Introduction

The conventional approach of initially treating glaucoma medically and holding surgical intervention as a reserve option was endorsed by the findings of the Collaborative Initial Glaucoma Treatment Study (CIGTS) study. This study reported that patients had similar visual field outcomes at five years from either medical treatment or immediate filtration surgery and supported the status quo of glaucoma management.

The market for medical treatments has since increased and polypharmacy is now an accepted norm for glaucoma treatment. Surgical remedies for glaucoma have existed in a less pressured environment such that trabeculectomy, after four decades of slow evolution and complications, remains the most commonly performed type of glaucoma surgery worldwide.

This ecosystem has begun to change in recent years. New surgical alternatives have arrived, reached a sizeable number and gained considerable traction as viable competitors to conventional glaucoma medical and surgical treatments. This raises important questions as to how these advances in glaucoma surgical options may affect the future landscape of glaucoma treatment. Has trabeculectomy already yielded some of its high ground? Why has trabeculectomy not been able to evolve more rapidly in response to new competitive pressures? If trabeculectomy has reached its evolutionary zenith are the newer alternatives any better? And, is it time to re-examine the conventional ‘medical before surgical’ approach to glaucoma?

This article reviews the evidence for current surgical techniques available to patients with glaucoma.

Trabeculectomy

Trabeculectomy for the treatment of glaucoma is supported by a considerable body of evidence, accumulated over many years. However, sequential surveys of the American Glaucoma Society members and American Medicare insurance claims have demonstrated a recent decrease in the popularity of trabeculectomy across a variety of clinical scenarios. CIGTS demonstrated that over five years of follow-up, patients with a primary 5-fluorouracil (5FU) trabeculectomy achieved a lower mean intraocular pressure (IOP) than medically treated patients (14-15mmHg versus 17-18mmHg). Patients with trabeculectomy needed cataract surgery more commonly, but after cataract extraction the two different treatment approaches resulted in similar visual acuities. The incidence of peri-operative complications was high but few of these were serious or caused persistent visual loss. After 8 years of follow-up, visual field loss of ≥ 3dB of mean deviation (MD) was found in 21.3% and 25.5% of the surgical and medical patients, respectively. Patients with a baseline MD ≥ -10dB lost less visual field when treated initially with surgery. Patients with diabetes or African heritage lost more visual field when treated initially with surgery. Fluctuations of IOP were associated with less visual field loss in patients who were initially treated with surgery. Smokers treated with surgery had significantly higher postoperative IOPs, closer to those of medically treated patients. These results suggest a benefit for early trabeculectomy for certain patients presenting with moderately advanced glaucoma. CIGTS also reported early postoperative complications in 50% of eyes.

The five year risks of hypotony, blebitis and endophthalmitis were 1.5%, 1.5% and 1.1%, respectively.

The British National Survey of Trabeculectomy reported one year data on 1,240 primary trabeculectomies, mainly performed without anti-metabolite. IOP was successfully reduced by more than a third without supplementary anti-glaucoma medication in 67% of cases. An IOP of less than 16mmHg without supplementary anti-glaucoma medication was achieved in 55% of cases. Early post-operative complications were reported in 47% of cases. Complications later within the year were reported in 42% of cases including: loss of >1 line Snellen acuity including due to cataract in 19%, encapsulation of bleb in 3.4%, and endophthalmitis in 3 cases.

Stead et al described their outcomes for trabeculectomy with mitomycin C (MMC) in 103 patients with a baseline MD ≥ -20dB. At 5 years an IOP of less than 16mmHg was achieved in 85% of cases; an IOP of less than 21mmHg was achieved in 96% of cases. Visual field MD scores were reported to have remained stable for individual patients.

The Tube Versus Trabeculectomy Study (TVTS) reported five year data on eyes receiving trabeculectomy with MMC that had previously had cataract surgery or failed trabeculectomy. The TVTS found that 29% of trabeculectomy eyes required additional glaucoma surgery within five years. Of those not having further surgery, the mean IOP at 5 years was 12.6mmHg with use of a mean of 1.2 glaucoma medications. Sixty percent of patients had complications during the first 3 years of follow-up, 27% of which were serious enough to require re-operation and/or cause loss of ≥ 2 lines of Snellen acuity.
These trabeculectomy studies each have fundamental differences in the populations investigated and their use of anti-metabolites. However, they provide a picture of the strengths and limitations of trabeculectomy against which newer surgical techniques must be considered.

Aqueous shunt implants

Aqueous shunt implants drain aqueous from the eye to a bleb around a plate in the equatorial sub-Tenon’s space. The first such implant, the first generation Molteno implant was often associated with severe post-operative hypotony, such that aqueous shunts were relegated for use only in refractory glaucoma cases lacking other options.

Newer implant designs still employ a long tube to avoid limbal drainage but the plate surface area and “valved” or “non-valved” designs have evolved. As surgical results have improved, the indications for these implants have increased to include their use in both primary and secondary glaucomas.

The results of recent prospective, randomized, multicenter trials allow comparison between different implants types. Each implant study used similar definitions for failure, including an IOP > 21mmHg or > 18mmHg or an IOP not reduced > 20% from baseline, IOP < 5mmHg, additional glaucoma surgery or loss of light perception vision.

A study of 92 patients with refractory glaucoma compared the valved Ahmed FP7 implant with the non-valved Molteno single-plate implant. At 2 years, the Molteno implant group had a greater percentage drop in IOP but also required more glaucoma medication to achieve pressure control compared to the Ahmed implant. The rates of failure were similar in each group.

The valved Ahmed FP7 implant and non-valved Baerveldt 350mm² have been compared in two studies, the Ahmed Baerveldt Comparison (ABC) Study and the Ahmed versus Baerveldt (AVB) Study, both of which reported one year follow-up data in 2011. Both studies reported lower mean IOP and less use of glaucoma medication in the Baerveldt groups but the Baerveldt groups also had a higher rate of post-operative complications and needed more interventions. The ABC study reported the rate of failure as non-statistically significantly higher in the Ahmed group. However, the AVB study defined an IOP > 18mmHg as failure and by this more stringent criterion reported the rate of failure to be significantly higher than in the Ahmed group.

The valved Ahmed S2 implant was compared against trabeculectomy with or without MMC in a randomized controlled trial of 123 patients with primary open angle and chronic angle closure glaucoma. Results were reported with a mean follow-up of 31 months showing a similar IOP visual acuity and visual field outcomes. Use of glaucoma medications and the incidence of post-operative complications including failure were also non-significantly different between the two groups.

The non-valved Baerveldt 350mm² was compared against trabeculectomy with MMC in the Tube versus Trabeculectomy study. This study randomized 212 eyes that had previously had cataract surgery or failed trabeculectomy, 81% of which had primary open angle glaucoma. Five year data showed a non-statistically significantly lower mean IOP in the trabeculectomy group and a similar need for glaucoma medication. Post-operative complications and failure were both more common in the trabeculectomy group.

Overall, the valved Ahmed implant probably remains the most popular implant used worldwide as it can provide early post-operative lowering of IOP, its valve mechanism helps to avoid hypotony and it is relatively simple to implant. However, study data support the use of the Baerveldt implant when lower longer-term IOPs and a reduced rate of encapsulation and failure are significant considerations.

In terms of surgical complications, the placement of Baerveldt implants under the rectus muscles gives rise to a higher incidence of diplopia although this is rare and usually manageable with prisms or resolves with time. All tube devices carry a risk of corneal endothelial damage and corneal decompensation when placed in the anterior chamber angle. Tube placement in the sulcus or pars plana may reduce the risk to the cornea.

The Ex-PRESS mini shunt

The Express mini-shunt is a small, non-valved stainless steel implant with an internal diameter of 50 microns. This tiny shunt is placed below a scleral flap near the limbus to drain aqueous from the anterior chamber to a limbal sub-conjunctival bleb as an alternative to trabeculectomy and iridotomy. Absence of an iridotomy has been suggested to cause less inflammation and avoid cataract formation. Anti-metabolites are used as for trabeculectomy to prevent scarring in
the area around the scleral flap to allow for bleb formation.

One small prospective study (n=24) and one sizeable retrospective study (n=100) have examined the outcomes of the Express mini-shunt. The prospective study used 0.05% MMC under the scleral flap and reported a 48% IOP reduction at 24 months with 5 cases of hypotony.14 The retrospective study age and sex matched Ex-PRESS cases with controls receiving trabeculectomy, all with 0.4mg/ml MMC for 1 or 2 minutes.15 At 15 months Ex-PRESS and trabeculectomy cases had an IOP reduction of 55% and 47%, respectively, with a comparable reduced need for glaucoma medication. Time of surgery is similar in both groups so selection bias seems possible in this non-randomized study.

Two prospective case series of combined Ex-PRESS mini shunt implantation with cataract extraction have reported their experience of a total of 61 eyes.16,17 One year postoperative cataract extraction have reported their Ex-PRESS mini shunt implantation with this non-randomized study.

The Trabectome

The Trabectome uses ab interno electrocautery to ablate and open trabecular meshwork and the inner wall of Schlemm’s canal to create a direct pathway for aqueous to reach Schlemm’s canal. The Trabectome aims to reduce intraocular pressure without formation of a bleb.

A prospective case series of 101 eyes with up to 30 months follow-up reported a 41% and 45% IOP reduction at 1 and 2 years, respectively.18 However, reporting of follow-up data was voluntary and is incomplete so as to prevent useful analysis of these data. Another prospective case series of 304 consecutive eyes reported the outcomes of combined Trabectome and cataract extraction in eyes with open angle glaucoma and clinically significant cataracts.19 At 21 months of follow-up, a 16.5% IOP reduction was reported. Complications were rare but 9% had an IOP spike after surgery. Loss to follow-up and the lack of a cataract extraction only control arm make it impossible to determine how effective the Trabectome procedure is at lowering IOP by itself without a contribution from cataract surgery.

A randomised controlled trial of Trabectome versus trabeculectomy with MMC is underway.

The SOLX suprachoroidal implant

The SOLX Gold Shunt (SOLX, Boston, MA) forms an ab interno communication that allows aqueous to drain from the anterior chamber to the suprachoroidal space and exit the eye via the uveoscleral pathway. A prospective case series recruited 38 eyes with inclusion criteria of visual acuity worse
than “finger counting” and four quadrants of conjunctival scarring. With a mean follow-up time of 12 months, a 34% IOP reduction was observed. Complications included hypHEMA in 8 eyes and shunt removal secondary to complications from 10 eyes.

Conclusions
Trabeculectomy with anti-metabolite remains the global gold standard for primary surgical intervention against which new techniques need to be evaluated in well designed prospective clinical trials. Such comparative data does not yet exist.

REFERENCES