LONG-TERM RESULTS OF TRABECULECTOMY IN EYES THAT WERE INITIALLY SUCCESSFUL

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ABSTRACT

A number of published case series provide short-term and intermediate success rates for the surgical treatment of glaucoma with trabeculectomy. There is little information, however, regarding long-term outcomes that extend beyond 10 years. Therefore, we conducted a retrospective study to determine the long-term outcome of eyes that had successful trabeculectomy surgery at 1 year (IOP < 21 mmHg, or lowering by 33% if preoperative IOP was < 21 mm Hg) and had been followed up for at least 10 years. We found 40 such eyes. With respect to IOP control, 83% were still considered to be successful at 5 years, 73% at 10 years, but only 42% at 15 years. Ten percent required additional glaucoma surgery by 5 years, 25% by 10 years, and 58% by 15 years. Forty percent of the eyes had cataract surgery by the time of the last follow-up examination. It appears that there is a significant late failure rate of trabeculectomy in eyes that were initially successful.

INTRODUCTION

Trabeculectomy was introduced in 1967 and is now the surgery of choice for glaucoma filtering procedures.[1] Although there have been numerous short-term follow-up studies of trabeculectomies,[2-20] few report a maximum follow-up of more than 12 years.[1] Thus when patients ask us what is the prognosis for trabeculectomy, we are able to provide good information about 1-, 2-, or 5-year outcomes but not about outcomes beyond 10 years. The present study is an attempt to provide the latter information.

MATERIALS AND METHODS

We performed a retrospective study of patients with all types of glaucoma who underwent primary trabeculectomy without metabolites between 1967 and 1985 at the University of Illinois Eye and Ear Infirmary. For each patient who underwent bilateral trabeculectomies, only the first eye was used for statistical analysis.

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Only patients whose surgeries resulted in successful control of intraocular pressure, as defined below, at 1 year were included. Because some studies suggest that lowering of intraocular pressure from trabeculectomy is not always associated with cessation of glaucoma disease progression,[1-4, 21] we classified success in two ways. *Successful control of intraocular pressure* was lowering of intraocular pressure to less than 21 mm Hg or, if the preoperative intraocular pressure was less than 21 mm Hg, lowering by 33%. *Successful control of disease progression* occurred if there was no progression of cup-disc ratios or visual fields. Failure also occurred when further glaucoma surgery was indicated.

Patients who had less than 10 years of follow-up were excluded. Patients were also excluded if they had had previous ocular surgery not including laser trabeculoplasty, if they had retinal or neurologic disease that could independently affect their visual field, if they had poor compliance documented on at least 3 visits, or if they had a combined procedure with cataract extraction.

Preoperative data included date of birth, race, sex, type of glaucoma, medications used, previous anterior laser trabeculoplasty, best-corrected visual acuity by Snellen chart, average intraocular pressure by Goldmann applanation tonometry, average cup-disc ratio, visual field defects, and significant anterior segment abnormalities (eg. presence of cataract).

Indications for surgery included evidence of disease progression despite maximum tolerated medical treatment or IOP considered too high for preservation of optic nerve or visual field. Trabeculectomies were done with limbal-based incisions. Partial-thickness scleral flaps were dissected to clear cornea. After resection of the trabecular blocks, basal iridectomies were done. Conjunctiva was then reapproximated. Postoperative medications included topical steroids, antibiotics, and atropine. Intraoperative and postoperative complications were recorded. Two thirds of the trabeculectomies were done by one of us (J. T. W.). The other trabeculectomies were done by other attending physicians at the Eye and Ear Infirmary.

Postoperative examinations at 5, 10, and 15 years and at the last obtainable follow-up period included visual acuity, intraocular pressure, cup-disc ratio, and visual field progression. Appearances of the bleb, the cornea, and the lens were also documented. Also recorded was the number of antiglaucoma medications used.

Time of subsequent cataract extraction and/or repeat filter surgery was also recorded. We also studied long-term visual acuity after trabeculectomy.

Intraocular pressures were the average of at least three Goldmann

applanation readings. Cup-disc ratios were determined either by stereoscopic techniques such as 78- and 90-diopter lenses or color photographs or, in earlier years in some patients, by direct ophthalmoscopy. At each examination, the optic disc was described by horizontal cup-disc ratio and by location of any neural rim thinning (ie. notching or saucerization). Criteria for progression included an increase in cup-disc ratio by 0.2 or more or a localized loss of rim tissue consistently observed for at least three successive examinations.[21]

Visual fields were assessed by either kinetic Goldmann or static Octopus perimetry. Visual field changes occurred when any of the following were present: (1) deepening of a scotoma on static perimetry by 0.5 log units or more, or a change of a scotoma from relative to absolute, (2) widening of a scotoma on static perimetry by 6° or more, (3) widening of a nasal step or other peripheral defect on kinetic perimetry by 10° or more,[2] (4) disappearance of an existing defect, and (5) appearance of a new defect.[22] Results are expressed as a mean (± standard deviation).

RESULTS

A total of 40 eyes from 40 patients who had successful trabeculectomy at 1 year and who had a minimum follow-up of 10 years were identified (Table I). Mean age was 50.4 (± 20) years. Age range for all patients was between 7 and 79 years. There were 24 black and 16 white patients.

TABLE I: PATIENT DATA

GLAUCOMA DIAGNOSIS	NO. OF EYES (%)	MEAN PATIENT AGE (YR) (RANGE)	RATIO BLACK:WHITE	RATIO MALE:FEMALE
Open angle	21 (52.5)	61.1 (36-79)	15:6	10:11
Narrow angle	5 (12.5)	55.8 (44-67)	2:3	1:4
Juvenile	4 (10.0)	23.3 (11-37)	2:2	2:2
Pigmentary	3 (7.5)	47.7 (39-62)	0:3	2:1
Uveitic	2 (5.0)	29.0 (24-34)	2:0	0:2
Low tension	2 (5.0)	59.5 (55-64)	1:1	0:2
Congenital	2 (5.0)	8.5 (7-10)	1:1	1:1
Angle recession	1 (2.5)	24	1:0	1:0
Total	40 (100)	50.4 (7-79)	24:16	17:23

Seventeen patients were men and 23 were women. There were 20 right eyes and 20 left eyes.

Follow-up range was 10 to 21 years (Fig 1). Average follow-up was 12.9 (±2.8) years for all patients, 13.1 (±3.0) years for patients not needing reoperation, and 12.6 (±2.0) years for patients needing reoperation.

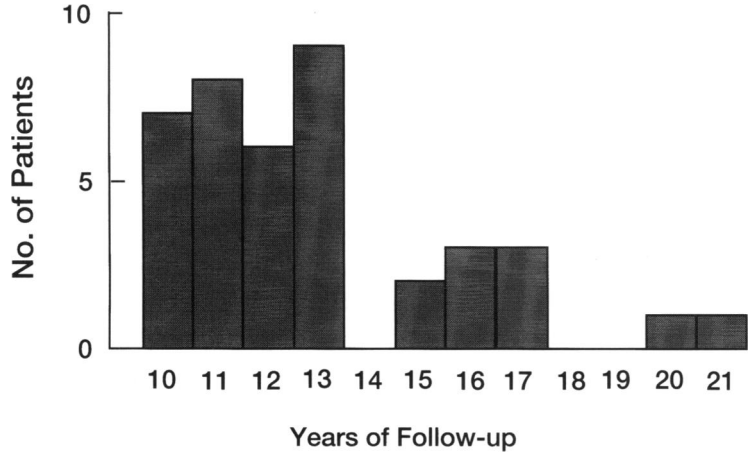

FIGURE 1
Length of follow-up in 40 patients who underwent trabeculectomy.

Of patients with successful control at 1 year, the percentage of patients with successful control of IOP at 5 years was 83%, at 10 years 73%, at 15 years 42%, and at 20 years 15% (Fig 2). Of patients who were considered successful at 1 year, the percentage of patients with successful control of disease progression at 5 years was 77%, at 10 years 63%, at 15 years 37%, and at 20 years 8% (Fig 3). In order to control IOP or glaucomatous damage, reoperation was needed in 10% of eyes at 5 years, 25% at 10 years, 58% at 15 years, and 85% at 20 years (Fig 4).

The average time medications were restarted after initial trabeculectomy was 41 months. Seventy-seven percent of patients were restarted on medications within the first 5 years, an additional 19% in the next 5 years, and another 3% in the next 5 years (Fig 5). The average number of medications used before surgery was 2.9. The average number of medications used if reoperation was not needed was 0.83 at 5 years, 1.00 at 10 and 15 years, and 1.50 at 20 years (Fig 6).

At the time of last follow-up, cataract extraction had been performed in 40% of eyes, that is, 16 eyes, of which 69% (11 patients) were done by 5 years and 94% (15 patients) by 10 years (Fig 7). The average age at time

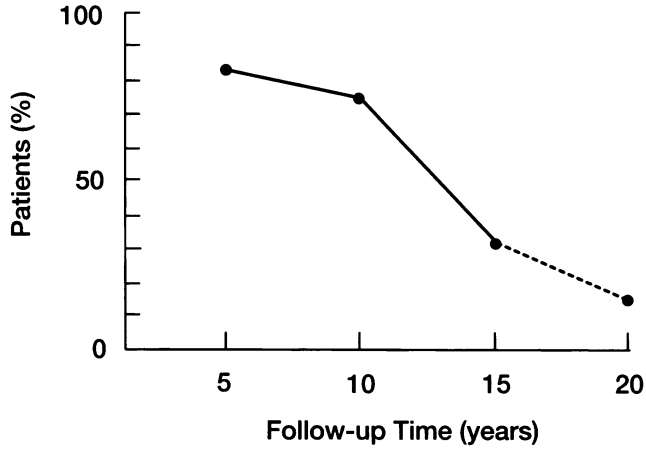

FIGURE 2
Percentage of eyes with successful control of IOP at 5, 10, 15, and 20 years.

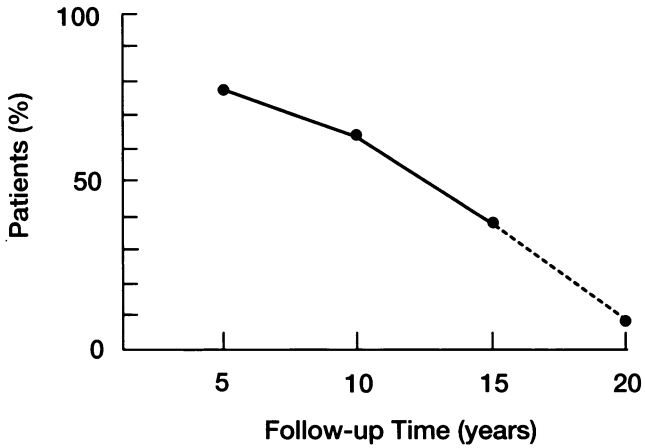

FIGURE 3
Percentage of eyes with successful control of disease progression at 5, 10, 15, and 20 years.

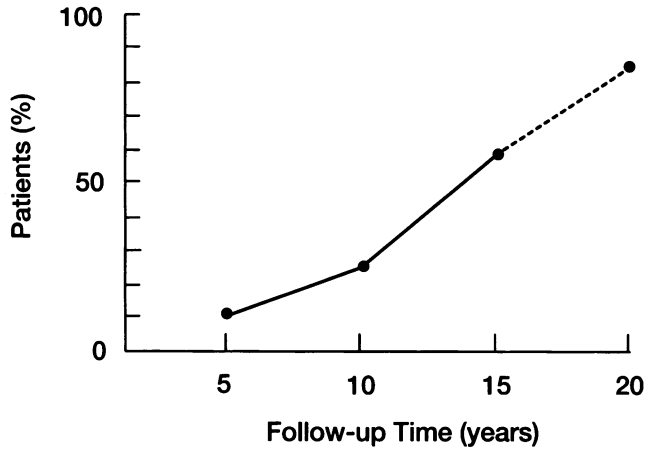

FIGURE 4
Rate of reoperation needed to control IOP or disease progression.

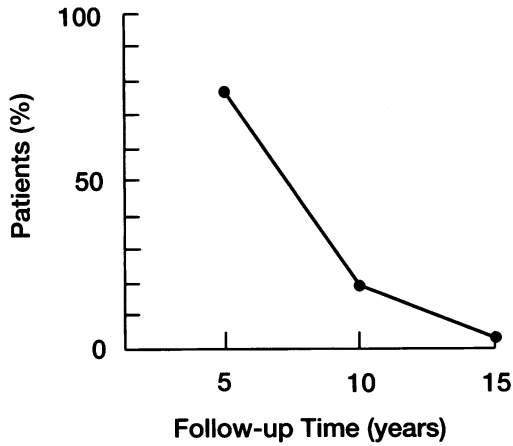

FIGURE 5
Average time when medications were restarted after initial trabeculectomy.

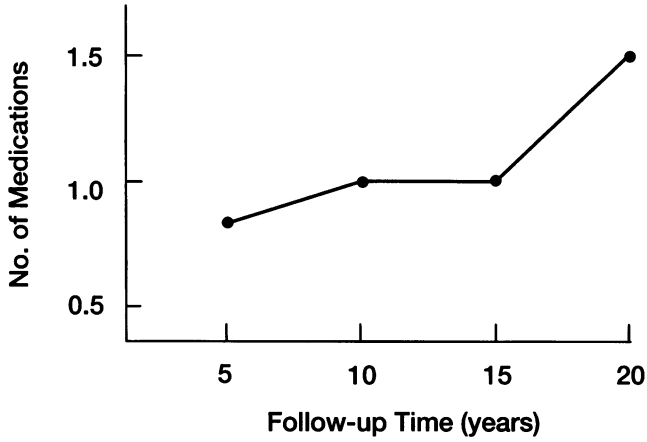

FIGURE 6
Number of medications used by patients in whom reoperation was not performed.

of initial trabeculectomy was 43.9 years in eyes that did not undergo subsequent cataract extraction compared with 59.7 years in eyes that underwent subsequent cataract extraction. Average age at time of investigated cataract extraction was 64.4 years.

The average IOP before cataract surgery was 14.1 mm Hg. It increased to 18.4 mm Hg after cataract surgery. Five patients required further glaucoma surgery after cataract extraction. Of these patients, the time of repeat glaucoma surgery was an average of 25 months (range, 3 to 52 months) after cataract extraction. Two patients had combined surgeries (one at 24 and one at 79 months after initial trabeculectomy).

In 62.5% of patients, visual acuity was stable at last follow-up compared with pretrabeculectomy vision (Fig 8).

DISCUSSION

Glaucoma is the third most important global cause of blindness after cataract and trachoma. Applying the international definition of blindness as the inability to count fingers at a distance of 3 m (10 ft), there are an estimated 5.2 million persons who are blind from glaucoma. This condition is thought to be responsible for 15% of global blindness.[23]

Trabeculectomy is the most common operation for the treatment of glaucoma. Because glaucoma is a chronic and sometimes lifelong disease, it is important to study the general outcome of trabeculectomy for as long a follow-up period as possible. It would be important to know not only tra-

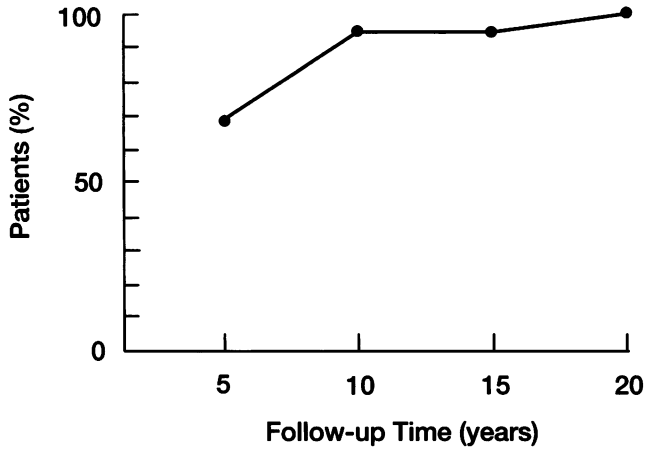

FIGURE 7

Time at which patients had cataract extraction after trabeculectomy. (Only 40% of patients in the study had cataract extraction.)

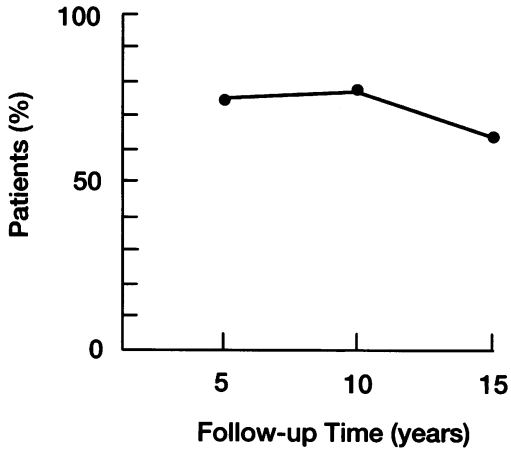

FIGURE 8

Patients with stable visual acuity at follow-up.

beculectomy's effect on controlling disease progression but also the number of life-quality interventions, such as additional surgery, that may be needed after initial trabeculectomy.

A review of the literature of IOP control and trabeculectomies without metabolites reveals many studies with an average follow-up of less than 10 years or with a maximum follow-up of less than 12 years. Of these short-term studies that investigated IOP control,[5-6,11-12] successful IOP control at last follow-up ranged from 95% to 60%. Follow-up periods ranged from 1 year to 10 years. To our knowledge, the longest follow-up study was done by Watson and associates,[1] who analyzed patients with a follow-up period ranging from 4 to 240 months. At last follow-up, 90% of patients had an IOP of less than 20 mmHg. The investigators, therefore, suggested that long-term follow-up over 20 years shows no tendency for trabeculectomy to fail once drainage is established. Our results are more in agreement with the short-term studies, which suggest that successful control of IOP decreases with time (Fig 2). Our results are also more in agreement with the decreasing success rate over time seen in the standard filtering control group of the Fluorouracil Filtering Surgery Study Group,[24] which showed a 21% success rate at 5 years in patients who had had previous cataract extraction or had failed filtering surgery.

The different study results are not easily compared or generalized because of several variables: (1) The criteria for successful control of IOP differed between studies. (2) The length of follow-up varied. (3) The patient composition was not uniform between studies (eg. One study only evaluated young adults,[5] and other studies included patients with previous surgeries[1,11,12]). (4) There may have been differences in the length of time preoperative medications were used prior to trabeculectomy that may have influenced filtration surgery outcomes.[25-27] (5) Although not all studies mentioned what postoperative medications were used, some studies may have used postoperative steroids, which may have improved surgical outcome.[19,28]

When comparing our long-term results and other short-term study results[5-6,11-12] with those of Watson and associates,[1] our lower rates of successful control of IOP would not be from varying definitions of successful IOP control, which was less than 21 mm Hg in our study and less than 20 mm Hg in Watson's study. Watson's figure of 90% successful IOP control represents only final IOP at last available follow-up, which ranged from 4 months to 20 years. Perhaps if Watson would have compared IOP control at 1 year to control at, for example, 10 years, he would have noticed less successful IOP control over time also. Our follow-up range was from 10 to 21 years, and Watson's follow-up was not only from 4 months to 240

months but also with a shorter average follow-up. Watson's patient population was almost exclusively white and was drawn from the population of Cambridge, England. Sixty percent of our patients were black. Some previous investigators have suggested that blacks are more prone to scarring and loss of filtration.[29-31] It has been suggested that the increased keloid-like activity in black connective tissue is responsible for the rapid scarring down of conjunctival blebs that occurs shortly after surgery.[29] Watson also included patients even if they had previous cataract extraction, which would be a confounding factor interfering with success rates reported. Both our study and Watson's study, however, did include patients with all types of glaucoma, so the type of glaucoma studied would not readily explain the differences in our results. Perhaps some of the differences between our study results and Watson's are real.

More important than IOP control is control of disease progression, because progression of cup-disc ratios or visual fields can occur despite adequate IOP control.[4,9] There are several short-term studies with less than 12 years of maximum follow-up that evaluated success of trabeculectomy in terms of disease progression (ie. cup-disc ratio increase and/or visual field loss).[14] Jerndal and associates[10] showed 91.5% of patients with arrest of visual field changes with 1.5 to 3 years of follow-up. Werner and coworkers[2] showed only 58% of patients with no progression postoperatively with median follow-up of 3.5 years. Lamping and colleagues[16] showed successful disease control in 76% of patients at 4 years. Popovic and Sjostrand[3] showed stable visual fields in about three fourths of patients after 5 years. Nouri-Mahdavi and colleagues[18] showed successful control of disease after 3 years in 81% of eyes and after 6 years in 65%. Tornqvist and Drolsum,[7] whose study had a follow-up range of 1 to 12 years, showed stabilization of disease in 57% of patients after 5 years and in 42% after 10 years. Although Watson mentioned that a progressive field change was noted in 59% of eyes at last follow-up, there is no mention of specific percentages at specific follow-up times; therefore, it is difficult to compare his results with those of other studies. Lamping also noted that if an eye was considered successful at 2 years, the probability of success at 5 years was only 82% for trabeculectomies. Our study showed that of eyes that were successful at 1 year, the percentage of successful eyes decreases not only at 5 years but even more by 20 years (Fig 3). This is in agreement with the other short-term studies that suggest a decrease over time in successful control of disease after trabeculectomy. Results differed partly from different definitions of visual field progression. The other problems with comparing these studies are similar to the problems mentioned when comparing the IOP studies.

At any given time interval, there was a small percentage of patients who had successful control of IOP without control of disease progression (Figs 2 and 3).

Other information patients may want to know is the likelihood that reoperation would be needed. By 10 years, only one fourth of patients needed reoperation; however, by 20 years, up to 85% of patients needed reoperation (Fig 4). Of patients undergoing at least one repeat filtering operation, there was an average of 2.3 glaucoma operations (including the initial trabeculectomy) needed by the last available follow-up. One patient refused further operations despite recommendations.

The average time medications were restarted was 3.4 years after initial trabeculectomy (Fig 5). Trabeculectomy also decreased the number of medications needed from 2.9 preoperatively to 1.5 at last follow-up (Fig 6).

Cataract is a well-documented complication of trabeculectomy surgery, and important life-quality interventions after trabeculectomy may include cataract extraction. It does not seem that eyes with glaucoma per se are more at risk for developing cataracts than are normal control eyes;[32,33] however, most of the risk associated with glaucoma appears to be associated with surgical procedures.[34] Aside from direct surgical trauma, retrospective studies have suggested that a flat anterior chamber with lens-corneal touch and that hypotony may be associated with cataract formation after trabeculectomy.[11,13,32] Our study showed 40% of patients electing to have cataract extraction by 21-year follow-up. Other studies that have shorter follow-up noted 28% to 47% of patients electing to have cataract extraction over only a 9.3- to 12-year follow-up period.[7,17-19] This is consistent with our study, because we noted that 94% of our patients had cataract extraction by 10 years (Fig 7). Almost two-thirds of patients had stable visual acuity at last follow-up compared with preoperative visual acuity (Fig 8). In addition to cataract progression, decrease in acuity was noted to be secondary to aphakic bullous keratopathy in two patients and to Irvine Gass syndrome in 1 patient. Other patients could have had a decrease in vision secondary to glaucomatous damage.

Our study had some limitations. We did not have complete long-term follow-up results for all patients. Comparison of patients needing and not needing reoperation, however, showed similar average follow-up periods. Therefore, perhaps incomplete follow-up may not have biased our results significantly. Also, since our hospital is a tertiary-care referral center, there could have been a selection bias for more advanced glaucoma in our study, which would show worse outcomes compared with the general population. In advanced glaucoma, progressive damage can occur even after signifi-

cant reduction of IOP.[18] Also, visual fields are more variable with advanced glaucoma, making comparisons of visual field progression difficult. Also, only 2 of our patients had automated fields (Octopus Interzeag), leaving some interexaminer variability with Goldmann visual fields. Many of our patients were black, which could also bias the results toward a poorer prognosis.

In addition, the use of antimetabolites, such as 5-fluorouracil and mitomycin C, in filtering surgery was first introduced in the 1980s and only became more popular in the 1990s. It would be useful to have a long-term follow-up study on trabeculectomy with antimetabolites with a larger number of study patients.

CONCLUSIONS

Our data suggest that if adequate control of IOP is achieved at 1 year, control tends to remain for up to 10 years, after which successful control is difficult to maintain without reoperation in over half of patients. There was a small percentage of patients with successful control of IOP but without control of disease progression. Trabeculectomy is associated with a decrease in the number of medications needed to control disease progression. However, it can be associated with subsequent cataract extraction in up to 40% of patients and with stable visual acuity in up to two thirds of patients at last follow-up. There can be loss of IOP control after cataract extraction, which may necessitate additional glaucoma surgery.

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DISCUSSION

DR ALLAN E. KOLKER. This paper attempts to address some of the major concerns of all patients (and their surgeons) who undergo surgery for glaucoma. How successful is the surgery? Assuming the operation is successful, what are the chances of long-term control of intraocular pressure (IOP)? Will long-term pressure control guarantee retention of vision? What is the likelihood of needing medication or further surgery for either cataracts or glaucoma?

The authors correctly point out that these questions are difficult to answer and relatively little data are available in the literature to provide accurate information. The current study population consists of 40 previously unoperated glaucoma patients who underwent primary trabeculectomy between 1967 and 1985, with successful IOP and disease control for at least 1 year, with a minimum follow-up of 10 years. Unfortunately, the long-term results are miserable! While by definition, 100% of eyes were controlled 1 year following surgery, by 5 years this was reduced to about 80%. Within 5 years of surgery, 77% of eyes required reinstitution of medical therapy. Ten years after surgery the success rate was reduced to about 70%, while after 15 years only 40% of eyes were felt to be under adequate control without progression of disease. Of the 7 eyes followed for 15 to 20 years, only 1 eye maintained IOP control.

Although these figures are obviously disturbing, several factors in this study design may have a bearing on the results reported. The study involves patients with multiple types of glaucoma. For example, only 21 of 40 patients (52%) had primary open-angle glaucoma; average age was 61 years. Most of the other patients were much younger and had other factors often associated with long-term failure of glaucoma surgery. These included patients with uveitic glaucoma, congenital glaucoma, low-tension and juvenile-onset glaucoma, and traumatic angle recession. Also, 60% of the patients were African American. In addition, the authors state that 40% of eyes underwent cataract surgery during the time of follow-up. Average IOP increased from 14.1 to 18.4 mmHg after such surgery. Failure of glaucoma control in these cases should be considered a result of surgical reintervention for cataract rather than failure of the primary glaucoma procedure, unless failure occurred prior to the need for cataract surgery.

Studies during the last 10 years have provided increasing evidence that progression of visual damage following glaucoma is closely related to the IOP achieved by the surgery. The lower the IOP control, the less the likelihood of progressive visual and optic nerve damage. This is true even when all pressures are statistically "normalized." Because of this, current

techniques of glaucoma surgery are designed to achieve pressures as low as possible without resulting in profound hypotony and the complications associated with extremely low IOPs. Many glaucoma surgeons currently use intraoperative fibroblast inhibitors such as 5-fluorouracil or mitomycin C in order to achieve very low pressures. It is difficult to predict the clinical significance of such changes and how these modifications in surgical techniques will affect future long-term results—both pressure control and maintenance of visual function.

The authors are to be congratulated for their efforts in attempting to answer many of the questions associated with long-term results of glaucoma surgery, especially in eyes traditionally considered "successfully controlled" 1 year after operation.

EDWARD RAAB, MD. I, too, enjoyed this paper and have one question about the methodology. I ask it as someone who is not an expert in the design of glaucoma studies. If I understood your criteria for success and failure correctly, a pressure of 22 that was lowered to 20 would be considered a success, and a pressure of 20 that was lowered to 18 would be considered a failure. That strikes me as an aberrational result. Other less exaggerated combinations of numbers would also give that anomaly. I would like to hear a comment on that.

ALAN L. ROBIN, MD. I would like to first congratulate both Drs. Chen and Wilensky for helping us better put the success rate of filtration surgery in perspective. This is especially important in light of Dr. Harry A. Quigley's recent meta-analyses finding that perhaps 85% of those diagnosed with glaucoma never attain legal blindness. Additionally, in those who do go blind from glaucoma, it takes approximately twelve years.

First, we must remember that there are many potential pitfalls to any retrospective analysis. The report does not analyze one surgical technique as our notion of filtration surgery has drastically changed over the last decades. As we have gained experience, we have used laser suture lysis and releasible sutures. The study began in a time when antimetabolites were not used in glaucoma surgery and has spanned the use of 5-fluoruracil and mitomycin C. Not only has filtration surgery changed, but so has cataract surgery. The manuscript includes eyes that underwent intracapsular, extracapsular, and phacoemulsification. The presence of an intact anterior hyaloid face was a great accomplishment with intracapsular cataract surgery. An intact posterior capsule (extracapsular surgery) and smaller incision size (phacoemulsification) surely must influence the outcome of filtration surgery. We must interpret the reported success rate

with caution when considering present filtration techniques.

The most promising point of this manuscript is that 80% of patients maintained good visual acuity. Perhaps, you have shown that filtration surgery may indeed prevent blindness from glaucoma.

My only question is how many patients have you identified who did not complete follow-up and did not complete the study.

Thank you.

JAMES AUGSBURGER, MD. Dr. Chen, I have a few questions about how some of the calculations were performed.

First, were the success rates that you reported calculated actuarially or were they computed as simple percentages of the eyes evaluated at each point in time?

Secondly, what was the median follow-up time of the patients in your series? Could you comment on the biostatistical validity of predicting outcomes at longer than the median follow-up time, namely 15 to 20 years?

Finally, could you also comment on the possibility of bias in terms of the selection of these patients with regard to use of long-term follow-up as a selection criteria? In other words, could it be patients who had long-term follow-up in your clinic were ones who were having problems over the course of time and were, therefore, still being followed and that patients who were doing well may have been returned to their primary ophthalmologist and not followed for ten or more years in your clinic?

Thank you.

JACOB WILENSKY, MD. I would like to thank Dr. Kolker for his usual insightful discussion and comments. I would like to try to answer some of the questions that were raised.

Dr. Raab is correct that those criteria are somewhat arbitrary. Ideally, what we should have done was use criteria such as were used in the GLT study where reduction had to be by a percentage if the pretreatment IOP was below a certain level. Thus, if a 25% reduction was used and the presurgery IOP were 24, the pressure would have to be lower than 6mm or to 18 to be successful, not just to 211. But we did that in this particular case. So you are correct in chastising us for that.

With regard to Dr. Augsburger's comments, it was actuarial as you suggested. That is if a patient failed at any point, then they were projected on for the whole follow-up and that is why those numbers are fairly low at the end. It is not a percentage of just those who were being followed at that time.

Dr. Robin commented about the drop out rate. When we started out

there were 400 eyes who had surgery during this period of time. Obviously not all of those were successful at one year. So the denominator, if you will, that could have been followed was lower than that 400. We do not know, as Dr. Chen mentioned in the presentation, why people were lost to follow-up. Obviously among the older population there was a considerable death rate. The average patient at our institution who is having a primary trabeculectomy done is in the sixties and so you would expect that there is going to be significant mortality rate in that population and many of these people are not going to make out ten years or more. So that is one reason why you are going to have drop out. But then there is the other question as to why did some of the living patients not continue and have that follow-up. We do not know the answer to that and that is why that was listed as the first caveat to our results. We do not know how that affects our answers.

I would like to stress one thing. That has to do with this concept of failure rate over time. Watson in his paper suggested that if you got a good result at one year then it was going to continue for a long period of time. There was a study from Boston a number of years ago that showed with trabeculectomies in particular, comparing the 2 year to the 5 year success rates, there was a significant drop off or an increasing failure rate over that period of time. Just recently Fluorouracil Filtering Surgery Study published its five year results, I think in the April AJO. It showed a very significant continued failure rate both in the control and in the 5-FU treated patients over that five year time. Now admittedly those were secondary cases. They had all had previous surgery of some sort or another. But I think both of these two studies that I have cited do indicate strongly that there is going to be a continued failure rate over time which is what we are showing here. I think this is something of which we need to remind people.

Thank you.

APPENDUM*

As a result of comments made at the meeting, we readdressed our outcome analysis using different statistical approaches, and these yielded somewhat different results. We are adding these new survival analysis calculations, because the product limit probabilities suggest a more accurate long term prognosis for trabeculectomies than a previous life table analysis, which can underestimate success rates (Miller RG Jr: *Survival Analysis*. New York, John Wiley & Sons, 1981). The results, which are expressed as probabilities (95% confidence limits or ± 2 standard devia-

tions), are as follows:

If an eye was considered successful by intraocular pressure at one year, the probability of successful control of intraocular pressure is 83% (± 12%) at five years and 67% (± 15%) at ten and fifteen years. If an eye was considered successful by intraocular pressure at one year, the probability of successful control of disease progression is 77% (± 13%) at five years, 62% (± 16%) at ten years, and 48% (± 21%) at fifteen years. If an eye did not require further glaucoma surgery at one year, the probability that it still would not need further surgery at five years is 90% (± 10%), at ten years 75% (± 14%), and at fifteen yeras 67% (± 20%). These probabilities apply only to subjects who completed the follow-up for the specified period of time.

The new analysis continues to show that despite successful control of intraocular pressure at one year, control of intraocular pressure decreases in the first ten postoperative years, although not as much as was indicated by the previous analysis.

The probabilities of successful disease control not only are still lower than that of intraocular pressure control, but also continue to decrease over the first fifteen years. These results also suggest that the probability of successful control of IOP and disease progression without reoperation decreases over time.

Thus, the long term prognosis by this method is more encouraging, but there are still some eyes that will lose control and/or require additional glaucoma surgery even after ten years.

*In collaboration with Marlos Viana, PhD.