REVIEW

Novel surgical implants in the treatment of childhood glaucoma

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Purpose of review
Conventional glaucoma drainage devices (GDDs), such as the Ahmed Glaucoma Valve and Baerveldt Glaucoma Implant, are widely used in childhood glaucoma. Recently, newer surgical options, including the PRESERFLO microshunt, Paul Glaucoma Implant (PGI), eyePlate-S, and ClearPath, have emerged with potential advantages to childhood glaucoma patients. This review summarizes current evidence regarding the design, outcomes, and safety profiles of these newer implants in childhood glaucoma patients.

Recent findings
The PRESERFLO offers a minimally invasive approach with favorable safety and intraocular pressure (IOP)-lowering outcomes in small pediatric case series, including eyes with prior GDD implantation. It is typically used with adjunctive mitomycin C. Technical modifications, such as ripcord insertion, reduce the risk of postoperative hypotony.
The PGI features a valveless design that enables controlled flow via a 6-0 Prolene ripcord without external ligation. Additionally, its design reduces contact with the corneal endothelium and extraocular muscles. Retrospective series and early randomized data suggest good IOP control with an acceptable safety profile.
The eyePlate-S features a valveless design that allows controlled flow through a 5-0 Prolene ripcord, eliminating the need for external ligation. Its tube has an external diameter comparable to the PGI (0.47 mm) but a larger internal diameter (0.18 mm in the eyePlate-S vs. 0.13 mm in the PGI). The eyePlate-200S can also be positioned between extraocular muscles, which may reduce the risk of postoperative diplopia. In addition, the thin, flexible silicone plate can be folded to facilitate implantation.
The ClearPath enables flexible implantation in complex pediatric anatomy. Early multiyear results show sustained IOP reduction and decreased medication burden, with a success rate of 79% at 4 years.

Summary
Newer devices such as the PRESERFLO, PGI, and ACP demonstrate encouraging mid-term efficacy and safety in the management of childhood glaucoma, particularly in refractory cases or eyes with prior surgeries. While early outcomes are promising, larger comparative studies with extended follow-up are needed to better establish their long-term role relative to conventional GDDs in childhood glaucoma management.

Keywords
Ahmed ClearPath, childhood glaucoma, glaucoma, intraocular pressure, microshunt, Paul Glaucoma Implant, pediatric glaucoma, PreserFlo

INTRODUCTION

Childhood glaucoma comprises a heterogeneous group of disorders that can lead to irreversible visual impairment if not promptly and effectively treated [1,2]. Filtration surgery, including conventional trabeculectomy and glaucoma drainage device (GDD) implantation, is often reserved for refractory cases or selected secondary glaucomas as a first-line surgical intervention [3,4]. The most commonly used GDDs in pediatric populations are the Baerveldt Glaucoma Implant (BGI, Abbott Medical Optics Inc., Santa Ana, California, USA) and the Ahmed Glaucoma Valve (AGV, New World Medical Inc., Rancho Cucamonga, California, USA) [3]. In recent years, newer devices have been introduced, such as the Paul Glaucoma Implant (PGI, Advanced Ophthalmic Innovations,

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Curr Opin Ophthalmol 2026, 37:89–98

DOI:10.1097/ICU.0000000000001194

KEY POINTS

- Newer devices such as the PRESERFLO microshunt, Paul Glaucoma Implant, Ahmed ClearPath, and eyePlate S provide innovative surgical options for childhood glaucoma, offering less invasive approaches, valveless designs, and flexible implantation.
- Early studies and case series demonstrate that these devices achieve significant intraocular pressure reduction, decreased medication burden, and acceptable safety profiles, with features like ripcord stenting reducing postoperative hypotony and flexible plates minimizing motility disturbances.
- While mid-term outcomes are promising, larger, comparative studies with extended follow-up are needed to establish the long-term effectiveness and optimal role of these newer implants relative to conventional glaucoma drainage devices in pediatric populations.

Singapore) and the Ahmed ClearPath (ACP, New World Medical Inc., Rancho Cucamonga, California, USA) [5–7].

In parallel, subconjunctival minimally invasive bleb-forming surgeries (MIBS) using small-lumen microshunts have garnered increasing interest as a potential intermediate step before resorting to traditional GDDs in childhood glaucoma [8]. These include the PRESERFLO ab-externo microshunt (formerly known as InnFocus microshunt) (Santen, Osaka, Japan) and the XEN Gel Stent (Allergan, Dublin, Ireland). These procedures are typically performed with adjunctive mitomycin C (MMC) to enhance surgical success and are designed to divert aqueous humor through a narrow lumen into the subconjunctival and sub-Tenon's spaces via a minimally invasive approach and a relatively small conjunctival incision [9,10]. The XEN stent, composed of porcine-derived collagen, raises concerns regarding long-term durability in pediatric patients due to the potential for biodegradation [11]. Current evidence supporting its use in children is limited to small case series and individual case reports, with variable outcomes [12,13].

In this article, we review the current evidence regarding the effectiveness and safety of the PRESERFLO microshunt, the PGI, and the ACP in the management of childhood glaucoma.

PRESERFLO AB-EXTERNO MICROSHUNT

Design

The PRESERFLO MicroShunt is made from poly-(styrene-block-isobutylene-block-styrene) (SIBS), a biocompatible and biologically inert polymer [14,15]. Unlike the XEN gel stent, SIBS exhibits long-term stability and has been previously utilized in coronary stents, making it more suitable for use in the pediatric population. Moreover, SIBS is thought to minimize the risk of postoperative episcleral scarring and fibrosis [14,15].

The device measures 8.5 mm in length and is divided by a 1 mm fin into two segments: a 3 mm distal portion and a 4.5 mm proximal portion. The fin prevents migration of the device into the anterior chamber and reduces the risk of peritubular leakage. The external diameter is 350 μm, while the internal lumen diameter is 70 μm. The lumen size is designed to be small enough to prevent hypotony under normal aqueous flow yet large enough to resist occlusion by sloughed endothelial cells (40–50 μm). The proximal end is beveled to facilitate insertion into the anterior chamber (Fig. 1) [14–17]. The smaller dimensions of the PRSERFLO, compared to most GDDs, may theoretically reduce the risk of endothelial cell loss in pediatric patients.

The surgery is typically performed via an ab-externo approach and augmented by MMC, either by subconjunctival injection [8] or application using soaked sponges [18]. Some surgeons prefer MMC injection over sponge application to avoid the need for a larger incision [8]. The preferred surgical site is the superonasal quadrant through a small periotomy incision (less than 2 o'clock hours), preserving the superotemporal quadrant for potential future GDD surgery if needed [19].

A possible technical modification involves inserting a 9-0 or a 10-0 nylon suture as a temporary ripcord to control postoperative aqueous flow, reducing the risk of hypotony, especially in high-risk patients such as those with Sturge–Weber syndrome (SWS)-associated glaucoma, with only one case report in pediatric literature using this technique [20]. However, in the adult glaucoma literature, a recent study by Verma-Fuehring *et al.* [21] compared the outcomes of PRESERFLO MicroShunt implantation with and without 10-0 nylon suture stenting. The stent was removed between 21 and 42 days postoperatively. While the median IOP after 3 months was similar between both groups, the incidence of hypotony was significantly lower in the stented group (6.2%) compared to the nonstented group (15.8%).

Outcomes

Table 1 summarizes the studies evaluating the efficacy and safety of the PRESERFLO MicroShunt in childhood glaucoma. To date, five studies, including a total of 70 eyes, have been reported [8,18,20,22▪,23].

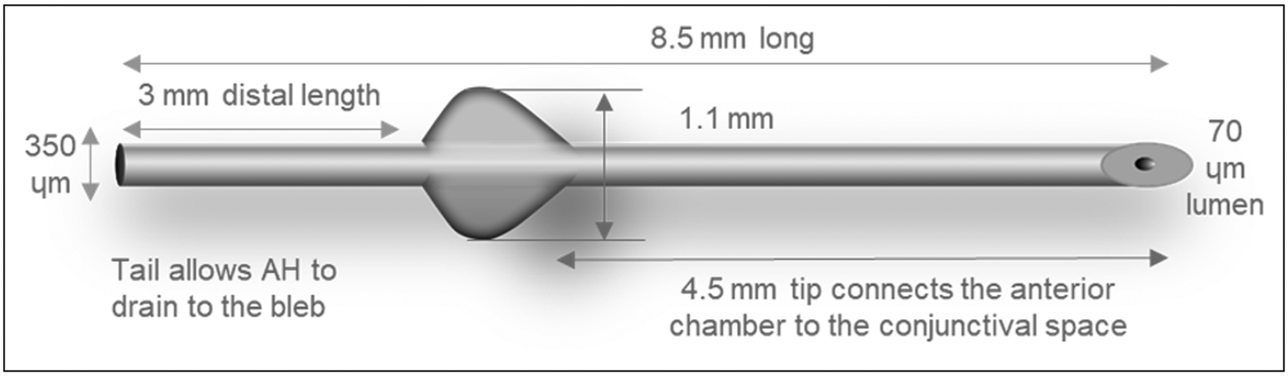

FIGURE 1. The PRESERFLO MicroShunt detailed specifications. Reprinted with permission from Glaukos.

Although PRESERFLO is not currently approved by the US Food and Drug Administration, the first published study was a prospective case series by Brandt [8], involving 12 pediatric patients who underwent PRESERFLO implantation under a compassionate use investigational device exemption. All eyes had a history of at least one prior glaucoma surgery, and all received an intraoperative injection of 40 μg of MMC. At 1 year, the mean IOP was reduced by 45% from baseline, and nine eyes met the criteria for surgical success (defined as ≥25% IOP reduction without evidence of glaucoma progression). One case of low-lying choroidal effusion occurred in a patient with SWS, which resolved with cycloplegia. In cases of postoperative IOP elevation despite restarting glaucoma medications, Brandt suggested injecting an additional 40 μg of MMC and using a 25-gauge needle to revise the encapsulated bleb.

A subsequent prospective study by Burgos-Blasco *et al.* [18]included 14 eyes with prior trabeculectomy and/or GDD surgery. MMC (0.04%) was applied using three soaked sponges for 2.5 min. At 12 months postoperatively, the authors reported a mean IOP reduction of 11.3 ± 4.9 mmHg, with ~80% of eyes having at least 30% IOP reduction from baseline. No intraoperative or postoperative complications were observed; however, one patient required bleb needling during the follow-up period.

Durante and colleagues conducted a retrospective study of 20 eyes, including eight with uveitic glaucoma, with a mean follow-up of 18.3 ± 7.7 months [23]. They reported a significant reduction in mean IOP from 27.8 ± 1.3 mmHg on 2.9 ± 1.1 medications preoperatively to 14.2 ± 8.5 mmHg on 1.2 ± 1.2 medications at 12 months. The overall success rate – defined as IOP between 6 and 21 mmHg with a ≥20% reduction, with or without medications – was 60% at 1 year. A subgroup analysis comparing primary versus secondary PRESERFLO implantation (i.e. after failed previous surgeries) showed no statistically significant differences in postoperative IOP, medication use, or success rates at 12 months. One case of early, asymptomatic hypotony was reported.

Another retrospective study focused exclusively on pediatric eyes that had previously undergone AGV implantation [22▪]. This study included 23 eyes with a median follow-up of 23 months. A significant reduction in mean IOP was observed, from 27.0 ± 4.3 mmHg on 3.2 ± 0.5 medications preoperatively to 16.9 ± 3.6 mmHg on 1.2 ± 1.5 medications postoperatively. The success rate – defined as at least 20% IOP reduction – was 91% at 1 year and 73% at 2 years.

None of the aforementioned studies utilized ripcord stenting of the device. However, Sesma *et al.* [20] reported a successful case of PRESERFLO implantation in a 32-week-old girl with SWS-associated glaucoma. Their technique included the insertion of a 9-0 nylon suture as a temporary ripcord, which was removed 3 months postoperatively to facilitate further IOP reduction. At 24 weeks, the patient required revision surgery, after which the IOP stabilized at 13 mmHg at the last follow-up visit.

These studies demonstrated that the PRESERFLO effectively lowers IOP with a favorable safety profile [8,18,20,22▪,23]. In our view, PRESERFLO can be considered an intermediate surgical step prior to GDD implantation or as an alternative to a second tube in eyes with previously failed tube surgery.

PAUL GLAUCOMA IMPLANT

Design

The PGI incorporates several distinct design features (Fig. 2). It is a valveless GDD constructed from medical-grade silicone, offering both pliability and ease of implantation (Fig. 3). The endplate is designed to maximize aqueous drainage while minimizing the portion that extends beneath the rectus muscles.

Table 1. Studies evaluating the outcomes of PRESERFLO Microshunt in childhood glaucoma

Study	Number of eyes (patients)	Age[a]	Type of glaucoma	Previous glaucoma surgeries	Preoperative IOP[a] (mmHg)	Preoperative GM[a]	Postoperative IOP[a]	Postoperative GM[a]	Success rates	Complications
Brandt, 2022	12 (12)	15 months to 14 years	6 PCG 6 SG	4 angle surgery only 5 angle surgery +GDD 3 GDD only	20.9 ± 4.4	3.4 ± 0.8	11.0 ± 2.5	0.3 ± 0.8	75% at 1 year	Shallow anterior chamber and choroidal effusion (one eye)
Burgos-Blasco *et al.*, 2022	14 (14)	27.5 ± 13.5 years	11 PCG 1 JOAG 2 SG	13 had ≥1 trabeculectomy 9 had ≥2 trabeculectomy 6 had ≥1 trabeculectomy +GDD	26.3 ± 5.1	3.9 ± 0.7	15.0 ± 4.1 at 1 year	0.7 ± 1.3 at 1 year	71% at 1 year	None
Durate *et al.*, 2025	20 (20) with 11 patients completing the 2-year follow-up	11.7 ± 1.1 years	5 PCG 2 JOAG 13 SG	8 had no previous surgeries 7 had one previous surgery 5 had >one previous surgery	27.8 ± 1.3	2.9 ± 1.1	14.2 ± 8.5 at 1 year 14.6 ± 13.9 at 2 years	1.2 ± 1.2 at 1 year 0.9 ± 1.3 at 2 years	50–60% at 1 year 45% at 2 years	Hyphema (one eye) Hypotony (one eye) Bleb encapsulation (four eyes)
Garcia-Bardera *et al.*, 2025[b]	23 (22), with 11 patients completing the 2-year follow-up	19.9 ± 15.7 years	18 PCG 5 SG	Mean of 4.6 ± 2.3 surgeries	27 ± 4.3	3.2 ± 0.5	14.1 ± 4.4 at 1 year 16.9 ± 3.6 at 2 years	0.5 ± 1.0 at 1 year 1.2 ± 1.5 at 2 years	82.6–91.3% at 1 year 63.6–72.7% at 2 years	- Device extrusion (one eye) - Early hypertensive spike (one eye)
Sesma *et al.*, 2025	1 (1)	32 weeks infant	SWS-	associated glaucoma	0	40	0	13 at 32 weeks	0	N/A
Iris incarceration										

GDD, glaucoma drainage device; GM, glaucoma medications; IOP, intraocular pressure; JOAG, juvenile open-angle glaucoma; N/A, not available; PCG, primary congenital glaucoma; SD, standard deviation; SG, secondary glaucoma; SWS, Sturge–Weber syndrome.
[a]Values are expressed in terms of mean ± standard deviation.
[b]All patients had previous Ahmed Glaucoma Valve implantation.

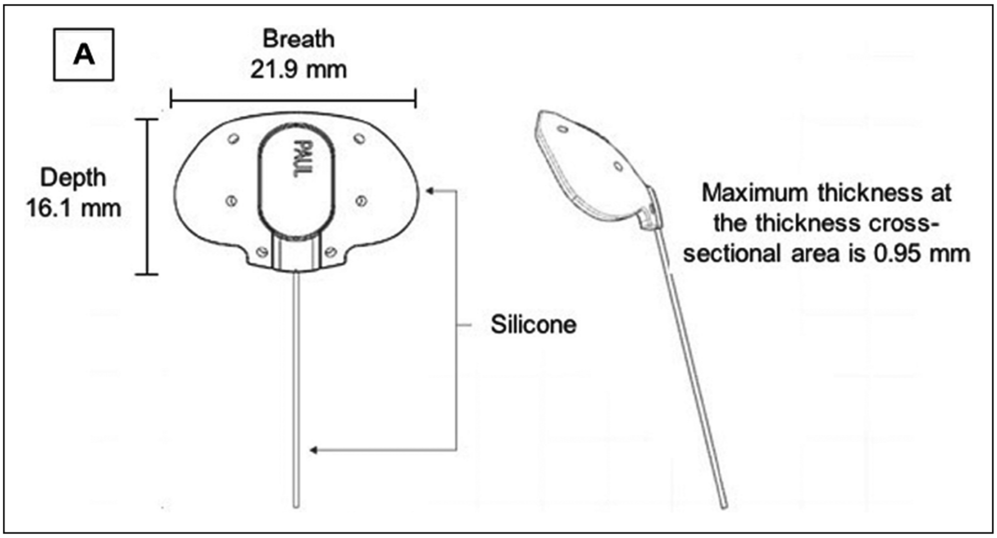

FIGURE 2. Design of Paul glaucoma implant. Reprinted with permission from Advanced Ophthalmic Innovations.

With a surface area of 342.1 mm^2, the PGI plate is slightly smaller than that of the BGI 350 yet substantially larger than that of the AGV (184 mm^2). The plate measures 21.9 mm in width and 16.11 mm in length and features a greater anteroposterior depth compared to the BGI, allowing it to extend further posteriorly. Conversely, its narrower wingspan reduces the area of the plate located beneath the extraocular muscles, theoretically lowering the risk of postoperative strabismus and diplopia.

The PGI tube has smaller internal (0.127 mm) and external (0.467 mm) diameters compared to the AGV or BGI. These smaller dimensions reduce the contact surface with the corneal endothelium, potentially lowering the risk of endothelial cell loss. Despite the smaller caliber, the device does not exhibit resistance to aqueous flow and may help reduce the risk of early postoperative hypotony. The tube lumen is specifically designed to accommodate a 6-0 Prolene ripcord (0.07–0.079 mm), as opposed to the larger 3-0 Prolene commonly used in the BGI, thereby allowing for partial occlusion. This configuration promotes controlled aqueous outflow, effective IOP reduction in the early postoperative phase, and a lower risk of hypotony – all without requiring an external ligature suture. The Prolene ripcord may be removed during the follow-up if further IOP reduction is needed [24,25].

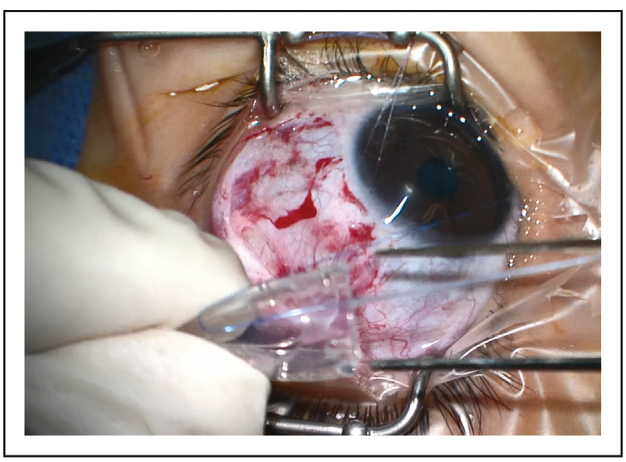

FIGURE 3. Intraoperative view demonstrating the flexibility of the Paul Glaucoma Implant endplate during surgical manipulation.

In pediatric patients, the authors' preferred technique avoids the use of a ligating suture, except in cases of SWS-associated glaucoma, where the risk of postoperative hypotony is higher [26]. This approach has also been adopted by other authors in adult populations with similarly low reported incidences of hypotony [27]. Some surgeons have employed intraoperative augmentation with MMC [28], while others have not [26].

Outcomes

To date, four studies have evaluated the efficacy and safety of the PGI in a total of 63 eyes with childhood glaucoma (Table 2). Three were noncomparative retrospective case series [28,29▪▪,30], and one was a randomized controlled trial comparing PGI to AGV [26]. In all studies, a 6-0 prolene ripcord was inserted without external ligation, except in one eye with SWS-associated glaucoma in the study by Elhusseiny *et al*. [26].

In the first published report regarding PGI use in childhood glaucoma, Vallabh *et al*. evaluated 25 eyes

Table 2. Studies evaluating the outcomes of Paul Gaucoma Implant and Ahmed ClearPath in childhood glaucoma

Study	Number of eyes (patients)	Age[a]	Type of glaucoma	Previous glaucoma surgeries	Preoperative IOP[a] (mmHg)	Preoperative GM[a]	Postoperative IOP[a]	Postoperative GM[a]	Success rates	Complications
Paul Glaucoma Implant studies										
Elhusseiny *et al.*, 2023	3 (3)	6 years 15 years 7 years	1 GFCS 1 PCG 1 Mixed	None Trabeculectomy Goniotomy	24 46 28	4 5 4	18 10 11	2 0 0	N/A	None
Vallabh *et al.*, 2023	25 (21)	8.3 ± 8.4 years	5 PCG 3 JOAG 4 GFCS 13 SG	3 BGI 3 Trabeculotomy/ combined trabeculotomy trabeculectomy 2 Goniotomy 3 CPC	30.9 ± 5.9	3.8 ± 0.7	13.2 ± 4.9 at 1 year 11.8 ± 7.7 at 2 years	1.0 ± 1.3 at 1 year 1.3 ± 1.6 at 2 years	84% at 1 and 2 years	2 Hypotony 1 Graft failure 1 Tube occlusion by vitreous
Mendoza-Moreira *et al.*, 2024[b]	10 (9)	13.0 ± 3.64 years	GFCS	8/10 eyes	29.5 ± 9.5	Median: 3.5	14.70 ± 3.95 at the last follow-up	2.0 at the last follow-up	90% at the last follow-up	1 Hypotony
Elhusseiny *et al.*, 2025	25 (25)	7.54 ± 5.00 years	15 PCG 1 JOAG 3 GFCS 6 SG	22/25 eyes	32.6 ± 6.1	3.6 ± 0.6	13.2 ± 3 at 1 year	1.1 ± 1.0 at 1 year	80% at 1 year	1 Hypotony 1 Tube extrusion 1 Tube exposure
Ahmed ClearPath studies										
Elhusseiny and VanderVeen, 2021	7 (5)	Range: 4.5 months to 13 years	1 PCG 2 JOAG 3 GFCS 1 SG	5/7 eyes	36 ± 3.5	2.7 ± 0.6	12.4 ± 2.8 at the final follow-up	0.7 ± 0.8 at the final follow-up	100% at the final follow-up	None
Elhusseiny *et al.*, 2025	19 (17)[c]				32.2 ± 4.4		14.2 ± 3.7 at 1 year 15.3 ± 4 at 2 years 16 ± 3.8 at 3 years 16.1 ± 3.1 at 4 years	Median of 1 from year 1 to year 4	90% at 1 year 84% at 2 years 79% at 3 and 4 years	5 Hypotony 1 Tube trimming 1 Exotropia 1 CME

BGI, Baerveldt glaucoma implant; CME, cystoid macular edema; CPC, cyclophotocoagulation; GDD, glaucoma drainage device; GM, glaucoma medications; IOP, intraocular pressure; JOAG, juvenile open-angle glaucoma; N/A, not available; PCG, primary congenital glaucoma; SD, standard deviation; SG, secondary glaucoma; SWS, Sturge–Weber syndrome.
[a]Values are expressed in terms of mean ± standard deviation.
[b]The mean follow-up was 7.70 ± 4.22 months.
[c]The seven eyes from the earlier series by Elhusseiny and VanderVeen, 2021 were part of this cohort.

with primary and secondary childhood glaucoma [28]. They reported a qualified success, defined as IOP between 6 and 20 with or without glaucoma medications, of 84% (21 eyes) at 24 months. Mean IOP decreased significantly from 30.9 ± 5.9 mmHg on 3.8 ± 0.7 glaucoma medications at baseline to 11.8 ± 4.6 mmHg on 1.3 ± 1.6 glaucoma medications at 24 months postoperatively. Four eyes were classified as failures: two due to inadequate IOP control requiring additional glaucoma surgery (gonioscopy-assisted transluminal trabeculotomy), and two due to late-onset hypotony (~7 months postoperatively) shortly after ripcord removal. It should be noted that the authors in this series applied MMC subconjunctivally (0.5 mg/ml for 3 min) [28]. The ripcord was removed in nine eyes at a mean of 5.6 ± 5.12 months, resulting in a significant reduction of the IOP by a mean of 13.9 ± 5.2 mmHg.

A separate retrospective case series by Mendoza-Moreira *et al*. [30] included 10 eyes of aphakic patients with glaucoma following cataract surgery. At a mean follow-up of 7.70 ± 4.22 months, 90% of eyes achieved an IOP between 6 and 21 mmHg with at least 25% IOP reduction from baseline, with or without glaucoma medications. One eye developed numerical hypotony (IOP of 4 mmHg), although without clinical manifestations such as choroidal detachment or anterior chamber shallowing. MMC of 0.02% for 3 min was used in eight eyes, and the ripcord was removed in one eye.

An ongoing randomized controlled trial by our group compared the PGI to AGV in a heterogeneous group of refractory childhood glaucoma patients. Early results from patients who completed 1-year follow-up (25 eyes in the PGI group vs. 19 eyes in the AGV group) showed no significant difference in mean IOP (14.9 ± 4.1 mmHg for PGI vs. 15.5 ± 3.5 mmHg for AGV, $P = 0.6$), mean number of glaucoma medications (1.1 ± 1 for PGI vs. 1.6 ± 1.03 for AGV, $P = 0.1$), or success rate (80 vs. 74%, respectively) between both groups at 1 year. One case of early hypotony occurred in the PGI group and two in the AGV group. Notably, MMC was not used in either group. The ripcord remained in place in seven PGI eyes. In those where the ripcord was removed (at approximately 3 months), no postoperative hypotony was observed [26].

AHMED CLEARPATH

Design

The ACP device is available in two plate sizes – 250 and 350 mm^2 – to address varying anatomical and surgical requirements. The 250 mm^2 model is specifically designed for placement between the rectus muscles, eliminating the need for muscle isolation. In contrast, the 350 mm^2 version must be inserted beneath the muscles, but its contoured, winged design and posterior plate positioning help minimize interference with rectus muscle insertions and enhance implant stability.

The ACP is constructed from a low-profile, flexible material, allowing for insertion through smaller incisions – particularly advantageous in patients with anatomical limitations such as buphthalmos or small orbits (Fig. 4). This flexibility enhances surgical maneuverability and facilitates implantation in tight orbital spaces. The anterior positioning of the suture fixation eyelets further simplifies the procedure by enabling secure plate anchoring with minimal posterior dissection [31,32].

Each ACP is packaged with a pre-threaded 4-0 polypropylene ripcord suture and a 23-gauge needle for sclerostomy creation. In pediatric cases, the ripcord is often removed intraoperatively due to the challenges of postoperative removal in clinic settings. However, some surgeons opt to retain the ripcord and remove it later under anesthesia if IOP control proves inadequate. In both approaches, the tube is typically ligated externally with a 7-0 polyglactin suture, with anterior fenestrations created to permit early aqueous flow. To date, there are no published reports describing the use of MMC with the ACP in pediatric populations.

In a laboratory-based comparison, Langenberg and colleagues evaluated the ACP 350 mm^2 model against the Baerveldt 350 mm^2 implant, assessing flow resistance and suture eyelet durability. Their findings demonstrated comparable performance in both outflow resistance and structural integrity, supporting the design reliability of the ACP [33].

Table 3 summarizes key design features of the PGI and ACP in comparison with the BGI and AGV [33].

Outcomes

Data on the use of the ACP in childhood glaucoma remain limited, with only two retrospective case series encompassing a total of 19 patients. The initial report by Elhusseiny and VanderVeen included seven eyes of five patients, with a median follow-up of 1 year [34]. Subsequently, the authors expanded their analysis to include 19 eyes from two centers – incorporating the original seven eyes – with a minimum follow-up of 4 years [35▪].

The study demonstrated a significant and sustained reduction in IOP, with the mean IOP decreasing from 32.2 ± 4.4 mmHg at baseline to 14.2 ± 3.7 mmHg at 1 year, 15.3 ± 4 mmHg at 2 years, 16 ± 3.8 mmHg at 3 years, and 16.1 ± 3.1 mmHg at 4 years.

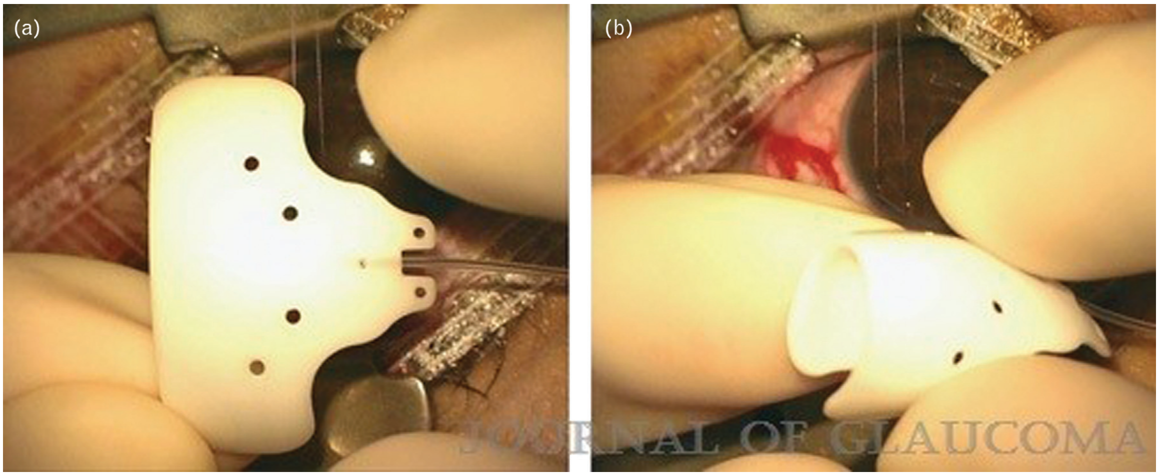

FIGURE 4. (a) Ahmed ClearPath 350 mm^2 model before implantation. (b) Flexibility allows easier insertion behind rectus muscles. Reprinted with permission from Elhusseiny and VanderVeen [34].

Similarly, the number of glaucoma medications was reduced from a median of 2.5 at baseline to 1 medication from 6 months postoperatively through the 4-year follow-up period.

The success rate – defined as an IOP between 6 and 21 mmHg with or without the use of glaucoma medications – was 90% at 1 year and 79% at 4 years. These outcomes compare favorably to the reported 3–5-year success rates for other commonly used implants, such as the AGV (43–63%) and the BGI (56–79%) [36].

While these early results are promising, current evidence remains limited. Larger studies – ideally including direct comparisons between the ACP and other GDDs – are needed to better define the long-term safety and efficacy of the ACP in the pediatric population.

DEVICES IN THE PIPELINE

The ACP ST is a newer iteration of the ACP, retaining its flexible plate and anterior suture points and available in two sizes. Its tube dimensions are similar to the PGI, with an inner diameter of 0.127 mm and an outer diameter of 0.457 mm. By combining design features from both the PGI and ACP, the ClearPath ST shows promise for pediatric glaucoma, though it has only recently become commercially available

Table 3. Summary of the main design features of glaucoma drainage devices

	Ahmed Glaucoma Valve FP7	Baerveldt Glaucoma Implant	Paul Glaucoma Implant	Ahmed ClearPath
Endplate surface area (mm^2)	184	350	342	350
Endplate length (mm)	16	15	16.1	16.48
Endplate width (mm)	13	32	21.9	30.47
Endplate thickness (mm)	1.0	0.84	0.95	0.86
Tube outer diameter (μm)	630	630	467	635
Tube inner diameter (μm)	300	300	127	305
Valved system	Yes	No	No	No
Endplate material	Medical grade silicone	Barium-impregnated medical grade silicone	Medical grade silicone	Barium-impregnated medical grade silicone

and requires further clinical validation. The device comes with a preinserted 6-0 Prolene ripcord within the tube lumen, simplifying the surgical procedure.

The EyePlate-S is another emerging device, with a larger inner tube diameter (0.18 mm) than both the PGI and ClearPath ST, while maintaining a comparable outer diameter to the PGI (0.47 mm). Its tube lumen is designed to accommodate stenting with a 5-0 suture. Available in two plate sizes (200 and 300 mm^2), the EyePlate-S features a thin, flexible design that facilitates implantation, particularly in eyes with buphthalmos or complex orbital anatomy. The 200-S version can be placed between extraocular muscles, potentially reducing the risk of postoperative motility disturbances and diplopia. The eyePlate-S has recently received the CE-mark (MDR) approval and has been introduced outside the United States. Although published pediatric data are not yet available, the senior author (T.S.) has recently used it in a heterogeneous cohort of refractory childhood glaucoma, demonstrating favorable short-term safety and IOP reduction; longer follow-up is needed to confirm these outcomes.

CONCLUSION

Innovations in glaucoma surgical implants, including the PRESERFLO, PGI, and ACP, offer promising new options for children with refractory glaucoma, with encouraging mid-term safety and efficacy data. Early adaptations like the ACP ST and eyePlate-S further expand the pipeline of potential tools tailored for the pediatric eye. While initial findings are favorable, robust, long-term comparative studies are essential to define the optimal role of these newer implants in managing childhood glaucoma.

Acknowledgements

None.

Financial support and sponsorship

None.

Conflicts of interest

There are no conflicts of interest.

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Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

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