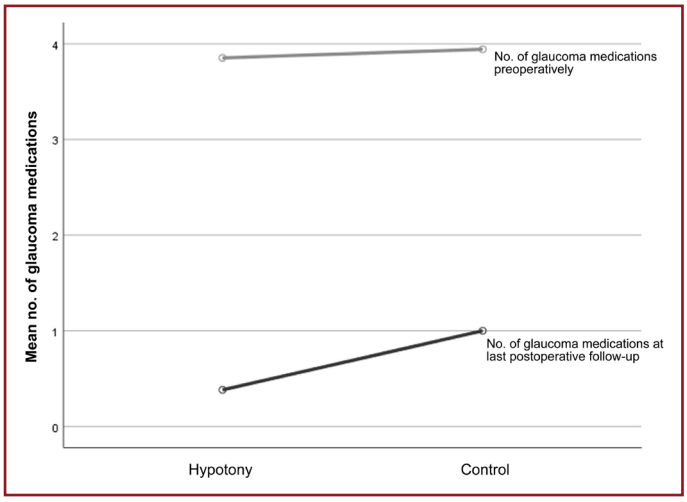


**Figure 2.** Glaucoma medication use in both groups.

in the hypotony group and 2.94±1.37 in the control group (p<0.05). The proportion of patients using a topical antiglaucomatous medication at the final follow-up visit was 11.8% in the hypotony group and 42.9% in the control group, indicating significantly less need to initiate glaucoma medication during follow-up in the hypotony group (p<0.001; Table 3).

During follow-up, 2 patients (5.9%) in the hypotony group required trabeculectomy, and 1 (2.9%) required Ahmed glaucoma valve (AGV) implantation, while 1 patient (2.9%) in the control group required trabeculectomy. We retrospectively reviewed the records of patients who needed additional glaucoma surgery. One patient in the hypotony group who underwent retrabeculectomy surgery was 61 years old, had pseudoexfoliative glaucoma (Stage 5), underwent primary trabeculectomy without MMC, had a post-operative final IOP of 21 mmHg, CCT of 488 µm, cup-to-disk ratio of 0.8, and used a total of four glaucoma medications at final follow-up after trabeculectomy surgery. The patient's retrabeculectomy was performed using MMC. The second patient in the hypotony group who needed retrabeculectomy was 31 years old, had steroid-induced glaucoma (Stage 5), underwent trabeculectomy with MMC, had a post-operative final IOP of 21 mmHg, CCT of 470 µm, cup-to-disk ratio of 0.8, and also used four glaucoma medications at final post-trabeculectomy follow-up. The hypotony patient who underwent AGV implantation was 62 years old, had XEN® gel stent implantation before trabeculectomy surgery, had pseudoexfoliative glaucoma (Stage 5), underwent trabeculectomy without MMC, had a post-operative final IOP of 24 mmHg, CCT of 550 µm, cup-to-disk ratio of 0.9, used two glaucoma medications at last follow-up after trabeculectomy, and had an additional ocular surface problem. The patient in the control group who required retrabeculectomy was a 74-year-old man with primary open-angle glaucoma (Stage 5), underwent trabeculectomy with MMC, had a post-operative final IOP of 34 mmHg, CCT of 530 µm, cup-to-disk ratio of 1.0, and used four glaucoma medications at last follow-up after trabeculectomy.

## Discussion

The results of our study showed, as expected, that patients with hypotony had lower IOP values than patients without hypotony between post-operative 1 day and 3 months. Some noteworthy findings from this study were that patients in the hypotony group were less likely to start using glaucoma medication postoperatively, used fewer glaucoma medications at final post-operative examination and had a greater decrease in the number of glaucoma medications used when compared with the control group. We determined that hypotony resolved in 4 weeks on average, and there was no significant difference between the groups in terms of post-operative vision loss.

**Table 3.** Pre-operative and post-operative number of glaucoma medications

| | Hypotony Mean±SD Med. (Min.-Max.) | | Control Mean±SD Med. (Min.-Max.) | | p |
|---|---|---|---|---|---|
| No. of glaucoma medications preoperatively | 4±0 4 (2–4) | | 4±0 4 (3–4) | | 0.363[1] |
| No. of glaucoma medications at last post-operative follow-up | 0.38±1.1 0 (0–4) | | 1±1.4 0 (0–4) | | 0.009[1] |
| p | <0.001[2] | | <0.001[2] | | |
| Decrease in number of glaucoma medications | 3.47±1.2 4 (0–4) | | 2.94±1.37 4 (0–4) | | 0.028[1] |
| | **n** | **%** | **n** | **%** | **p** |
| Patients using medication at the last post-operative follow-up | 4 | 11.8 | 15 | 42.9 | <0.001[3] |

Mann–Whitney U-test test[1]; Wilcoxon test[2]; Fisher's Exact test[3]; SD: Standard deviation; Med.: Median; Min: Minimum; Max: Maximum.

Post-trabeculectomy hypotony has been reported at rates ranging from 1.6% to 12.4% in various clinical studies[20-22]. In observational studies, this rate varies between 7.2% and 42.2%[23-26]. Edmunds et al.[27] reported the prevalence of post-trabeculectomy hypotony as 24.3% in their study of 1240 patients. This rate was 21.79% in our study. However, considering the different definitions of hypotony used in various studies, as noted by Abbas et al.,[10] the prevalence of hypotony in our study is within the range reported in observational studies and is similar to the results of Edmunds et al.[27] The hypotony group in our study included eyes with IOP of 5 mmHg or lower in any post-operative examination, consistent with the statistical definition of hypotony recommended by the World Glaucoma Association[11].

In a study by Tunç et al.[17] including 52 patients who developed hypotony after trabeculectomy, the mean IOP was 3.82 mmHg on post-operative day 1, 10.3±1.78 mmHg at 1 month, 13.57±1.69 mmHg at 3 months, and 15.32±2.96 mmHg at 6 months. In our study, mean IOP values in the hypotony group at post-operative 1 day, 1 week, 1 month, 3 months, 6 months, and the last follow-up were found to be 5±3 mmHg, 6±4 mmHg, 9±6 mmHg, 11±4 mmHg, 12±4 mmHg, and 13±4 mmHg, respectively. The post-operative IOP values observed in our study are fairly similar to those in the study by Tunç et al.[17] As is known, hypotony refers to a very low IOP[9]. As expected, IOP values were significantly lower in the hypotony group than the control group in the first 3 months postoperatively. As the average hypotony resolution time in our study was approximately 1 month, the low mean IOP after post-operative 1 month is likely due to the presence of some patients who still had low IOP at post-operative 3 months, and the absence hypotony in any eyes after post-operative 3 months resulted in no significant difference in IOP between the groups later in follow-up (post-operative 6 months, final examination).

In their study of long-term outcomes and risk factors in patients with low IOP after trabeculectomy, Tseng et al.[28] compared patients with and without post-trabeculectomy hypotony and reported similar reoperation, vision loss, and surgical failure rates. They attributed vision loss primarily to hypotony maculopathy in patients with ocular hypotony and to advanced glaucoma in those without hypotony[28]. In our study, there was no significant difference between the hypotony and control groups in terms of post-operative vision loss.

Numerous studies have shown that hypotony can cause vision loss[17,29,30]. Tunç et al.[17] detected hypotony maculopathy in 6 (11.5%) of 52 eyes that developed hypotony and reported reduced visual acuity in half (three eyes) of the eyes with hypotony maculopathy[17]. Lee et al.[31] observed no significant difference between mean pre-operative and final visual acuity levels in their study but noted that visual acuity did not return to pre-operative level in three eyes (two patients, 16.7%). Five eyes (14.7%) in our hypotony group had decreased vision postoperatively and the cause was determined to be hypotony maculopathy in three patients and cataract progression in two patients. Of the eight eyes that developed hypotony maculopathy in our study, only three did not exhibit visual recovery. These eyes had received medical treatment after developing hypotony and IOP recovered at post-operative 4 weeks in two patients and 10 weeks in one patient. This demonstrates that maculopathy can occur even with hypotony of short duration, suggesting that more aggressive management may be necessary in eyes with maculopathy. In our study, there were more patients with post-operative vision loss in the hypotony group than the control group (five eyes vs. one eye), but the difference was not statistically significant.

Several studies have reported that transient hypotony after trabeculectomy occurs more frequently, with an incidence between 5% and 87% in the first 1–2 weeks postoperatively[4,32-34]. Seah et al.[35] also reported that hypotony was common after trabeculectomy, but resolved within 2 weeks. Alagöz et al.[36] reported that low IOP resolved within the first month in eyes with early hypotony after trabeculectomy. Of 35 hypotonic eyes, they detected prolonged hypotony at post-operative 1 month in 8 eyes (22.8%), at post-operative 3 months in 4 eyes (11.4%), and at post-operative 6 months in 1 eye (2.9%)[36]. In our study, similar to the results of Alagöz et al., the mean hypotony resolution time was found to be 4 weeks.

Gedde et al.[16] reported that the mean IOP level in their trabeculectomy group was 25.6±5.3 mmHg preoperatively and decreased to 13.5±6.9 mmHg at 3-year follow-up, while the number of medications decreased from 3±1.2 preoperatively to 1.0±1.5 at 3-year follow-up. In our study, the mean pre-operative IOP was 35±7 mmHg in both groups, and the mean number of glaucoma medications decreased from four in both groups preoperatively to 0.38±1.1 in the hypotony group and 1±1.4 in the control group at the end of follow-up (mean 30±18 months in the hypotony group, 29±18 months in the control group). According to the study by Gedde et al.[16], the higher pre-operative IOP levels in our patients may have resulted in the higher number of pre-operative medications. Gedde et al.[16] included all eyes that underwent trabeculectomy in their study, while

we included eyes with low IOP in the hypotony group and eyes without low post-operative IOP in the control group. This may have contributed to the lower number of post-operative glaucoma medications in the hypotony group in particular. Tunç et al.[17] reported in their study that 25% of patients who developed hypotony after trabeculectomy surgery needed to start antiglaucoma medication during follow-up. In their study including 33 patients who developed hypotony maculopathy after trabeculectomy, Bitrian et al.[37] reported that at final follow-up, 52% of the patients did not require topical treatment, while 27% of the patients required two or more topical glaucoma medications for adequate IOP control. In our study, the rate of post-operative drug use at final follow-up was lower in the hypotony group compared to the control group (11.8% vs. 42.9%). The number of glaucoma medications used at final post-operative follow-up was also lower in the hypotony group (0.38±1.1 vs. 1±1.4) and the reduction from pre-operative number of glaucoma medications used was higher in the hypotony group (3.47±1.2 vs. 2.94±1.37). Based on the studies by Tunç et al.[17] and Bitrian et al.[37], the proportion of patients who used glaucoma medication postoperatively was lower in our patients who developed hypotony. There are several studies indicating that MMC is a risk factor for post-trabeculectomy hypotony[38,39]. In addition, some studies have shown that higher dose and duration of intraoperative MMC is associated with increased frequency of hypotony maculopathy[37]. Tunç et al.[17] included patients in whom antifibrotic agents were not used in their study, while we determined that MMC was used in 41.2% of the patients in our study. In addition, Tunç et al.[17] followed their patients until post-operative 6 months and reported the mean IOP at the last follow-up to be 15.32±2.96 mmHg. In our study, the mean IOP at post-operative 6 months was 12±4 mmHg. This may explain why the patients in our study used fewer glaucoma medications later. On the other hand, all of the patients in the study by Bitrian et al.[37] received MMC, developed post-operative hypotony maculopathy, and underwent primary bleb revision. The mean IOP at the last follow-up reported in their study was from 1-year examination[37]. In our study, only three patients underwent bleb revision. Surgical revision in the patients in the study by Bitrian et al.[37] may have resulted in higher mean IOP levels later and the subsequent need to use post-operative drugs in more patients. However, our follow-up period was longer than that of Bitrian et al.[37] and so IOP data were not given for every year, only at the last follow-up. Therefore, we cannot compare the mean IOP levels at post-operative year 1 between the studies.

IOP may be low or high depending on whether CCT is increased or decreased[40]. Corneal thinning is an important risk factor for glaucoma development[41]. The results of a meta-analysis indicated that CCT in normal eyes was 534 µm[40]. Both of the patients in the hypotony group who required retrabeculectomy surgery had Stage 5 glaucoma and low CCT values, and the presence of central corneal thinning, advanced optic nerve head damage, and post-trabeculectomy IOP of 21 mmHg despite using four glaucoma medications contributed to the decision to perform retrabeculectomy. It has been shown that MMC-augmented trabeculectomy can significantly reduce IOP in the short and medium term, with a favorable safety profile[42]. We think the fact that MMC was not used during primary trabeculectomy may have contributed to the need for a second surgery in the pseudoexfoliative glaucoma patient in the hypotony group who underwent retrabeculectomy. The patient's retrabeculectomy was performed using MMC. Re-operation was shown to be associated with surgical complications in patients undergoing trabeculectomy[43]. Similarly, for the patient in the hypotony group who later underwent AGV implantation, we believe performing trabeculectomy without MMC and the patient's previous glaucoma surgery (XEN® gel stent implantation) may also have been factors in the trabeculectomy failing and the patient undergoing AGV implantation. We think the patient's ocular surface disorder also led to the indication for AGV implantation instead of initiating additional glaucoma medication. The patient in the control group who underwent retrabeculectomy needed reoperation due to high IOP (34 mmHg) despite using four glaucoma medications.

Our study has several limitations. First, the study was retrospective and data were collected by reviewing the patient's examination records. In addition, as a single-center study, the patient sample was small. However, the inclusion of a control group is a strength of our study. It will be beneficial to conduct new studies with more patients and longer follow-up.

In conclusion, although post-trabeculectomy hypotony is regarded as a complication, it may have a positive side in terms of reducing the need to start antiglaucoma drugs or the number of drugs used. This may reduce our fear of hypotony as clinicians, provided that necessary precautions are taken against potential vision loss.

**Ethics Committee Approval:** The study was approved by the Ethics Committee of Kartal Doctor Lutfi Kırdar City Hospital (clinical trial protocol number: 2021/514/210/14) and was carried out in accordance with the principles of the Declaration of Helsinki.

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: R.D.G.; Design: R.D.G.; Supervision: R.D.G., A.A., Ş.Ş.; Data Collection or Processing: R.D.G., B.Y., A.P.; Analysis or Interpretation: R.D.G., A.A., Ş.Ş.; Literature Search: R.D.G.; Writing: R.D.G.; Critical Review: R.D.G., A.A., Ş.Ş.

**Conflict of Interest:** None declared.

**Financial Disclosure:** The authors declared that this study received no financial support.

## References

1. Koike KJ, Chang PT. Trabeculectomy: A brief history and review of current trends. Int Ophthalmol Clin 2018;58:117–33.
2. Razeghinejad MR, Spaeth GL. A history of the surgical management of glaucoma. Optom Vis Sci 2011;88:e39–47.
3. Sawchyn AK, Slabaugh MA. Innovations and adaptations in trabeculectomy. Curr Opin Ophthalmol 2016;27:158–63.
4. Watson PG, Jakeman C, Ozturk M, Barnett MF, Barnett F, Khaw KT. The complications of trabeculectomy: A 20-year follow-up. Eye Lond 1990;4:425–38.
5. Murdoch I. Post-operative management of trabeculectomy in the first three months. CEHJ 2012;25:73–5.
6. Agarwal HC, Anuradha VK, Titiyal JS, Gupta V. Effect of intraoperative intracameral 2% hydroxypropyl methylcellulose viscoelastic during trabeculectomy. Ophthalmic Surg Lasers Imaging 2005;36:280–5.
7. Aykan U, Bilge AH, Akin T, Certel I, Bayer A. Laser suture lysis or releasable sutures after trabeculectomy. J Glaucoma 2007;16:240–5.
8. Hornová J, Nováková D. Immediate and late intraocular pressure levels after trabeculectomy with releasable sutures. Cesk Slov Oftalmol 2001;57:403–7.
9. Stein JD, McCoy AN, Asrani S, Herndon LW, Lee PP, McKinnon SJ, et al. Surgical management of hypotony owing to overfiltration in eyes receiving glaucoma drainage devices. J Glaucoma 2009;18:638–41.
10. Abbas A, Agrawal P, King AJ. Exploring literature-based definitions of hypotony following glaucoma filtration surgery and the impact on clinical outcomes. Acta Ophthalmol 2018;96:e285–9.
11. Jampel HD. Reporting post-operative complications in glaucoma surgical trials. In: Shaarawy TMS, Sherwood MB, Grehn F, editors. Guidelines on Design and Reporting of Glaucoma Surgical Trials. Amsterdam, Netherlands: Kugler Publications; 2009. p.33e9.
12. Gass J. Hypotony maculopathy. In: Bellows J, editor. Contemporary Ophthalmology Honoring Sir Stewart Duke-Elder. 1st ed. Baltimore: Lippincott Williams & Wilkins; 1972. p343.
13. Harrington DL. The visual fields. St Louis: Mosby; 1971. p.199.
14. Stewart WC, Stewart JA, Nelson LA. Ocular surface disease in patients with ocular hypertension and glaucoma. Curr Eye Res 2011;36:391–8.
15. Fechtner RD, Godfrey DG, Budenz D, Stewart JA, Stewart WC, Jasek MC. Prevalence of ocular surface complaints in patients with glaucoma using topical intraocular pressure-lowering medications. Cornea 2010;29:618–21.
16. Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL; Tube versus Trabeculectomy Study Group. Treatment outcomes in the Tube Versus Trabeculectomy (TVT) study after five years of follow-up. Am J Ophthalmol 2012;153:789–803.
17. Tunç Y, Tetikoglu M, Kara N, Sagdık HM, Özarpaci S, Elçioğlu MN. Management of hypotony and flat anterior chamber associated with glaucoma filtration surgery. Int J Ophthalmol 2015;8:950–3.
18. Brusini P. OCT Glaucoma Staging System: A new method for retinal nerve fiber layer damage classification using spectral-domain OCT. Eye Lond 2018;32:113–9.
19. Cairns JE. Trabeculectomy. Preliminary report of a new method. Am J Ophthalmol 1968;66:673–9.
20. Gedde SJ, Schiffman JC, Feuer WJ, Parrish RK 2nd, Heuer DK, Brandt JD; Tube Versus Trabeculectomy Study Group. The tube versus trabeculectomy study: Design and baseline characteristics of study patients. Am J Ophthalmol 2005;140:275–87.
21. Wilson MR, Mendis U, Smith SD, Paliwal A. Ahmed glaucoma valve implant vs trabeculectomy in the surgical treatment of glaucoma: A randomized clinical trial. Am J Ophthalmol 2000;130:267–73.
22. Wilson MR, Mendis U, Paliwal A, Haynatzka V. Long-term follow-up of primary glaucoma surgery with Ahmed glaucoma valve implant versus trabeculectomy. Am J Ophthalmol 2003;136:464–70.
23. Bindlish R, Condon GP, Schlosser JD, D'Antonio J, Lauer KB, Lehrer R. Efficacy and safety of mitomycin-C in primary trabeculectomy: Five-year follow-up. Ophthalmology 2002;109:1336–41.
24. Kirwan JF, Lockwood AJ, Shah P, Macleod A, Broadway DC, King AJ, et al; Trabeculectomy Outcomes Group Audit Study Group. Trabeculectomy in the 21st century: A multicenter analysis. Ophthalmology 2013;120:2532–9.
25. Schultz SK, Iverson SM, Shi W, Greenfield DS. Safety and efficacy of achieving single-digit intraocular pressure targets with filtration surgery in eyes with progressive normal-tension glaucoma. J Glaucoma 2016;25:217–22.
26. Saeedi OJ, Jefferys JL, Solus JF, Jampel HD, Quigley HA. Risk factors for adverse consequences of low intraocular pressure after trabeculectomy. J Glaucoma 2014;23:e60–8.
27. Edmunds B, Thompson JR, Salmon JF, Wormald RP. The national survey of trabeculectomy III. Early and late complications. Eye Lond 2002;16:297–303.
28. Tseng VL, Kim CH, Romero PT, Yu F, Robertson-Brown KW, Phung L, et al. Risk factors and long-term outcomes in patients with low intraocular pressure after trabeculectomy. Ophthalmology 2017;124:1457–65.
29. de Barros DS, Navarro JB, Mantravadi AV, Siam GA, Gheith ME, Tittler EH, et al. The early flat anterior chamber after trabeculectomy: A randomized, prospective study of 3 methods of management. J Glaucoma 2009;18:13–20.

30. Law SK, Nguyen AM, Coleman AL, Caprioli J. Severe loss of central vision in patients with advanced glaucoma undergoing trabeculectomy. Arch Ophthalmol 2007;125:1044–50.
31. Lee K, Hyung S. Effect of excision of avascular bleb and advancement of adjacent conjunctiva for treatment of hypotony. Korean J Ophthalmol 2009;23:281–5.
32. Ridgway AE. Trabeculectomy. A follow-up study. Br J Ophthalmol 1974;58:680–6.
33. Migdal C, Hitchings R. Morbidity following prolonged postoperative hypotony after trabeculectomy. Ophthalmic Surg 1988;19:865–7.
34. Stewart WC, Shields MB, Miller KN, Blasini M, Sutherland SE. Early postoperative prognostic indicators following trabeculectomy. Ophthalmic Surg 1991;22:23–6.
35. Seah SK, Prata JA Jr, Minckler DS, Baerveldt G, Lee PP, Heuer DK. Hypotony following trabeculectomy. J Glaucoma 1995;4:73–9.
36. Alagöz N, Taskoparan S, Altan AC, Solmaz B, Basgil Pasaoglu I, Basarır B, et al. Pressure restoration and visual recovery time in hypotony after trabeculectomy. Int Ophthalmol 2021;41:3183–90.
37. Bitrian E, Song BJ, Caprioli J. Bleb revision for resolution of hypotony maculopathy following primary trabeculectomy. Am J Ophthalmol 2014;158:597–604.
38. Shah P, Agrawal P, Khaw PT, Shafi F, Sii F. ReGAE 7: Long-term outcomes of augmented trabeculectomy with mitomycin C in African Caribbean patients. Clin Exp Ophthalmol 2012;40:e176–82.
39. Zacharia PT, Deppermann SR, Schuman JS. Ocular hypotony after trabeculectomy with mitomycin C. Am J Ophthalmol 1993;116:314–26.
40. Doughty MJ, Zaman ML. Human corneal thickness and its impact on intraocular pressure measures: A review and meta-analysis approach. Surv Ophthalmol 2000;44:367–408.
41. Gordon MO, Beiser JA, Brandt JD, Heuer DK, Higginbotham EJ, Johnson CA, et al. The ocular hypertension treatment study: Baseline factors that predict the onset of primary open-angle glaucoma. Arch Ophthalmol 2002;120:714–20.
42. Lusthaus JA, Kubay O, Karim R, Wechsler D, Booth F. Primary trabeculectomy with mitomycin C: Safety and efficacy at 2 years. Clin Exp Ophthalmol 2010;38:831–8.
43. Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL; Tube Versus Trabeculectomy Study Group. Three-year follow-up of the tube versus trabeculectomy study. Am J Ophthalmol 2009;148:670–84.