

## Revision of trabeculectomy filtering blebs with mitomycin C: Long term results

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**Aim:** The aim of the study is to assess the outcomes of transconjunctival mitomycin C (MMC)-augmented revision in eyes with failed trabeculectomy. **Materials and Methods:** This is a retrospective, noncomparative case series. One hundred and twenty-one eyes of 113 consecutive glaucoma patients with previously failed trabeculectomy who underwent transconjunctival revision with at least 12 months of follow-up were initially included in the study. The success was determined on the basis of intraocular pressure (IOP) alone. The main outcome measures were IOP, best-corrected distance visual acuity, complications, bleb appearance, lens status, visual field progression, and time between primary trabeculectomy and MMC revision. The main purpose of the study was to determine the efficacy of a single MMC-augmented needle revision. **Results:** Mean follow-up was 2.3 years. Twelve months after revision, IOP had declined from  $26.1 \pm 8.4$  mmHg to  $14.1 \pm 4.8$  mmHg ( $P < 0.05$ ) and remained  $16.0 \pm 5.6$  mmHg at 24 months,  $15.7 \pm 5.8$  mmHg at 48 months, and  $15.2 \pm 4.0$  mmHg at 60 months. Complete success was achieved in 53% of cases, 84% achieved qualified success, and 16% were classified as failures 12 months after revision. Early complications developed in 45 of the initial 121 eyes (37.2%). **Conclusions:** Transconjunctival MMC-augmented revision appears to be a safe and useful tool in reducing IOP and re-establishing filtration after trabeculectomy failure. This simple procedure has a high rate of success and helps avoid other surgical interventions which are more destructive for the conjunctiva.

**Key words:** Filtering bleb, mitomycin C, trabeculectomy, transconjunctival revision

Trabeculectomy is a standard surgical procedure for glaucoma patients whose elevated intraocular pressure (IOP) fails to respond adequately to drug therapy. Filtration failure is regarded as the most frequent complication of trabeculectomy, which arises with time during the healing process. Filtering bleb failure or scarring of the bleb site is due to fibrosis involving the episclera, Tenon's capsule, and subconjunctival tissue. Among the clinical signs of scarring are increased IOP and bleb vascularization.<sup>[1]</sup>

The challenge is, therefore, to maintain the function of the filtering bleb and patency of the filtration channel. The patient may need further medical treatment, including digital massage, removal of releasable sutures, laser suture lysis, repeated filtration surgery, revision of the filtering site, or emplacement of a glaucoma drainage implant. Although a second trabeculectomy procedure may be necessary, its outcome may be similar to that of the first, with further conjunctival destruction. The second procedure is generally more time-consuming and is prone to cause intraoperative bleeding. The subsequent failure rate increases with each attempt due to more dramatic inflammation, scarring, and associated complications.<sup>[2]</sup>

To improve the success rate of filtration surgery and to reduce scarring, steroids, bevacizumab (Avastin),<sup>[3]</sup> and antifibrotic agents such as mitomycin C (MMC)<sup>[4]</sup> or 5-fluorouracil<sup>[5]</sup> may

be administered. MMC applied transconjunctivally may also enhance the success of the procedure when the filtering bleb is found to be failing.<sup>[4]</sup> Risk factors of filtering procedures are uveitis, secondary (i.e., neovascular) glaucoma, chronic exposure to topical antiglaucoma medication, young age, Afroamerican race, a fornix-based conjunctival flap, or previous surgery involving conjunctival incision.<sup>[5]</sup>

Another method for improving the function of fibrosed filtering blebs is revision with an adjunctive antimetabolite performed to restore the filtering bleb and filtration channel created during a primary filtering procedure. In general, revision procedures after trabeculectomy face two problems: Increased IOP due to filtration failure and/or hypotony due to hyperfiltration or wound leakage.<sup>[6,7]</sup> Transconjunctival revision opposite to surgical revision does not need formal redissection of the conjunctiva over the bleb area, excision of fibrotic tissues, freshening the edges of the redissected scleral flap, and resuturing. Significant incidence of severe complications associated with surgical revision such as suprachoroidal hemorrhage, choroidal detachment, bleb leaks, late hypotony and blebitis, or cataract formation is less common in transconjunctival revision.<sup>[8]</sup>

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## Materials and Methods

We reviewed retrospectively 121 eyes of 113 consecutive Caucasian glaucoma patients - 69 women (73 eyes) and 44 men (48 eyes) (mean age:  $68.0 \pm 12.1$  years) who underwent MMC-augmented revision. Mean follow-up was 2.3 years (range: 1–5 years). The criteria for inclusion in the study were primary open-angle glaucoma, a history of primary trabeculectomy with adjunctive MMC, failure to reach the desired IOP with maximum tolerated drug therapy after trabeculectomy, and closed sclerostomy confirmed at the gonioscopic examination. Criteria for exclusion were other types of glaucoma, previous ocular surgery with the involvement of conjunctiva, and repeated revision procedures [Table 1].

The final study group comprised 100 patients who had undergone a single revision after a primary trabeculectomy and had not undergone any other ocular surgery during the observation period. Eyes with more than one revisions (21 cases: 18 eyes with 2 revisions, 3 eyes with 3 revisions) were treated as a failure and included in the statistic concerning complications. Sixty-two of these 100 eyes were phakic and 38 were pseudophakic.

All patients underwent a complete preoperative ophthalmic examination, including best-corrected distance visual acuity (BCDVA), applanation tonometry, slit-lamp examination, ophthalmoscopy, gonioscopy, and visual field examination (Humphrey Perimeter, SITA Standard 30-2 program). The primary indicators used to measure outcomes were IOP, BCDVA, the number of antiglaucoma medications used, complications, bleb appearance, lens status, the time between trabeculectomy and the first MMC revision, and the number of MMC revisions.

### Transconjunctival revision augmented with mitomycin C – surgical technique

Topical anesthesia (Proxymetacaine Hydrochloride, Alcaine®; Alcon, TX, USA) was applied to the eye three times, with 1 min between each drop. Levofloxacin eye drops (Oftaquix®; Santen) and one drop of povidone-iodine 5% solution (Betadine; Alcon, TX, USA) were then applied to the conjunctival surface. An aseptic technique was used. The procedure was performed as a clinical procedure in the operating room. Local anesthesia was also achieved with a 1 ml subconjunctival injection of nonpreserved 1% lidocaine before needling, raising a subconjunctival bleb, and the anterior chamber was

irrigated with 0.1 ml of nonpreserved 1% lidocaine through paracentesis. Then, the subconjunctival space was accessed with a 27-gauge disposable needle attached to 1.0-ml syringe inserted superior 5–10 mm distal to the bleb and then guided beneath the conjunctiva toward the failed filtration bleb site and beneath the scleral flap through the dense scar tissue, where sweeping motions and/or to-and-fro movements were repeated three to five times. The 27-gauge needle was bent at the hub manually by the surgeon using an additional pair of tweezers to get comfortable angle of entry. The cutting edges of the needle tip were used for dissection of subconjunctival fibrosis, and the scleral flap was lifted until free movement without resistance was attained. If necessary, the needle was moved forward and backward until local elevation of the conjunctiva was observed due to increased filtration and egress of aqueous humor. Then, the needle tip was inserted underneath or through the scleral flap to the level of the sclerostomy (scleral flap edge visibility was not necessary) and to the anterior chamber. After this maneuver, IOP remained low. The filtration bleb should form around the needle tract during needling and after checking the filtration through paracentesis. At the end of the operation, after the needling, subconjunctival injection of 0.1 ml of 0.3 mg/ml (0.03 mg) was performed, with the same or another 27-gauge needle through a separate injection site superior to the bleb, approximately 10 mm from the scleral fistula and away from the sclerostomy site to avoid inadvertent intracameral administration of MMC (MMC was available in a 5 ml vial [2 mg/ml]). It was further resolved with normal saline to make 0.3 mg/ml solution (6 ml of normal saline was added to 2 mg of MMC; and 1 ml of such prepared solution was diluted with 1 ml of natural to make 0.3 mg/ml solution of MMC). There were no further MMC injections given in the postoperative period.<sup>[9-11]</sup> After the procedure, the eyes were examined for aqueous leak through the needle injection hole. The conjunctival hole wound was closed with a brief tamponade with a cotton applicator.<sup>[10]</sup> We do not need to apply cautery after the procedure. At the conclusion of the procedure, one drop each of levofloxacin (Oftaquix®; Santen) and povidone-iodine 5% solution (Betadine; Alcon, TX, USA) were instilled in the eyes and the eyes were patched [Tables 2 and 3].

All patients were placed on a combination of steroid and antibiotic eye drops (tobramycin 3 mg/1 ml and dexamethasone 1 mg/1 ml, Tobradex®; Alcon), four times a day. This was continued during the follow-up period and tapered as clinically indicated, usually over the course of 6–8 weeks. There were no cycloplegics given after standard revision procedure. Follow-up visits were scheduled for postoperative day 1, week 1, the 1<sup>st</sup> month, at 3 months, at 6 months, and 12 months after MMC revision. Subsequent visits were scheduled once a year or more frequently as needed. At each follow-up visit, BCDVA testing, IOP measurement with Goldmann applanation tonometry, and routine anterior and posterior segment examinations were carried out to assess and document the appearance of the bleb and the surrounding conjunctival tissue, lens status, and the morphology of the optic nerve head.

The success was determined on the basis of IOP and need for further surgery. A complete success was defined as an IOP  $\leq 18$  mmHg and  $> 5$  mmHg without any antiglaucoma medication or further surgery. Eyes gained qualified success as an IOP  $\leq 18$  mmHg and  $> 5$  mmHg with or without a hypotensive medication and without further surgery. Failure

**Table 1: Description of the study population**

Transconjunctival MMC revision	Total number/ percentage of the eyes
Number of eyes with 1/2/3 revisions	100/18/3
Number of eyes with primary open-angle glaucoma	121
Gender (%)	
Women	57
Men	43
Mean age (years)	
Women	68.2±15.4
Men	66.3±11.3

MMC: Mitomycin C

**Table 2: Success rate after revision**

Time after revision (months)	Total number of patients (eyes)	Number of patients' eyes/success (%)	Number of patients' eyes/qualified success (%)	Number of patients' eyes/failure (%)
12	100	53 (53)	84 (84)	16 (16)
24	46	9 (41.3)	34 (73.9)	12 (26.1)
36	33	9 (27.3)	21 (63.6)	7 (21.2)
48	25	8 (32)	18 (72)	4 (16)
60	14	6 (42.9)	10 (71.4)	3 (21.4)

**Table 3: Results of the patient data subdivided into early and late revision**

	IOP before surgery (mmHg)	Medications before surgery	IOP after surgery (mmHg)	Medications after surgery	All	Complete success	Qualified success	Failure
Early revision	28.5	1.2	15.7	0.85	22	9	17	5
Late revision	25.3	1.7	14.8	0.74	78	46	60	18

IOP: Intraocular pressure

was defined >18 mmHg with a medication or <5 mmHg or if additional (repeated) revision was required.

### Statistics

Data analysis was performed using STATISTICA version 8.0 (StatSoft, Poland) and GraphPad Prism version 5.0, (GraphPad Software, USA).  $P \leq 0.05$  was regarded statistically significant. Student's *t*-test, Wilcoxon matched paired test, and Mann-Whitney U-test were used to assess parameter differences.

### Results

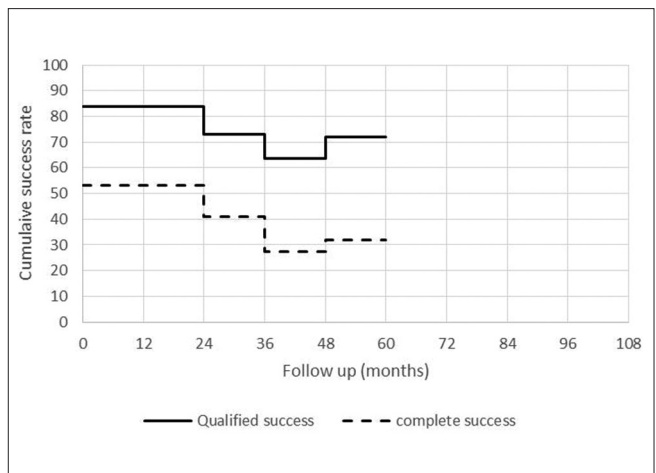
IOP during the first year: Mean postoperative IOP was  $12.1 \pm 9.5$  mmHg a day after the procedure,  $13.2 \pm 5.7$  mmHg after 1 week,  $15 \pm 4.3$  mmHg after 1 month,  $15.3 \pm 5.7$  mmHg after 3 months,  $15.1 \pm 3.6$  mmHg after 6 months, and  $14.1 \pm 4.8$  mmHg after 12 months after a single transconjunctival MMC revision.

Mean IOP decreased from  $26.1 \pm 8.4$  mmHg to  $14.1 \pm 4.8$  mmHg ( $P < 0.05$ ) at 12 months ( $n = 100$ ),  $16.0 \pm 5.6$  mmHg at 24 months ( $n = 46$ ),  $16.7 \pm 4.1$  mmHg at 36 months ( $n = 33$ ),  $15.7 \pm 5.8$  mmHg at 48 months ( $n = 25$ ), and  $15.2 \pm 4.0$  mmHg at 60 months ( $n = 14$ ). Twelve months after MMC revision ( $n = 100$ ), complete success was achieved in 53 eyes (53%). Qualified success had been achieved in 84 eyes (84%). Sixteen of 100 eyes (16%) were classified as failures. Twenty-four months after MMC revision ( $n = 46$ ), complete success was achieved in 19 eyes (41.3%), qualified success was achieved in 34 eyes (73.9%), and 12 eyes (26.1%) were classified as failures. Thirty-six months after MMC revision ( $n = 33$ ), complete success was achieved in 9 eyes (27.3%), qualified success was achieved in 21 eyes (63.6%), and 12 eyes (36.4%) were classified as failures. Forty-eight months after MMC revision ( $n = 25$ ), complete success was achieved in 8 eyes (32%), qualified success was achieved in 18 eyes (72%), and 7 eyes (28%) were classified as failures. Sixty months after MMC revision ( $n = 14$ ), complete success was achieved in 6 eyes (21.4%), qualified success was achieved in 10 eyes (71.4%), and 4 eyes (28.6%) were classified as failures [Table 4].

Kaplan–Meier survival analysis showed a probability of qualified success at 12 months of 84%, at 24 months of 73.9%, at 36 months of 63.6%, at 48 months of 72%, and at 60 months of 71.4% [Fig. 1].

**Table 4: The mean number of medications used before and after revision**

Time after revision (months)	Total number of patients (eyes)	Number of medications
Before	121	1.5±0.4
12	100	0.8±1.0
24	46	1.1±1.0
36	33	1.3±1.0
48	25	1.5±1.2
60	14	1.9±1.1

**Figure 1: Kaplan–Meier survival analysis for surgical success of mitomycin C revision in the study group**

The average time between the last failed filtration surgery and revision was  $2.3 \pm 2.48$  years (range: 1–5 years) ( $n = 121$ ). The length of the interval between trabeculectomy and revision correlated positively with IOP reduction (mean IOP reduction was 7.5 mmHg, 9.9 mmHg, and 12.3 mmHg at 20-, 60-, and 100-month interval between trabeculectomy and revision, respectively,  $P < 0.05$ ) and lower final IOP level (mean IOP reduction was 15.9 mmHg, 15.3 mmHg, and 14.7 mmHg at

20-, 60-, and 100-month interval between trabeculectomy and revision, respectively,  $P=0.24$ ) as compared to the preoperative values [Figs. 2 and 3].

On the other hand, when the patients were subdivided into two groups: With early revision ( $n = 22$ ) (below 6 months after primary trabeculectomy) versus late revisions ( $n = 78$ ) (over 6 months after primary trabeculectomy), no statistically significant difference in mean IOP was observed (15.7 mmHg vs. 14.8 mmHg,  $P = 0.66$ ) at 12 months [Table 3].

Twelve months after the MMC-augmented procedure, no statistically significant difference in IOP was observed between patients with initial IOP over ( $n = 24$ ) and under ( $n = 76$ ) 30 mmHg (14.3 vs. 14.7 mmHg,  $P = 0.7$ ). In the group of patients with IOP <10.0 mmHg ( $n = 32$ ) just after the revision (1 day–1 week), mean IOP at 12 months postoperatively was 11.9 mmHg, whereas in patients with IOP >10.0 mmHg immediately after the revision ( $n = 68$ ), mean IOP at 12 months postoperatively was 15.7 mmHg ( $P \leq 0.05$ ).

### Visual acuity

Mean visual acuity which was Snellen  $0.4 \pm 0.2$  did not change significantly at 12 months following the MMC-augmented revision and it was Snellen  $0.4 \pm 0.3$  with  $P = 0.76$ .

### Lens status

Mean IOP before surgery was 25.5 mmHg in phakic patients ( $n = 62$ ) and 27.2 mmHg in pseudophakic patients ( $n = 38$ ) ( $P = 0.40$ ). Mean IOP at 12 months postoperatively was 14.3 mmHg in the phakic group and 14.1 mmHg in pseudophakic patients ( $P = 0.77$ ). The percentage of IOP reduction compared to baseline was also higher in the pseudophakic group: 48.2% versus 43.9%, respectively ( $P = 0.1$ ).

### Bleb appearance

The filtering blebs before revision ( $n = 100$ ) were flat in 77 eyes and elevated or encapsulated with a thick wall of fibrous tissue or thin avascular circumcised blebs in 23 eyes. Twelve months after MMC revision ( $n = 100$ ), 90 blebs (75 in the flat group and 15 in the nonflat group) were diffused and elevated, but 10 blebs (2 in the flat group and 8 in the previously nonflat group) were flat and difficult to massage (10 of them were assessed as qualified successes and 2 as complete successes). There were

no statistically significant differences in IOP between these two groups before and after revision (26.09 mmHg/14.06 mmHg in the group with flat blebs and 26.13 mmHg/14.21 mmHg in the nonflat group, respectively,  $P = 0.7$ ).

### Visual field

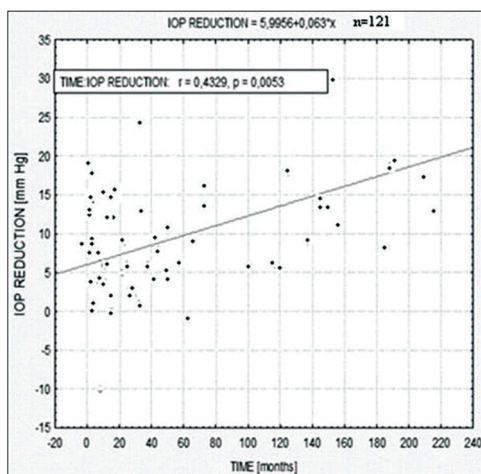
The mean defect of  $20.5 \text{ dB} \pm 8.8$  did not change significantly: At 12 months after MMC-augmented revision; it was  $-21.3 \text{ dB}$  ( $n = 100$ ) ( $P = 0.9$ ); at 24 months, it was  $21.9 \text{ dB}$  ( $n = 46$ ) ( $P = 0.9$ ); at 36 months, it was  $22.1 \text{ dB}$  ( $n = 33$ ) ( $P = 0.9$ ); at 48 months, it was  $23.3 \text{ dB}$  ( $n = 25$ ) ( $P = 0.7$ ); and at 60 months, it was  $22.9 \text{ dB}$  ( $n = 14$ ) ( $P = 0.8$ ).

### Medications

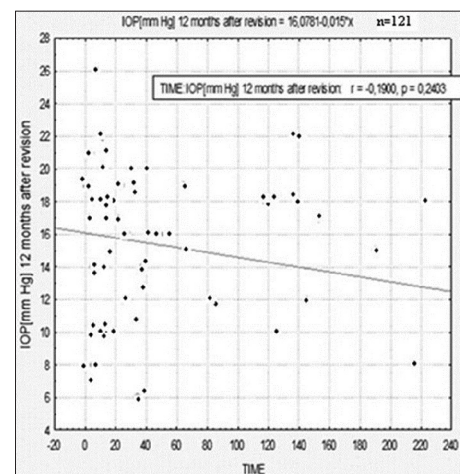
The mean number of administered medications was reduced from  $1.5 \pm 0.4$  preoperatively to  $0.8 \pm 1.0$  postoperatively ( $P < 0.05$ ) at 12 months ( $n = 100$ ). Twenty-four months ( $n = 46$ ) after the procedure, the mean number of medications was reduced to  $1.1 \pm 1.0$  ( $P < 0.05$ ); after 36 months ( $n = 33$ ) to  $1.3 \pm 1.0$  ( $P < 0.05$ ), after 48 months ( $n = 25$ ) to  $1.5 \pm 1.2$  ( $P = 0.9$ ), and after 60 months, the mean number of administered medications was increased ( $n = 14$ ) to  $1.9 \pm 1.1$  ( $P = 0.95$ ) [Table 4].

**Table 5: Number of complications after mitomycin C revision procedure**

Complications	Number of the eyes	Percentage of eyes
All eyes with complications	45	37.2
Filtration failure	37	30.6
Hyphema	11	9.1
Hypotony (with choroidal detachments)	9 (5)	7.4 (4.1)
Subconjunctival hemorrhage	7	5.8
Shallowing of anterior chamber	4	3.3
Conjunctival wound leaks (button hole)	3	2.5
Transient corneal epithelial defects	3	2.5
Bullous keratopathy	1	0.9
Suprachoroidal hemorrhage with significant visual loss	1	0.8



**Figure 2:** Correlation between intraocular pressure reduction and the time elapsed between trabeculectomy and revision



**Figure 3:** Correlation between final IOP level and the time elapsed between trabeculectomy and revision

### Number of revisions

Twenty-one of 121 eyes required repeated revisions: 18 of them once and 3 of them twice. Twelve months after the revision, in the group with two revisions ( $n = 18$ ), IOP was reduced to  $17.4 \pm 6.8$  mmHg and was not significantly reduced compared to the preoperative values (mean:  $25.6 \pm 6.3$  mmHg) ( $P = 0.1$ ). In the group with three revisions, IOP decreased from  $27.7 \pm 2.5$  mmHg to  $13.8 \pm 6.4$  mmHg and the reduction was significant compared to the preoperative values ( $P < 0.05$ ). Cases which required more than one revision were regarded as filtration failures of the primary MMC revision procedure and were added to statistics related to the complications.

Complications after MMC revision were observed in 45 of 121 eyes (37.2%). Most of these (44 eyes) were early complications which resolved spontaneously within few days. One was serious (suprachoroidal hemorrhage) and resulted in severe visual loss (hand motion). The most common complications were filtration failure (37 cases, 30.6%), hyphema (11 cases, 9.1%), hypotony  $<4-5$  mmHg (9 cases, 7.4%), choroidal detachment (5 cases, 4.1%), anterior chamber shallowing (4 cases, 3.3%), and conjunctival wound leaks (3 cases, 2.5%). Transient corneal epithelial defects were observed in 3 cases (2.5%) and bullous keratopathy in 1 case (0.9%). Long-term results with the use of subconjunctival MMC were unavailable [Table 5].

### Discussion

Failure of the filtering procedure is a common problem after glaucoma surgery. The clinical options for the patient whose filtration bleb has failed are often limited. Surgical intervention is almost always required when the filtration channel starts to shrink, fibrous tissue grows, and IOP cannot be adequately controlled with medication. Depending on the severity and type of glaucoma, a second trabeculectomy at a different site, a glaucoma drainage implant, or a cyclodestructive procedure may be required.

Numerous authors have reported that revision of failed filtration blebs permits better IOP control and helps restore the filtration fistula with low rate of complications and without further destruction of the conjunctiva.<sup>[4,12]</sup> In our study, 84 of 100 eyes achieved success or qualified success, yielding a total success rate of 84% over a 12-month follow-up. We found a statistically significant drop in IOP after the transconjunctival MMC revision. Our study revealed a statistically significant decrease in IOP 12–108 months after MMC revision, with a complete success rate of 28%–40% 12–60 months after surgery. This remained constant at 30% for the next 48 months. Some authors have also observed that their success rate did not change during a longer follow-up.<sup>[13]</sup> Our overall success rate is comparable to the results of other studies, in which complete success was observed in 39%–46% of patients at 12 months after surgery.<sup>[5,14]</sup> However, other authors have reported that the cumulative success rate of revision diminished over time to 13%–28% at 4 years.<sup>[15]</sup> These authors concluded that revision seems to be an effective form of intervention in the short- to medium-term, but that additional intervention was subsequently necessary in the majority of cases.

Trabeculectomy has limitations due to healing processes in the filtration channel, the scleral flap, and the filtering bleb,

and sometimes ends in failure. Scarring of the filtering site is most commonly due to fibrosis. Surgical revision has been reported to be less successful in eyes when bleb failure occurs shortly after the initial surgery, as opposed to eyes in which bleb failure occurs longer after the initial surgery.<sup>[16]</sup> Feldman recommended that revision can be considered before a more aggressive surgical intervention or before additional medical therapy.<sup>[17]</sup> Other authors advocate revision procedures for functional blebs which fail to lower IOP adequately. Our results show that the period between the initial filtration procedure (trabeculectomy) and MMC revision seems to be one of the most important factors for success. Our data show that the longer the period lasts between trabeculectomy and revision, the greater is IOP reduction and the lower is the IOP level because of the silence of healing process. This might be due to the fact that the late revisions are usually performed on the eye without the intensive flare which is customary during the acute postoperative period following primary trabeculectomy and can be avoided due to late revisions. Remodeling of the bleb usually lasts from 6 months to 2 years. A desired wound healing process should hold back from complete normal healing of the area of the filtration channel and filtering bleb, and the surrounding conjunctiva should heal normally.<sup>[17]</sup> According to Feldman, best results can be expected in eyes with functional blebs and when IOP needs lowering. These are most common after more than a year following the initial surgery.<sup>[17,18]</sup>

Cataract is the most frequent late complication after trabeculectomy, and phacoemulsification is considered to be a significant risk factor for trabeculectomy, with elevated IOP and a tendency toward a reduced size of the filtering bleb (bleb surface and elevation). A deterioration of filtering bleb morphology and a reduction of bleb function after phacoemulsification have been observed in eyes with previously successful trabeculectomy.<sup>[8,19]</sup> In our study, it was easier to re-establish a patent fistula in pseudophakic eyes than in phakic eyes because of deeper anterior chambers in pseudophakic group. In phakic group, surgeon should also pay attention and more caution to the lens, and the natural lens is thicker than artificial one. We were not able to show statistical significance, but pseudophakic patients had a slightly lower mean IOP level, and the reduction of IOP compared to baseline was also greater in the pseudophakic group at 12 months postoperatively. In our study, pseudophakia appeared not to be as great a risk factor for revision as it is for trabeculectomy.<sup>[8,9]</sup> In contrast, Hawkins *et al.* reported that pseudophakic or aphakic patients were more likely to experience trabeculectomy failure than phakic patients.<sup>[20]</sup> This tendency is also the same in primary trabeculectomy and might be due to previous surgery, regardless of lens status, since eyes with a history of surgery tend to be at higher risk than unoperated eyes.<sup>[18]</sup>

Many other risk factors such as uveitis, secondary (i.e., neovascular) glaucoma, chronic exposure to topical antiglaucoma medication, young age, Afroamerican race, a fornix-based conjunctival flap, previous surgery involving conjunctival incision, and a higher initial IOP may cause fibroblastic overstimulation and early or late proliferation of subconjunctival fibrous tissue and scarring, thus reducing the success of the filtration procedure, with or without the bleb collapse.<sup>[4,16,19]</sup> An IOP  $>30.0$  mmHg and an IOP  $>10.0$  mmHg immediately after this procedure were found to be the

significant risk factors for failure.<sup>[5]</sup> Our results support the significance of low IOP just after the surgery for the success of the final outcome. If the physician is able to achieve an IOP below 10.0 mmHg following a revision, the procedure can at least be judged a preliminary success. Such IOP indicates that the surgeon was able to re-establish a fistula large enough to restore a significant flow to the subconjunctival space, and the fistula is more likely to remain patent.<sup>[16]</sup>

Initial bleb morphology was identified as a significant determinant of success. Bleb height at the time of the revision procedure strongly predicted survival, but this effect was restricted (1) to blebs that were needled within the first 3 months after trabeculectomy, (2) to highly vascularized blebs, and (3) to microcystic blebs.<sup>[16]</sup> In our study flat, nonfunctioning blebs without strong vascularization were best suited for MMC revision procedures. The flat blebs (Group A) versus elevated encapsulated blebs with a thick wall of fibrous tissue (Tenon cyst) and thin avascular, circumcised, nonfunctioning blebs (Group B) made it possible to achieve elevated, well-filtering blebs in most cases. It has generally been accepted that patients with encapsulated blebs have a better response. This may be aided by carrying out a more prompt needling procedure augmented with MMC.<sup>[4]</sup> In our experience, it is better to maintain a “wait-and-see” policy regarding Tenon cysts within the first few months and to let them resolve spontaneously over the course of time under anti-inflammatory and anti-glaucoma medications.

The most common complication of transconjunctival revision is failure to achieve adequate IOP control. Sometimes, more than one revision procedure may be required. In our study, eyes subjected to a single procedure had better and much clear results. Three of the eyes in our study underwent second revision 1 month after the first revision procedure, the other three revisions were performed 3 months after the first one, another four revisions were performed after 6 months, two repeated revisions were done after 2 months and the other three after 3 years, and another 2 revisions were done after 4 years from the first procedure. Three of the third revision were done after 1 month, 3 years, and 4 years, respectively. Eyes with more than one revision were excluded from the study because they did not achieve the desired result, i.e., adequate reduction of IOP with the first procedure. Moreover, it was thought that the likelihood of success of repeated revision is reduced with each attempt and blebs which undergo more than one revision have a much poorer prognosis than those which undergo only one.<sup>[5,9,21]</sup> The Early Manifest Glaucoma Trial Investigators demonstrated a small postoperative mean visual acuity decline resulting from the additional attempts to reduce IOP medically, surgically, or by laser, which was due to accelerated cataract formation, age-related macular degeneration, or glaucoma progression, despite very good IOP control.<sup>[4,22]</sup>

Topical antiglaucoma medication may lead to ocular surface disorders because of preservatives or the glaucoma medications itself.<sup>[23]</sup> Successful revision may reduce the quantity of antiglaucomatous medication and contribute to a better quality of life in patients who experience adverse effects from topical eye drops.

Bleeding into the bleb occurs frequently. It is almost always a self-limited problem but sometimes require direct pressure application to the bleeding vessels to prevent larger bleeds.

Extensive intrableb hemorrhage is a poor prognostic sign for success because it can lead to intrableb fibrous tissue growing and bleb failure.<sup>[4,12,24]</sup>

Short-term hypotony without choroidal detachment (1–2 weeks) has been reported as a common and self-resolving problem. Patients should avoid the Valsalva maneuver to prevent suprachoroidal hemorrhaging. The type and rate of complications observed in our study were similar to those described by other authors.<sup>[14,15]</sup> Most of these complications were early complications (hyphema, hypotony, and subconjunctival hemorrhage) which resolved spontaneously within a few days.

We found revision with MMC to be a simple, safe, effective option for regaining IOP control for up to 24–48 months following trabeculectomy. Transconjunctival MMC revision is used to re-establish aqueous outflow after primary failed trabeculectomy. Nevertheless, this simplicity may be misleading. All complications which can develop after trabeculectomy can also develop after an MMC revision.

## Conclusions

Filtration failure is a common problem after antiglaucoma surgery, and MMC transconjunctival revision appears to be a useful tool in the management of glaucoma in such cases. It is a safe, straightforward procedure, which restores filtering function in a good proportion of cases while minimizing intraocular dissection and sparing conjunctiva.

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## Conflicts of interest

There are no conflicts of interest.

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