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Evaluating the Effectiveness of Ahmed Glaucoma Valve Implantation in Reducing Intraocular Pressure in Refractory Glaucoma in the Saudi Arabian Population at a Tertiary Care Centre

Nawaf Almarzouki*

Department of Ophthalmology, King Abdulaziz University Hospital, Jeddah, Saudi Arabia.
*Correspondence to: Nawaf Almarzouki (E-mail: nawaf.almarzouki@gmail.com)
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Abstract

Objective: To assess the efficacy of Ahmed glaucoma valve implantation (AGVI) in lowering intraocular pressure (IOP) in patients with refractory glaucoma.

Methods: In this retrospective study, we analyzed the medical records of 60 patients who received AGVI for refractory glaucoma. Data collected included demographics, type of glaucoma, preoperative and postoperative IOP, number of glaucoma medications, and any surgical complications. Success was defined as achieving an IOP <21 mmHg at the final follow-up visit.

Results: At the final follow-up (mean duration of 11.6 months), AGVI achieved successful IOP control (IOP of <21 mmHg) in 40 eyes (66.7%). The mean number of glaucoma medications decreased significantly from 2.95 preoperatively to 1.98 postoperatively ($P < 0.001$). Neovascular glaucoma (NVG) had a lower success rate compared to other types of glaucoma. Prior glaucoma surgery was associated with a higher risk of failing to reach target IOP, although this trend was not statistically significant ($P = 0.108$).

Conclusion: AGVI implantation effectively lowered IOP in patients with refractory glaucoma, especially in the short term. However, long-term success rates were lower, and NVG showed less favorable outcomes. AGVI is a valuable option for managing refractory glaucoma, but careful patient selection is essential. Further research is needed to evaluate long-term efficacy and refine treatment strategies.

Keywords: Ahmed glaucoma valve, refractory glaucoma, intraocular pressure, glaucoma surgery

Introduction

Glaucoma, which includes a range of progressive optic neuropathies, is a major cause of irreversible vision loss globally. It is characterized by the gradual degeneration of retinal ganglion cells (RGCs) and their axons, leading to a decline in visual function.[1] Intraocular pressure (IOP), the pressure exerted by the aqueous humor in the eye, is a well-established and modifiable risk factor for the progression of glaucoma.[2] Consequently, accurate control of IOP is fundamental to effective glaucoma management.

While topical medications such as prostaglandin analogs, beta-blockers, and alpha-adrenergic agonists are typically the first-line treatment for glaucoma, many patients eventually develop refractory glaucoma. This condition refers to cases where IOP remains uncontrolled despite the use of maximally tolerated medications and, in some cases, previous surgical interventions.[3] Managing refractory glaucoma is challenging, requiring innovative approaches to achieve long-term IOP reduction and preserve vision.

Surgical intervention for glaucoma aims to create a new pathway for aqueous humor outflow, thereby reducing IOP. Trabeculectomy, the most frequently performed glaucoma surgery, works by creating a filtration bleb—a subconjunctival reservoir that facilitates the drainage of aqueous humor from the anterior chamber.[4] However, postoperative fibrosis can compromise the effectiveness of trabeculectomy.[4] This underscores the need for alternative surgical techniques that are less prone to such complications.

The Ahmed glaucoma valve implantation (AGVI) is a promising alternative for refractory glaucoma. This minimally invasive procedure involves placing a small, pressure-regulated drainage device into the anterior chamber of the eye.[5] The AGV consists of a silicone plate attached to the sclera and a silicone tube connected to a pressure-regulating valve. Aqueous humor drains through the tube and valve in a controlled manner, bypassing the damaged trabecular meshwork, which is the conventional outflow pathway for aqueous humor.[5] This innovative method allows for sustained IOP reduction in patients with refractory glaucoma.

Increasing evidence suggests the potential effectiveness of AGVI in managing refractory glaucoma. Studies by Lee et al.[5] and Souza et al.[2] have reported promising results, with many patients reaching target IOP levels (typically defined as <21 mmHg) after AGVI surgery.[1,3] These results suggest that AGVI may be a valuable addition to the treatment options for refractory glaucoma. However, crucial knowledge gaps remain, highlighting the need for further investigation.

One of the limitations of existing studies is their relatively short follow-up periods. Many investigations have only assessed patients shortly after AGVI, which prevents a comprehensive evaluation of the long-term effectiveness of AGV in IOP control.[1,2] A longer follow-up is essential to determine whether the initial success of AGVI results in sustained IOP control over several years.

Another critical area for investigation is the safety profile of AGVI. Although AGVI is a promising solution for refractory glaucoma, the potential complications associated with the procedure require further examination.[4] One such complication is hypotony, which is characterized by excessively low IOP and can result in issues such as choroidal detachment and macular edema.[4] Additionally, corneal decompensation, where the cornea (the clear outer layer of the eye) loses its transparency and integrity, is another potential concern.[4] Rigorous monitoring for these complications after AGVI is crucial to ensure patient safety and achieve optimal outcomes.

Aims and Objectives

The aim of this study is to comprehensively evaluate the effectiveness of AGVI in lowering IOP in patients with refractory glaucoma. Specifically, we will investigate the following issues.

1. Short-term vs. long-term IOP control: To compare the short-term effectiveness of AGVI in reducing IOP with its ability to maintain controlled IOP over an extended follow-up period.
2. Success rates across different glaucoma subtypes: To analyze the success rates of AGVI for various types of refractory glaucoma, with a particular focus on neovascular glaucoma, which shows less favorable outcomes according to existing research.
3. Impact on medication burden: To assess whether AGVI considerably reduces the number of glaucoma medications needed by patients.
4. Influence of prior glaucoma surgery: To examine whether previous glaucoma surgeries affect the success rate of AGVI in achieving target IOP.

Experimental Method

This retrospective observational study assessed the effectiveness of AGVI in lowering IOP in patients with refractory glaucoma. Data were extracted from electronic medical records of patients who received AGVI for refractory glaucoma at King Abdulaziz University Hospital, Jeddah, Saudi Arabia between January 2021 and February 2023. Refractory glaucoma was defined as uncontrolled IOP (defined as IOP of ≥21 mmHg) despite the use of maximally tolerated topical medications and, if applicable, previous glaucoma surgeries.

Inclusion Criteria

Patients diagnosed with refractory glaucoma who underwent AGVI during the study period and had complete medical records available—including preoperative and postoperative IOP measurements, glaucoma subtype diagnosis, medications used, and any complications following surgery—were included in the analysis.

Exclusion Criteria

Patients with incomplete medical records and those who were lost to follow-up.

Data Collection

The following data were extracted from the electronic medical records:

Demographic information (age and gender)

Glaucoma subtype diagnosis (Primary open angle glaucoma (POAG), Primary angle closure glaucoma (PACG), Neovascular glaucoma (NVG), Uveitic glaucoma, etc.)

Preoperative IOP measurements

History of prior glaucoma surgery (surgery type)

Number of topical glaucoma medications used preoperatively

Postoperative IOP measurements at specific time points (e.g., 1 day, 1 week, 1 month, 6 months, and final follow-up visit)

Any complications after AGVI

Ethical Considerations

This study adhered to the principles of the Declaration of Helsinki and was approved by the institutional review board. Owing to its retrospective design, informed consent was not required. Patient confidentiality was maintained during data collection and analysis.

Surgical Technique

Surgery was performed using either sub-Tenon's or peribulbar anesthesia. The AGV was implanted in the superior temporal quadrant. The valve plate was secured to the sclera with interrupted 8–0 Prolene sutures. The tube, trimmed with the bevel facing up, was inserted into the anterior chamber through a 23-gauge needle track positioned 2 mm from the limbus. Care was taken to ensure the tube bevel faced away from the iris. The conjunctiva was closed with 8–0 Vicryl sutures, and a pericardial patch was used.

Statistical Analysis

Descriptive statistics, including frequencies and percentages, were used to summarize categorical variables. Means and standard deviations were calculated for continuous variables such as age and follow-up duration. The chi-square test was used to assess the statistical significance of differences in IOP control rates between the preoperative and final follow-up visits. A one-sample *t*-test was used to compare the mean number of glaucoma medication drops required preoperatively and at the last visit. Binary logistic regression analysis was performed to evaluate the impact of previous glaucoma surgery on the likelihood of failing to achieve the target IOP after AGVI. All analyses were performed using IBM SPSS version 29.0.0.0 (IBM Corp., Armonk, NY, USA)

Results

Table 1 summarizes data from 60 eyes that underwent AGVI for refractory glaucoma. Of these, 24 eyes (40.0%) were right eyes (OD), and 36 eyes (60.0%) were left eyes (OS). The study included 28 females (46.7%) and 32 males (53.3%) aged 56.9 ± 14.4 years. The mean follow-up duration was 11.6 months, with a standard deviation of 6.8 months.

Regarding the type of glaucoma, 1 eye (1.7%) had iridocorneal endothelial (ICE) syndrome, 18 eyes (30.0%) had neovascular glaucoma (NVG), 4 eyes (6.7%) had primary angle-closure glaucoma (PACG), 26 eyes (43.3%) had primary open-angle glaucoma (POAG), 4 eyes (6.7%) had pseudoexfoliative glaucoma (PXF), 1 eye (1.7%) had Sturge–Weber syndrome (SWS), and 6 eyes (10.0%) had uveitic glaucoma. Additionally, 33 eyes (55.0%) underwent cataract surgery in conjunction with AGVI, while 27 eyes (45.0%) did not receive cataract surgery.

Regarding postoperative complications, 47 eyes (78.3%) had no issues. Choroidal effusion occurred in 4 eyes (6.7%), diplopia in 1 eye (1.7%), a hypertensive phase in 3 eyes (5.0%), hypotony in 2 eyes (3.4%), plate exposure requiring revision surgery in 1 eye (1.7%), tube–iris touch in 1 eye (1.7%), and tube revision owing to iris blockage in 1 eye (1.7%).

Additionally, 11 eyes (18.3%) had undergone previous glaucoma surgery before AGVI, while 49 eyes (81.7%) had no

Table 1. **Descriptive statistics**

		N	N%
Operated eye	OD	24	40.0
	OS	36	60.0
Gender	Female	28	46.7
	Male	32	53.3
Age (Mean, SD)	Years	56.9	14.4
Duration of follow-up (Mean, SD)	Months	11.6	6.8
Diagnosis (type of glaucoma)	ICE syndrome	1	1.7
	NVG	18	30.0
	PACG	4	6.7
	POAG	26	43.3
	PXF	4	6.7
	SWS	1	1.7
	Uveitis glaucoma	6	10.0
Cataract surgery	No	27	45.0
	Yes	33	55.0
Post-op complications	None	47	78.3
	Choroidal effusion	4	6.7
	Diplopia	1	1.7
	Hypertensive phase	3	5.0
	Hypotony	2	3.4
	Plate exposure + revision	1	1.7
	Tube iris touch	1	1.7
	Tube revision due to blockage by iris	1	1.7
Glaucoma surgery	No	49	81.7
	Yes	11	18.3

history of prior glaucoma surgery. Among the 11 eyes with previous glaucoma surgery, 6 had undergone cyclophotocoagulation, 4 had trabeculectomy, and 1 had deep sclerotomy.

Before surgery, all 18 eyes with NVG had an IOP of ≥21 mmHg. At 6 months postoperatively, 7 NVG eyes had an IOP of <21 mmHg, while 11 eyes still had an IOP of ≥21 mmHg. By the last follow-up visit, only 5 NVG eyes achieved an IOP of <21 mmHg, with 13 eyes continuing to have uncontrolled IOP of ≥21 mmHg. This trend indicates inadequate IOP control in NVG eyes after AGVI over time.

For POAG, 24 out of 26 eyes had a baseline IOP of ≥21 mmHg. At 6 months postoperatively, 23 POAG eyes achieved an IOP of <21 mmHg, indicating effective initial IOP reduction. This improvement was sustained through the last follow-up visit.

All 4 eyes with PACG achieved excellent IOP control, with IOP of <21 mmHg, both at 6 months and at the last follow-up. The single eye with ICE syndrome and the eye with SWS did not achieve an IOP of <21 mmHg at the last follow-up after AGVI. For uveitic glaucoma, 5 out of 6 eyes had an IOP of <21 mmHg at 6 months, and this level of control was maintained in the same 5 eyes at the last visit.

In summary, AGVI achieved satisfactory initial IOP control at 6 months for most types of glaucoma, with the exception of NVG. However, long-term IOP control declined over time, particularly in NVG and other refractory glaucomas such as ICE syndrome (Table 2).

Before surgery, only 4 eyes (6.7%) had an IOP of <21 mmHg, whereas the majority, 56 eyes (93.3%), had uncontrolled IOP of ≥21 mmHg. By the last follow-up visit, 40 eyes (66.7%) achieved successful IOP control with levels <21 mmHg after AGVI. However, 20 eyes (33.3%) did not reach the target IOP of <21 mmHg. This difference in IOP levels was statistically significant ($P < 0.001$) (Table 3).

On the first postoperative day, all 60 eyes (100%) had an IOP of <21 mmHg after AGVI surgery. This reduction in IOP was maintained in 59 eyes (98.3%) at 1 week postoperative, with only 1 eye (1.7%) having IOP of ≥21 mmHg. At the 1-month follow-up, 49 eyes (81.7%) still had an IOP of <21 mmHg, while 11 eyes (18.3%) had an IOP of ≥21 mmHg. By the 6th month postoperative, 43 eyes (71.7%) maintained an IOP of <21 mmHg, which decreased to 40 eyes (66.7%) at the final follow-up, reflecting a gradual loss of IOP control over time (Table 4).

Before surgery, the number of glaucoma drops used was 2.95 ± 0.565. Specifically, 11 eyes (18.3%) required 2 drops, 41 eyes (68.3%) needed 3 drops, and 8 eyes (13.3%) required 4 topical glaucoma medications to manage IOP. After AGVI surgery, the number of drops used decreased to 1.98 ± 0.770 at the last follow-up visit. This reduction in the number of medications was statistically significant ($P < 0.001$).

At the final visit, 18 eyes (30.0%) required 1 glaucoma drop, 25 eyes (41.7%) needed 2 drops, and 17 eyes (28.3%) required 3 drops. In summary, AGVI considerably reduced the number of glaucoma medications needed to control IOP in

Table 2. **Preoperative and IOP after AGVI categorized by glaucoma type**

	Preoperative		6th month postoperative		Final visit	
IOP (mmHg)	**<21**	**≥21**	**<21**	**≥21**	**<21**	**≥21**
ICE syndrome	0	1	0	1	0	1
NVG	0	18	7	11	5	13
PACG	1	3	4	0	4	0
POAG	2	24	23	3	23	3
PXF	1	3	3	1	3	1
SWS*	0	1	1	0	0	1
Uveitis glaucoma	0	6	5	1	5	1

*SWS: Sturge–Weber syndrome

Table 3. **Success of AGVI in reducing long-term IOP**

	IOP (mmHg)				
	<21		≥21		*P*-Value
	N	N%	N	N%	
Preoperative	4	6.7	56	93.3	<0.001
Final visit	40	66.7	20	33.3	

Table 4. **IOP outcomes at each follow-up time point after AGVI**

	IOP (mmHg)			
	<21		≥21	
	N	N%	N	N%
Pre-op	4	6.7	56	93.3
1st day postoperative	60	100.0	0	0.0
1st week postoperative	59	98.3	1	1.7
1st month postoperative	49	81.7	11	18.3
6th month postoperative	43	71.7	17	28.3
Final visit	40	66.7	20	33.3

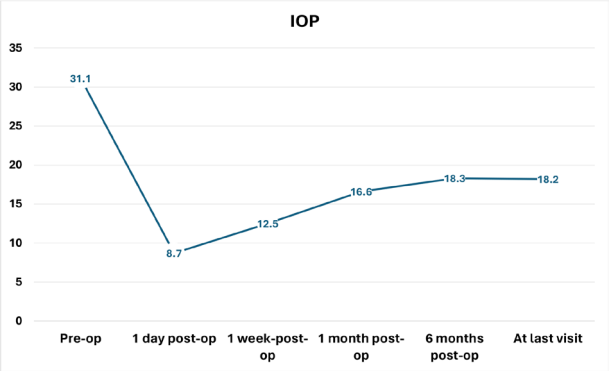

Fig. 1 **IOP before and after AGVI for refractory glaucoma.**

eyes with refractory glaucoma. While 81.6% of eyes required 3 or more drops preoperatively, only 71.7% of eyes required 1–2 drops at the last follow-up visit Table 5.

Among the 49 eyes that had not undergone any prior glaucoma surgery before AGVI, 35 eyes (71.4%) achieved normal IOP levels at the final visit, while 14 eyes (28.6%) had elevated IOP. In contrast, out of the 11 eyes that had previous glaucoma surgery before AGVI, only 5 eyes (45.5%) achieved normal IOP at the final visit, while 6 eyes (54.5%) did not achieve IOP control. Logistic regression analysis indicated that having previous glaucoma surgery was associated with a higher risk of failing to achieve normal IOP after AGVI, with an odds ratio of 3.000. However, this association was not statistically significant (P = 0.108) **(Supplementary Tables)**.

Table 5. **Effect of AGVI on reducing the number of medication drops**

	Mean	N	Std. Deviation	*P*-Value
No of drops at the final visit	1.98	60	.770	<0.001
No of drops preoperatively	2.95	60	.565	

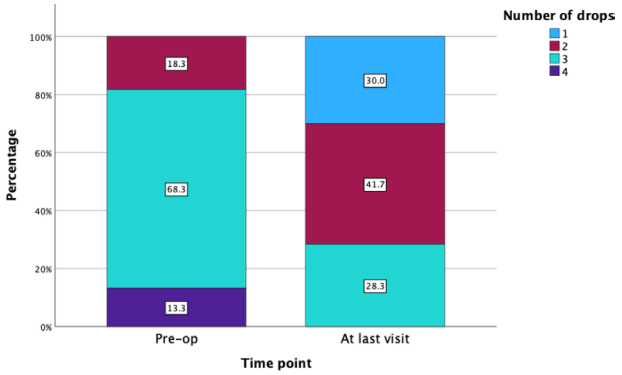

Fig. 2 **Number of medications required to control IOP before and after AGVI for refractory glaucoma.**

Discussion

This study evaluated the effectiveness of AGVI in lowering IOP in refractory glaucoma. The findings corroborate previous research that supports AGVI as a viable treatment option for this challenging condition. Multiple studies have reported successful IOP control after AGVI. For example, Lee et al.[5] reported an 89% success rate at 6 months, while Souza et al.[2] observed an 80% success rate at 1 year. These results are consistent with those observed in this study, reinforcing AGVI's effectiveness in managing IOP in refractory glaucoma.

Long-term success rates after AGVI appear to decline over time. For example, Lee et al.[5] reported a decrease in success rate to 44% at 10 years. This finding highlights the importance of long-term follow-up studies, as demonstrated by this research. Additionally, Lin et al.[4] compared AGVI with a combined AGV and trabeculectomy revision. Their results suggest that combining these procedures may improve long-term outcomes compared to AGV alone.

Additional tables not presented in the text (Supplementary tables):

	Pre-op		1st day post-op		1st week post-op		1st month post-op		6th month post-op		At last visit	
	<21	≥21	<21	≥21	<21	≥21	<21	≥21	<21	≥21	<21	≥21
ICE syndrome	0	1	1	0	1	0	1	0	0	1	0	1
NVG	0	18	18	0	17	1	14	4	7	11	5	13
PACG	1	3	4	0	4	0	4	0	4	0	4	0
POAG	2	24	26	0	26	0	22	4	23	3	23	3
PXF	1	3	4	0	4	0	2	2	3	1	3	1
SWS*	0	1	1	0	1	0	1	0	1	0	0	1
Uveitis glaucoma	0	6	6	0	6	0	5	1	5	1	5	1

		IOP final visit			
		Normal		Raised	
		Count	Row N %	Count	Row N %
Glaucoma surgery	No	35	71.4%	14	28.6%
	Yes	5	45.5%	6	54.5%

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	Glaucoma surgery, Yes	1.099	.683	2.586	1	.108	3.000

		N	N%
no of drops pre-op	2	11	18.3%
	3	41	68.3%
	4	8	13.3%
no of drop in las visit	1	18	30.0%
	2	25	41.7%
	3	17	28.3%

Studies have also compared AGVI with other glaucoma surgeries. HaiBo et al.[7] found AGV to be as effective as trabeculectomy in reducing IOP and medication use, with the additional advantage of a lower incidence of adverse events in the AGV group. Nilforushan et al.[6] compared AGV with trabeculectomy specifically for ICE syndrome glaucoma and reported similar success rates for both procedures. These findings suggest that AGV may be a viable alternative to trabeculectomy in certain cases. Additionally, preoperative factors can influence the success of AGVI. Arikan et al.[8] identified potential complications associated with AGVI, including tube/plate exposure, hypertensive phase, endophthalmitis, cataract formation, diplopia, and ocular hypotony. Furashova et al.[9] have reported that the long-term success rates for AGVI are influenced by the type of glaucoma. They found that a history of cyclocryotherapy or cyclophotocoagulation did not appear to be a risk factor for failure after AGVI. Analyzing these factors in the context of this study's data may provide additional insights into potential predictors of success and inform patient selection.

Complications associated with AGVI warrant careful consideration. Zarei et al.[3] reported a complication rate of 57.1%, with corneal decompensation being the most prevalent issue. Additionally, Alasbali et al.[10] noted an increased risk of vision loss after AGVI surgery. These potential complications underscore the need for thorough patient counseling and informed consent.

A recent study by Hong et al.[11] compared the implantation using the AGV and the newer Aurolab aqueous drainage implant (AADI). They found that AADI was more effective in reducing IOP and medication use. Including comparisons with newer glaucoma drainage devices can provide a more comprehensive view of the available treatment options for refractory glaucoma.

The success of AGVI depends on its ability to establish a controlled filtration pathway for aqueous humor drainage from the eye. However, the exact mechanisms by which AGV reduces IOP are still under investigation. Kaya et al.[12] found that encapsulated cyst formation was the most common complication hindering successful IOP control after AGVI for refractory glaucoma. They observed that patients not using antiglaucoma medication often did not achieve effective IOP reduction, even after cyst excision and treatment with antifibrotic drugs. Further research into these mechanisms could inform future improvements in implant design and surgical techniques to enhance long-term outcomes.

Given the potential complications associated with AGVI, careful patient selection is essential. Factors such as the severity of glaucoma, previous surgical history, and overall health status should be taken into account. Additionally, preoperative discussions should address realistic expectations regarding success rates and potential side effects to support informed decision-making. He et al. performed a clinical efficacy analysis of AGVI in NVG and determined that AGVI was associated with minimal intraocular surgery, a straightforward surgical process, a high success rate, and a low risk of complications. Age is a significant factor influencing the success rate of AGVI.[13] Investigating patient satisfaction and quality of life after AGVI can offer valuable insights into this aspect of patient care. The complication rates observed in our study warrant further investigation. Although Zarei et al.[3] reported a higher complication rate, factors such as surgical technique and patient selection can affect these outcomes. Totuk et al.[14] explored novel techniques to minimize complications, and incorporating such approaches may provide useful insights.

Our focus on careful patient selection aligns with the recommendations by Arikan et al.,[8] Christakis et al.,[15] and Posarelli et al.[16] Analyzing the factors influencing success in our data set may provide valuable insights for refining patient selection criteria. While our study focused on AGVI, incorporating comparisons with the Baerveldt implant, as examined by Wang et al.[17] and Christakis et al.,[18] may provide a more comprehensive overview of treatment options for our patient population.

Posarelli et al.[19] highlighted the importance of considering patient perspectives. In our study, investigating patient satisfaction and quality of life after AGVI may offer valuable insights for enhancing patient care. Although not directly addressed in our study, cost-effectiveness is a crucial factor for both patients and healthcare systems.

Limitations of this Study

While this study provides valuable insights into the effectiveness of AGVI for refractory glaucoma, there are several limitations to consider.

Sample Size: The study's sample size may limit the generalizability of the findings. A larger population may provide a more comprehensive understanding of AGVI's efficacy and complication rates across diverse patient demographics and disease severities.

Follow-up Duration: Assessing the long-term success of AGVI requires extended follow-up. This study may not fully capture how IOP control and complication rates evolve over a longer period. Including data from patients followed for five or ten years would strengthen the long-term efficacy analysis.

Retrospective Design: The retrospective nature of this study introduces the risk of selection bias and confounding factors. Prospective, randomized controlled trials comparing AGVI with other treatment modalities or a control group would offer a more robust assessment of AGVI's efficacy.

Conclusion

AGVI achieved excellent initial IOP reduction in nearly all cases of refractory glaucoma on the first postoperative day. However, a considerable number of patients experienced a loss of IOP control over time, with one-third failing to maintain an IOP of <21 mmHg at the last follow-up. Eyes with NVG, in particular, showed poorer outcomes. Although AGVI resulted in a statistically significant reduction in the burden of glaucoma medications, prior glaucoma surgery was associated with an increased risk of failing to achieve the target IOP. However, this association was not statistically significant in this study.

Conflict of Interest

None

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