

Outcomes of the Paul Glaucoma Implant in Refractory Secondary Glaucoma

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Purpose: To evaluate the efficacy and safety of the Paul Glaucoma Implant (PGI) surgery in patients with secondary glaucomas.

Patients and Methods: Retrospective chart review of adult patients with medically recalcitrant secondary glaucoma who underwent PGI implantation at a single tertiary center between August 2022 and June 2023. The primary outcome measure was surgical success. Surgical success was defined as intraocular pressure (IOP) between 6 and 21 mmHg with a $\geq 20\%$ reduction compared to baseline (with or without medications) with no need for implant removal, further glaucoma reoperation, or development of vision-threatening complications at 1 year of follow-up. The secondary outcomes were IOP, glaucoma medication numbers, visual acuity, and surgical complications.

Results: Thirty eyes of 30 patients were identified. Nine patients (30%) had neovascular glaucoma, and 9 patients (30%) had silicone-oil-induced glaucoma. At 12 months postoperatively, 28 eyes (93.3%) fulfilled the success criteria. The mean IOP at 12 months was 15.2 ± 4.6 mmHg compared to the mean baseline IOP of 32.6 ± 10 mmHg ($p < 0.001$). A significant reduction in the mean number of glaucoma medications at 12 months compared to the baseline was observed. The complication rate was 13.3% (4 eyes), with most complications being mild and transient.

Conclusion: The PGI demonstrated favorable efficacy and safety profiles in the management of medically uncontrolled secondary glaucomas.

Keywords: Paul Glaucoma Implant, secondary glaucoma, intraocular pressure, tube

Introduction

Glaucoma drainage devices (GDDs) implantation is a common surgical option for managing refractory glaucoma, especially secondary glaucomas, such as those related to uveitis, retinal surgeries, and neovascular causes.^{1,2} Currently, the most commonly used GDDs are the Ahmed glaucoma valve (AGV; New World Medical, Rancho Cucamonga, CA) and the non-valved Baerveldt glaucoma implant (BGI; Johnson & Johnson, Santa Ana, CA).^{3,4}

Studies show that BGIs are associated with higher success rates compared to AGVs but have a higher risk of hypotony.⁵ Postoperative hypotony can cause vision-threatening complications such as suprachoroidal hemorrhage, hypotony maculopathy, and cataract progression.⁶ Thus, non-valved GDDs require surgical modifications (eg; ligation of the tube or a tube-occluding ripcord) to restrict aqueous outflow during surgery and decrease the risk of postoperative hypotony.

The Paul Glaucoma Implant (PGI; Advanced Ophthalmic Innovations, Singapore, Republic of Singapore) is a newer GDD with a potentially improved safety profile.⁷ The internal and external tube diameters are significantly smaller than those of the AGV and BGI implants, which presumably lowers the risk of corneal endothelial cell loss due to a reduction in the area of contact between the tube and the endothelium. Additionally, a theoretically lower tube exposure rate is

proposed due to the external diameter of the extraocular part of the tube being smaller than in AGVs and BGIs.⁸ Even though the PGI tube has a smaller internal diameter compared to other GDDs, it exhibited minimal resistance to aqueous flow, which theoretically lowers the risk of early hypotony. Additionally, the PGI has a shorter plate size breadth compared to BGI, which reduces the area of the plate tucked under the recti muscles with a subsequent lower possible rate of postoperative strabismus.⁸

Previous studies evaluated the PGI in the management of medically recalcitrant primary open-angle glaucoma (POAG).^{8–10} Data regarding the outcomes and complications of PGI treating secondary glaucomas is very scarce. In this study, we report the efficacy and safety of PGI surgery in 30 eyes of 30 patients with refractory secondary glaucoma over a follow-up period of 1 year.

Materials and Methods

Study Design

This study is a single-center retrospective chart review of patients >18 years of age with refractory secondary glaucoma who had undergone PGI implantation between August 2022 and June 2023 with a minimum of 12 months postoperative follow-up. The study was approved by the Institutional Review Board (IRB) of Moorfields Eye Hospital Dubai and adheres to the Tenets of the Declaration of Helsinki (2013 version) and Health Insurance Portability and Accountability Act (HIPPA) regulations. Informed consent was not obtained due to its retrospective nature of the study and the lack of identifiable patient data.

The following data were collected from patient records: demographics, type of glaucoma, previous glaucoma surgeries, preoperative and postoperative intraocular pressure (IOP), number of glaucoma medications, visual acuity (VA), and any intraoperative or postoperative complications. Intraocular pressure was measured by Goldmann applanation tonometry.

Outcome Measures

Cumulative surgical success rate was the primary outcome of this study. Surgical success was defined as IOP from 6 to 21 mm Hg with a reduction $\geq 20\%$ from baseline on 2 consecutive visits (regardless of medication use) and without the need for implant removal or glaucoma reoperation, development of vision threatening complications, or loss of light perception (LP) vision. Secondary outcome measures included IOP reduction, glaucoma medication reduction, changes in VA, and intraoperative or postoperative complications.

Surgical Technique

A single glaucoma specialist (MSS) performed the surgeries. The PGI was placed in the superotemporal quadrant, although in specific situations (eg, silicone-filled eyes) the PGI was placed inferonasally. A fornix-based peritomy was created, followed by cauterization of bleeding points. The recti muscles were isolated. A 6–0 polypropylene ripcord was used as an intraluminal stent. The wings of the PGI were tucked under the recti muscles, and the plate was secured to the sclera using 8–0 nylon sutures. The surgeon tucked the other end of the ripcord under the temporal conjunctiva.

The tube was trimmed to an appropriate length with the bevel directed away from the iris and then inserted into the anterior chamber. A half-thickness corneal patch graft was used to cover the tube. Closure of the conjunctival peritomy was performed using 7–0 Vicryl sutures. Postoperatively, a standardized regimen of postoperative antibiotics and topical steroids was used depending on the clinical findings and postoperative course.

Statistical Analysis

Data entry was done using Microsoft Excel 2018 (Microsoft, Redmond, VA), and analysis was conducted with the Statistical Package for the Social Sciences (SPSS Inc., version 28, Chicago, IL, USA). The normality of the study variables was assessed using histograms and the Shapiro–Wilk test. For analysis, the VA values were converted to logarithms of the minimum angle of resolution (logMAR) equivalents. A paired *t*-test was used to compare patients'

preoperative and postoperative values at each follow-up visit. Kaplan–Meier survival analysis was employed to assess the cumulative success rate after PGI implantation. A p-value less than 0.05 was deemed statistically significant.

Results

A total of 30 eyes of 30 patients was included in the study. The mean age at the time of the surgery was 58.3 ± 7.4 years. Most patients were males (76.7%) and White (76.7%). The most common types of glaucoma were neovascular and silicone-oil-induced, nine eyes (30%) each. In 10 patients (33.3%), the PGI plate was placed inferonasally. In 20 patients (66.7%), the location of the plate was superotemporal. Out of the 30 patients, 16 patients (53.3%) required removal of the ripcord (3 patients at 2 months and 13 patients at 3 months postoperatively). Table 1 presents the baseline characteristics of the enrolled patients.

Surgical Success

The cumulative probability of success after PGI implantation was 96.7% (29 eyes) at postoperative month (POM) 1 and 93.3% (28 eyes) at POMs 3, 6, and 12 after PGI surgery. (Figure 1) The reasons for failure were inadequate IOP reduction in one eye and hypotony in another eye. Both eyes required reoperation in the form of cyclophotocoagulation in the eye with uncontrolled IOP and reinsertion of the ripcord in the eye with hypotony.

Table 1 Baseline Characteristics of Study Participants (N = 30)

Characteristics	
Age, years	
Mean (SD)	58.3 (7.4)
Follow-up, months	
Mean (SD)	14.6 (2.1)
Gender, N (%)	
Male	23 (76.7)
Female	7 (23.3)
Laterality, N (%)	
Right eye	15 (50)
Left eye	15 (50)
Race, N (%)	
White	23 (76.7)
Asian	7 (23.3)
Type of Glaucoma, N (%)	
Neovascular Glaucoma	9 (30)
Silicone-oil induced Glaucoma	9 (30)
Pseudoexfoliation Glaucoma	5 (16.7)
Post-Keratoplasty Glaucoma	3 (10)
Traumatic Glaucoma	2 (6.7)
Uveitic Glaucoma	1 (3.3)
Lens-induced Glaucoma	1 (3.3)
Lens Status	
Pseudophakic	16 (53.4)
Phakic	10 (33.3)
Aphakic	4 (13.3)

(Continued)

Table 1 (Continued).

Characteristics	
Number of Prior Ocular Procedures, N (%)	
0	8 (26.7)
1	7 (23.3)
2	9 (30.0)
3	4 (13.3)
4	2 (6.7)
Prior Glaucoma Surgeries, N (%)	
Yes*	3 (10)
No	27 (90)
VA, LogMAR	
Mean (SD)	1.1 (0.9)

Note: *One eye had trabeculectomy, transscleral cyclophotocoagulation (TSCPC), and Ahmed glaucoma valve (AGV) implantation, one eye had Preserflo microshunt implantation, and one eye had AGV implantation followed by TSCPC.

Abbreviations: VA, visual acuity; LogMAR, logarithm of the minimum angle of resolution; SD, standard deviation.

Intraocular Pressure, Glaucoma Medication, and Visual Acuity Changes

IOP and medication changes are summarized in [Table 2](#). PGI surgery resulted in a post-operative IOP reduction from 32.6 ± 10 mmHg at baseline to 19.3 ± 8.4 mmHg at POM 1, 15.4 ± 5.0 at POM 3, 15.6 ± 3.3 at POM 6 and 15.2 ± 4.6 at POM 12 (all $p < 0.001$). The mean percent reduction of IOP at 12 months was 53.4% from baseline measurements.

Similarly, after PGI surgery, there was a statically significant reduction in the number of glaucoma medications from 4.0 ± 0.9 preoperatively to post-operative follow-up 1.4 ± 1.2 at POM 1 ($p < 0.001$), 0.8 ± 1.1 at POM 3 ($p < 0.001$), $0.9 \pm$

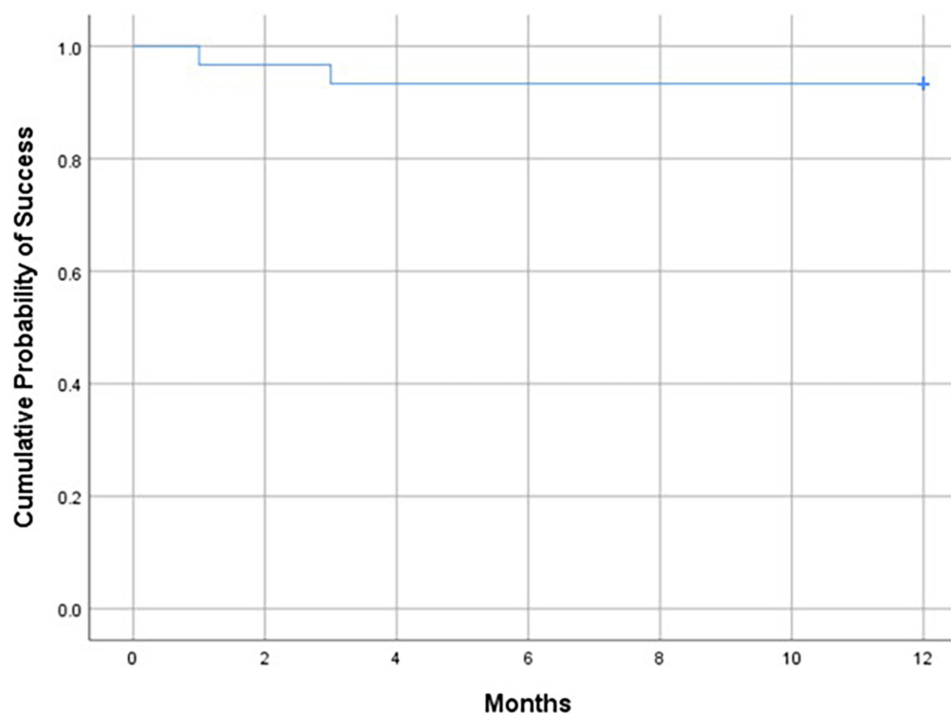


Figure 1 Kaplan-Meier plot indicates cumulative success rate after Paul Glaucoma Implant (PGI) surgery during the follow-up period.

Table 2 Changes in IOP and Number of Medications in Mean on Consecutive Follow-Up Visits

	Baseline	1 Month Postop	3 Months Postop	6 Months Postop	12 Months Postop
IOP (mmHg Mean (SD, Minimum – Maximum))	32.6 (10, 16–47)	19.3 (8.4, 6–49)	15.4 (5, 5–28)	15.6 (3.3, 8–21)	15.2 (4.6, 7–20)
p value	–	< 0.001	< 0.001	< 0.001	< 0.001
Change (Mean, SD, 95% CI)	–	–12.3 (10.2, 9.5–17.1)	–17.4 (10.6, 13.2–21.5)	–16.9 (11, 12.8–21)	–17.4 (11, 13.2–21.5)
Percentage Change	–	–37.7%	–53.4%	–51.8%	–53.4%
Glaucoma medications (no. Mean (SD, Minimum – Maximum))	4 (0.9, 2–5)	1.4 (1.2, 0–4)	0.8 (1.1, 0–4)	0.9 (1.2, 0–4)	0.9 (1.2, 0–4)
p value	–	< 0.001	< 0.001	< 0.001	< 0.001
Change (Mean, SD, 95% CI)	–	–2.6 (1.6, 2–3.2)	–3.2 (1.4, 2.7–3.8)	–3.1 (1.5, 2.6–3.7)	–3.1 (1.5, 2.6–3.7)
Percentage Change	–	–65%	–80%	–77.5%	–77.5%
N	30	30	29	30	30

1.2 at POM 6 ($p < 0.001$), and 0.9 ± 1.2 at POM 12 ($p < 0.001$). Prior to PGI implantation, 30 eyes (100%) were on topical antiglaucoma medications, and 15 eyes (50%) were on oral carbonic anhydrase inhibitors. Eighteen patients (60%) were medication-free at the last follow-up visit after surgery.

There was a non-statically significant reduction of logMAR VA from 1.1 ± 0.9 at baseline to 0.9 ± 0.9 at month 12 postoperatively ($p = 0.4$). Only one (3.3%) eye had a vision loss of 2 Snellen or more in VA, which was attributed to glaucoma progression and not a consequence of the PGI surgery.

Complications

Postoperative complications were largely mild. One eye (3.3%) had conjunctival retraction over a patch graft, with no tube exposure noted, and was managed with a bandage contact lens. Two eyes (6.7%) developed a postoperative hyphema that resolved spontaneously within 2 weeks of follow-up. One eye (3.3%), with a prior history of pars plana vitrectomy, developed hypotony after ripcord removal, which required reinsertion of the intraluminal stent suture. No cases of diplopia, corneal decompensation, cataract progression, tube or implant exposure, retinal detachment, or endophthalmitis were observed.

Discussion

This study evaluated the surgical outcomes of PGI in patients with secondary glaucoma. The success rate was 93.3% at 12 months of follow-up. Furthermore, IOP was significantly lower at all follow-up visits with a mean reduction of 17.4 mmHg from baseline. At 12 months of follow-up, patients required 3 fewer glaucoma medications on average compared to before PGI implantation. The findings of this study also suggest that PGI has a favorable safety profile, with no patients developing endophthalmitis, tube exposure, or corneal decompensation.

The success rate in the current study is comparable to previous glaucoma drainage implant studies.^{8–10} A prospective multicenter study by Koh and et al⁸ evaluated the outcomes of PGI in 82 glaucomatous patients. Of the enrolled participants, twenty-seven patients (36.5%) had secondary glaucomas. The failure rate (defined as IOP < 6 mmHg or > 21 mmHg or IOP reduction of $< 20\%$ from baseline on 2 consecutive visits, loss of vision, device removal, or glaucoma reoperation) was 5.4% at 12 months, which is similar to the failure rate reported in the current study. They also reported a significant reduction of IOP from 23.1 ± 8.2 mmHg on 3.3 ± 0.9 medications preoperatively to 13.2 ± 3.3 mmHg on 0.3 ± 0.6 medications at 12 months postoperatively, with a mean IOP reduction of 9.9 mmHg and medication reduction of 3, which is lower than the IOP reduction (17.4 mmHg) but similar to the medication changes (3.1 medications) in our study.

In a retrospective study that included 99 eyes with glaucoma (approximately 50% of eyes were diagnosed with secondary glaucomas) who underwent PGI implantation, the reported success rate (IOP < 21 mmHg or a $> 20\%$ reduction of IOP, without removal of the implant, further glaucoma intervention or visual loss to no LP) was 90.1%, which is comparable to our findings.⁹ During the last follow-up visit, the mean IOP reduction in the aforementioned study was 15.1 mmHg (versus 17.4 in our study), and the mean reduction of medication numbers was 2.38 (compared to 3.1 in our study).⁹

Jose and et al¹⁰ conducted a retrospective study involving 24 patients with a history of PGI surgery. Fifteen patients (62.5%) were diagnosed with secondary glaucomas prior to PGI implantation. Success was defined as an IOP between 6 and 18 mmHg, along with a minimum 30% reduction in IOP. They found an absolute success rate (without glaucoma medications) of 33% and a qualified success rate (with glaucoma medications) of 75%. The study also showed a significant drop in mean IOP, from a mean of 31.4 ± 10.0 mmHg before surgery to 12.5 ± 4.3 mmHg at 1 year. Moreover, the average number of glaucoma medications decreased from 3.0 at baseline to 0.9 at 12 months.¹⁰

Although the surface area of the PGI's plate (342 mm²) is slightly smaller than the BGI (350 mm²), the PGI has a larger effective surface area due to the shorter wingspan (so less area tucked under the recti muscles) and longer anteroposterior plate width compared to the BGI.¹¹ Previous studies suggested that postoperative IOP is also directly proportional to GDD size.¹² So, the low failure rates and good efficacy seen in this series and previous reports could possibly be due to the larger effective plate surface area of the PGI.

Recently, Berteloot et al¹³ compared the outcomes of 23 patients (43% with secondary glaucomas) who underwent PGI implantation versus 27 patients (52% with secondary glaucomas) who had BGI implant surgery. At 1 year, no significant difference between the success rates of PGI and BGI groups was observed. The mean IOP in the patients who underwent PGI implantation was lower than those who had BGI implantation at 12 months ($P = 0.024$). The complication rates between the PGI and BGI were comparable with a trend towards a higher number of complications with the BGI especially hypotony-related complications. The BGI patients also required a higher number of postoperative interventions.

Most of the reported complications in our cohort were minor and self-limiting. The most common reported complication was hyphema in 6.7% of the treated eyes, which resolved spontaneously within the first 2 postoperative weeks. One eye (3.3%) developed hypotony requiring surgical intervention. This rate is lower than that reported by Koch and colleagues⁸ (9.5%) but comparable to the rate of 2% reported by Vallabh and colleagues.⁹ This could possibly be due to the similar technique of using a 6–0 polypropylene intraluminal stent in all the patients in our series and Vallabh's; however, in the study by Koch's and colleagues, a stent was used in only approximately 15% of the patients. The smaller internal lumen of PGI might be associated with the lower rates of hypotony requiring intervention compared to other GDDs such as the BGI.¹⁴

One of the concerns with GDDs implantation is endothelial cell loss (ECL) and subsequent corneal decompensation. This is especially important in patients with shallower anterior chambers and shorter eyes. No cases of corneal decompensation were reported in the current series; however, a longer follow-up period might be needed to confirm our findings. The reported rates of corneal decompensation following AGV and BGI ranged from around 4% to 12%.^{15,16}

The exact cause of ECL after GDDs is not fully understood, but proposed mechanisms include mechanical trauma due to the tube's proximity to the endothelium, increased aqueous humor flow near the tube entry site, and postoperative inflammation.^{17,18} The PGI occupies less space in the anterior chamber compared to traditional GDDs, when the tube length is the same, due to its smaller tube diameter. According to the Hagen–Poiseuille equation, the narrower lumen of PGI leads to greater resistance to fluid flow, which is inversely proportional to the fourth power of the tube diameter.¹⁹ Consequently, the aqueous flow rate through PGI is lower than that of traditional GDDs. High flow rates and turbulence at the tube tip have been linked to ECL after GDD implantation.^{18,20} Theoretically, the reduced flow through the PGI could lower the risk of ECL. However, other factors such as the implant's position in the anterior chamber, its distance from the endothelium and iris, and overall tube length have not been fully explored in relation to ECL.

GDD-related tube and plate exposure and endophthalmitis are devastating complications that can occur even many years postoperatively.²¹ Although one patient had conjunctival retraction due to a broken suture near the limbus, the tube was still covered with the corneal patch graft and was managed conservatively. No cases of tube erosion or endophthalmitis were observed in this series. Compared to AGV and BGI, the smaller PGI tube external diameter with the lower cross-sectional profile outside the sclera, could potentially lead to a decreased risk of conjunctival erosion.²²

The limitations of this study include that it is a retrospective study that limits the analysis of some variables such as endothelial cell count. Additionally, the number of the study participants was modest, and the study has a relatively short follow-up period. Nevertheless, to our knowledge, this is the first study that evaluates PGI outcomes in a cohort of secondary refractory glaucomas.

In conclusion, this study suggests that PGI implantation is a relatively safe and efficient surgical treatment option in complex secondary glaucoma patients.

Data Sharing Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

The study was approved by the Institutional Review Board (IRB) of Moorfields Eye Hospital Dubai. Informed consent was not obtained due to its retrospective nature and the lack of identifiable patient data.

Author Contributions

All authors attest that they meet the current ICMJE criteria for Authorship.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Aref AA, Gedde SJ, Budenz DL. Glaucoma drainage implant surgery. *Dev Ophthalmol*. 2017;59:43–52.
2. Serhan HA, Ba-Shammakh SA, Hassan AK, et al. Effectiveness and safety of trabeculectomy versus tube shunt implantation for uveitic glaucoma: a systematic review and meta-analysis. *Am J Ophthalmol*. 2024;268:319–328. doi:10.1016/j.ajo.2024.08.045
3. Ayyala RS, Duarte JL, Sahiner N. Glaucoma drainage devices: state of the art. *Expert Rev Med Devices*. 2006;3(4):509–521. doi:10.1586/17434440.3.4.509
4. Lim KS. Control and optimisation of fluid flow in glaucoma drainage device surgery. *Eye (Lond)*. 2018;32(2):230–234. doi:10.1038/eye.2017.316
5. Christakis PG, Zhang D, Budenz DL, Barton K, Tsai JC, Ahmed IIK. Five-year pooled data analysis of the Ahmed baerveldt comparison study and the Ahmed versus baerveldt study. *Am J Ophthalmol*. 2017;176:118–126.
6. Bailey AK, SR S Jr. Complications of tube implants and their management. *Curr Opin Ophthalmol*. 2014;25(2):148–153. doi:10.1097/ICU.0000000000000034
7. Khodeiry M, Sayed MS. New glaucoma drainage implants available to glaucoma surgeons. *Curr Opin Ophthalmol*. 2023;34(2):176–180. doi:10.1097/ICU.0000000000000936
8. Koh V, Chew P, Triolo G, et al. Treatment Outcomes Using the PAUL Glaucoma Implant to Control Intraocular Pressure in Eyes with Refractory Glaucoma. *Ophthalmol Glaucoma*. 2020;3(5):350–359. doi:10.1016/j.ogla.2020.05.001
9. Vallabh NA, Mason F, JTS Y, et al. Surgical technique, perioperative management and early outcome data of the PAUL® glaucoma drainage device. *Eye (Lond)*. 2022;36(10):1905–1910. doi:10.1038/s41433-021-01737-1
10. José P, Barão RC, Teixeira FJ, et al. One-Year Efficacy and Safety of the PAUL Glaucoma Implant Using a Standardized Surgical Protocol. *J Glaucoma*. 2022;31(3):201–205. doi:10.1097/IJG.0000000000001969
11. Tan MCJ, Choy HYC, Koh Teck Chang V, et al. Two-Year Outcomes of the Paul Glaucoma Implant for Treatment of Glaucoma. *J Glaucoma*. 2022;31(6):449–455. doi:10.1097/IJG.0000000000001998
12. Schwartz KS, Lee RK, Gedde SJ. Glaucoma drainage implants: a critical comparison of types. *Curr Opin Ophthalmol*. 2006;17(2):181–189. doi:10.1097/01.icu.0000193080.55240.7e
13. Berteloot S, Correia Barão R, Abegão Pinto L, Vandewalle E, Stalmans I, Lemmens S. Treatment Outcomes Comparing the Paul and Baerveldt Glaucoma Implants After One Year of Follow-Up. *J Glaucoma*. 2024;33(8):594–600. doi:10.1097/IJG.0000000000002366
14. Elhusseiny AM, Khodeiry MM, Lee RK, Shaarawy T, Waqar S, Sayed MS. Early Experience with the Paul Glaucoma Implant in Childhood Glaucoma: a Case Series. *Clin Ophthalmol*. 2023;17:1939–1944. doi:10.2147/OPHTH.S414183
15. Budenz DL, Feuer WJ, Barton K, et al. Postoperative Complications in the Ahmed Baerveldt Comparison Study During Five Years of Follow-up. *Am J Ophthalmol*. 2016;163:75–82.e3. doi:10.1016/j.ajo.2015.11.023
16. Christakis PG, Kalenak JW, Tsai JC, et al. The Ahmed Versus Baerveldt Study: five-Year Treatment Outcomes. *Ophthalmology*. 2016;123(10):2093–2102. doi:10.1016/j.ophtha.2016.06.035
17. Lass JH, Benetz BA, He J, et al. Corneal Endothelial Cell Loss and Morphometric Changes 5 Years after Phacoemulsification with or without CyPass Micro-Stent. *Am J Ophthalmol*. 2019;208:211–218.
18. Koo EB, Hou J, Keenan JD, Stamper RL, Jeng BH, Han Y. Effects of Glaucoma Tube Surgery on Corneal Endothelial Cells: a Review. *Eye Contact Lens*. 2016;42(4):221–224. doi:10.1097/ICL.0000000000000171
19. McEwen WK. Application of Poiseuille's Law to Aqueous Outflow. *AMA Arch Ophthalmol*. 1958;60(2):290–294. doi:10.1001/archophth.1958.00940080306017
20. McDermott ML, Swendris RP, Shin DH, Juzych MS, Cowden JW. Corneal endothelial cell counts after Molteno implantation. *Am J Ophthalmol*. 1993;115(1):93–96.

21. Bains U, Hoguet A. Aqueous Drainage Device Erosion: a Review of Rates, Risks, Prevention, and Repair. *Semin Ophthalmol.* 2018;33(1):1–10. doi:10.1080/08820538.2017.1353805
22. Chaku M, Netland PA, Ishida K, Rhee DJ. Risk factors for tube exposure as a late complication of glaucoma drainage implant surgery. *Clin Ophthalmol.* 2016;10:547–553. doi:10.2147/OPTH.S104029

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