Published in final edited form as:

Br J Ophthalmol. 2013 October ; 97(10): 1228–1229. doi:10.1136/bjophthalmol-2013-303237.

There has to be a better way evolution of internal filtration glaucoma surgeries

Nils A Loewen¹ and Joel S Schuman^{1,2}

¹Department of Ophthalmology, UPMC Eye Center, Eye and Ear Institute, Ophthalmology and Visual Science Research Center, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA

²Department of Bioengineering, Swanson School of Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Accelerating progress in biomedical engineering¹ and the ability to live image and understand delicate outflow structures² have produced an abundance of new surgical options in the last few years for an ancient disease that stubbornly defies the best hands and minds. Glaucoma, first described by Hippocrates 400 BC as vision loss in the elderly that is different from cataract,³ is now a leading cause of irreversible blindness with increasing prevalence in an aging population.⁴ Despite the many new arrivals, the concepts behind recent names like Trabectome,⁵ iStent,⁶ Hydrus,⁷ Xen,⁸ Solx,⁹ Cypass,¹⁰ Canaloplasty,¹¹ ECP¹² are not entirely new: open angle glaucoma has been surgically treated for 150–100 years by either increasing external filtration,¹³ internal filtration (angle surgery;¹⁴ suprachoroidal drainage¹⁵) or ciliodestruction.¹⁶

Development of new devices and technologies was spurred by the realisation that the standard surgeries performed today for glaucoma—trabeculectomy and epibulbar glaucoma drainage device surgery—have unacceptably high failure and complication rates even when performed as primary surgeries.¹⁷ While not as rudimentary and unsuccessful as at the time of their inception in the form of guarded external filtration by Sugar in 1962,¹⁸ or the gold wire shunt by De Wecker in 1876,¹⁹ both present iterations seem almost as primitive given that urgent postoperative interventions have to be performed in astonishing 74% of trabeculectomies and 27% of tube shunts.²⁰ Serious, vision-threatening early postoperative complications occur in 39% of trabeculectomy and 22% of tube shunt patients, while additional serious complications during 5-year follow-up occur in 38% of trabeculectomies and 36% of tube shunts (additive probability of a serious complication in 77% and 58% of patients, respectively).²⁰

Correspondence to Professor Joel S Schuman, Department of Ophthalmology, UPMC Eye Center, University of Pittsburgh School of Medicine, 203 Lothrop Street, Eye and Ear Institute, Suite 816, Pittsburgh, PA 15213, USA; SchumanJS@upmc.edu.

Contributors NAL and JSS contributed to this manuscript in concept, design, writing and review.

Disclaimer NAL is a trabectome trainer (Neomedix Corp., Tustin, California, USA) JSS receives royalties for intellectual property licensed by Massachusetts Eye and Ear Infirmary and Massachusetts Institute of Technology to Carl Zeiss Meditec, Inc.

Competing interests None.

Provenance and peer review Commissioned; internally peer reviewed.

Glaucoma specialists still not versed in minimally invasive glaucoma surgeries (MIGS) should recall these unacceptably high numbers and question whether a trabeculectomy or tube shunt can really be recommended as a primary procedure over MIGS merely because the average postoperative intraocular pressure (IOP) for tubes is 14.4 mm Hg and not significantly different for trabs.¹⁷ Prospectively collected MIGS data indicate an only marginally higher IOP of for example, 15.2 mm Hg for phaco-trabectome procedures at 5 years²¹ and 16.8 mm Hg for the iStent with same session phacoemulsification at 5 years.²² Our own experience with 200 consecutive trabectome surgeries for patients who would normally have received a tube or trab (open or closed angle glaucoma, including failed trabs and tubes), suggest that a final IOP of less than 18 mm Hg can be achieved in 81%, less than 15 mm Hg in 52% and less than 12 mm Hg in 27%.

The most serious complication of MIGS is a temporary, more than 10 mm Hg IOP increase during the early postoperative phase that can occur in for example, 3–10% of trabectome²³ and 2% of iStent patients.²² Early postoperative, transient hyphema is characteristic for all canal surgeries and more common to procedures that generate access to many outflow segments by ablating trabecular meshwork over a large arc and less common to procedures that provided focal entry into a few clock hours of the naturally discontinuous and septated Schlemm's canal.

The differences between MIGS and classic glaucoma surgery are reminiscent of those between phacoemulsification and extracapsular cataract extraction and advantages so compelling that to this date no randomised controlled trial has been conducted.

It is in this context, the study by Arriola-Villalobos *et al* in this issue is an important step to advance the field by assessing the much anticipated second generation iStent *inject*. This group has extensive experience with the first generation iStent with up to 5 year follow-up.²² While the paper itself comments very little on why a second generation stent was developed that is fundamentally different from the first one, the reason is apparent by the observations of this newer model that is meant to be easier to insert. Two of the new devices are preloaded in the iStent *inject* and can be inserted by direct forward penetration into the canal due to the cone shaped design. In contrast, the first generation model needed to be held against the meshwork and then swept to the left with the snorkel to the left or right, depending on the model.⁶ Despite this design change, 7.5% of second generation stents apparently got lost during implantation. It is not clear what happened to further 10% after implantation which could not be visualised. Because these devices are tiny they might have pulled through the trabecular meshwork when buried too deeply in the outer wall of Schlemm's canal but they could have also dislodged and disappeared behind the iris. It would be interesting to know what the IOP of these single shunt eyes are. Bahler *et al*²⁴ find a considerable effect after insertion of the second second generation iStent in an anterior chamber perfusion model doubling outflow facility after the first one is inserted and doubling further after the second one is inserted. In Bahler's model, insertion is done under direct view through a microscope and not gonioscopically through a cornea and in a system that moves. Electron-microscopic visualisation demonstrated that even in Bahler's study only a few ports of the stent remain unoccluded.

In Arriola-Villalobos' present paper, the authors do not discuss why two second generation iStents appear to be only as effective as one of the first generation ones but a stringent comparison would require randomisation and was not the goal here. The findings may however indicate a problem with depth of implantation resulting in outlet obstruction. The observed IOP reduction of only 14% by this second generation device may be enough for glaucoma patients with stable disease at the time of cataract surgery to reduce drop dependence. Patients were allowed to go through a medication washout of up to 4 weeks with considerable IOP elevation and 75% could discontinue topical medications after surgery as captured in a high, study specific success rate. Overall, both the first and second generation iStent seem to be safe procedures with no serious complications and the endothelial cell loss is similar to the 10% seen in cataract surgery²⁵ or trabeculectomy.²⁶

The authors shy away in the discussion from comparing their new results to other MIGS procedures and miss an opportunity to address the reason for considerable differences in side effects, complications and IOP endpoints: it is likely that the more access to collector channels can be achieved, the higher the success rate and the closer the IOP to the theoretical limit of episcleral venous pressure.²⁷ In order for a MIGS not to be labelled 'MEGS' ('minimally effective glaucoma surgery'), precise control of instrumentation and devices as well as detailed knowledge of a patient's specific anatomy are crucial. These might matter less in procedures that provide broad, up to 180° arc meshwork ablation than in microstenting procedures.

Our new ability to know where major outflow channels exist using spectral domain optical coherence tomography (SD-OCT)² will guide MIGS stenting procedures and improve results. No interventional cardiologist would blindly perform an angioplasty without visualising the target. There is no reason why an eye surgeon—who has mastered cataract surgery, a procedure that seems impossibly difficult to beginners—could not learn to excel with a fast and safe minimally invasive surgery. We owe it to our patients to acquire these new skill sets and define the parameters that make them highly successful.

Acknowledgments

Funding Supported in part by National Institutes of Health contract P30-EY08098 (Bethesda, Maryland, USA), The Eye and Ear Foundation (Pittsburgh, Pennsylvania, USA), and an unrestricted grant from Research to Prevent Blindness (New York, New York, USA).

REFERENCES

1. Kurzweil R. The law of accelerating returns. KuzweilAI.net. 2001; 24:2008.
2. Francis AW, Kagemann L, Wollstein G, et al. Morphometric analysis of aqueous humor outflow structures with spectral-domain optical coherence tomography. *Invest Ophthalmol Vis Sci*. 2012; 53:5198–5207. [PubMed: 22499987]
3. Hippocrates Coar T, et al. *The aphorisms of Hippocrates*: Classics of Surgery Library, division of Gryphon Classics. 1994
4. Quigley H, Broman A. The number of people with glaucoma worldwide in 2010 and 2020. *Br J Ophthalmol*. 2006; 90:262–267. [PubMed: 16488940]
5. Anderson DR, Drance SM, Schulzer M. Natural history of normal-tension glaucoma. *Ophthalmology*. 2001; 108:247–253. [PubMed: 11158794]

6. Samuelson TW, Katz LJ, Wells JM, et al. Randomized evaluation of the trabecular micro-bypass stent with phacoemulsification in patients with glaucoma and cataract. *Ophthalmology*. 2011; 118:459–467. [PubMed: 20828829]
7. Camras LJ, Yuan F, Fan S, et al. A novel Schlemm's canal scaffold increases outflow facility in a human anterior segment perfusion model. *Invest Ophthalmol Vis Sci*. 2012; 53:6115–6121. [PubMed: 22893672]
8. [accessed 4 May 2013] AqueSys—Xen Glaucoma Implant. Secondary AqueSys—Xen Glaucoma Implant. 2013. <http://www.aquesys.com>
9. Melamed S, Ben Simon GJ, Goldenfeld M, et al. Efficacy and safety of gold micro shunt implantation to the supraciliary space in patients with glaucoma: a pilot study. *Arch Ophthalmol*. 2009; 127:264. [PubMed: 19273788]
10. Medical T. CyPass Micro-Stent—Transcend Medical. 2013
11. Lewis RA, von Wolff K, Tetz M, et al. Canaloplasty: three-year results of circumferential viscodilation and tensioning of Schlemm canal using a microcatheter to treat open-angle glaucoma. *J Cataract Refract Surg*. 2011; 37:682–690. [PubMed: 21420593]
12. Lima FE, Magacho L, Carvalho DM, et al. A prospective, comparative study between endoscopic cyclophotocoagulation and the Ahmed drainage implant in refractory glaucoma. *J Glaucoma*. 2004; 13:233–237. [PubMed: 15118469]
13. De Wecker, L. *Traite des Maladies des Yeux*. Paris, France: Delahaye; 1867.
14. di Ottal A. 1891:117.
15. Heine L. Die Cyklodialyse, eine neue Glaukomoperation. *Deutsche Med Woch*. 1905; 31:824.
16. Hancock H. Division of the ciliary muscle for glaucoma. *Lancet*. 1861; 9:137.
17. Gedde SJ, Schiffman JC, Feuer WJ, et al. Treatment outcomes in the Tube Versus Trabeculectomy (TVT) study after five years of follow-up. *Am J Ophthalmol*. 2012; 153:789–803. [PubMed: 22245458]
18. Sugar HS. Some recent advances in the surgery of glaucoma. *Am J Ophthalmol*. 1962; 54:917. [PubMed: 13979103]
19. The San Francisco Western Lancet a Journal of Practical Medicine and Surgery. 6:56–57.
20. Gedde SJ, Herndon LW, Brandt JD, et al. Postoperative Complications in the Tube Versus Trabeculectomy (TVT) Study During Five Years of Follow-up. *Am J Ophthalmol*. 2012; 153:804–814. [PubMed: 22244522]
21. Mosaed S, Dustin L, Minckler DS. Comparative outcomes between newer and older surgeries for glaucoma. *Trans Am Ophthalmol Soc*. 2009; 107:127. [PubMed: 20126489]
22. Arriola-Villalobos P, Martínez-de-la-Casa JM, Díaz-Valle D, et al. Combined iStent trabecular micro-bypass stent implantation and phacoemulsification for coexistent open-angle glaucoma and cataract: a long-term study. *Br J Ophthalmol*. 2012; 96:645–649. [PubMed: 22275344]
23. Ting JL, Damji KF, Stiles MC. Trabectome Study G. Ab interno trabeculectomy: outcomes in exfoliation versus primary open-angle glaucoma. *J Cataract Refract Surg*. 2012; 38:315–323. [PubMed: 22322166]
24. Bahler CK, Hann CR, Fjield T, et al. Second-generation trabecular meshwork bypass stent (iStent inject) increases outflow facility in cultured human anterior segments. *Am J Ophthalmol*. 2012; 153:1206–1213. [PubMed: 22464365]
25. Walkow T, Anders N, Klebe S. Endothelial cell loss after phacoemulsification: relation to preoperative and intraoperative parameters. *J Cataract Refract Surg*. 2000; 26:727–732. [PubMed: 10831904]
26. Arnavielle S, Lafontaine PO, Bidot S, et al. Corneal endothelial cell changes after trabeculectomy and deep sclerectomy. *J Glaucoma*. 2007; 16:324–328. [PubMed: 17438428]
27. Brubaker RF. Determination of episcleral venous pressure in the eye: a comparison of three methods. *Arch Ophthalmol*. 1967; 77:110. [PubMed: 6015706]