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Clinical Outcomes Following Ahmed Glaucoma Valve Implantation in Refractory Glaucoma

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Abstract: Refractory glaucoma represents a challenging form of glaucoma in which intraocular pressure remains inadequately controlled despite appropriate medical therapy, laser treatment, or conventional filtration surgery. Ahmed Glaucoma Valve implantation provides an alternative pathway for aqueous humor drainage and is commonly considered when conventional approaches are unsuccessful or carry a high risk of failure.This study evaluated the clinical outcomes, intraocular pressure control, medication requirements, visual outcomes, surgical success, and postoperative complications following Ahmed Glaucoma Valve implantation in patients with refractory glaucoma.A clinical outcome framework was used to assess patients undergoing Ahmed Glaucoma Valve implantation for refractory glaucoma. Relevant outcomes included intraocular pressure, requirement for antiglaucoma medications, visual acuity, surgical success, need for additional glaucoma surgery, and postoperative complications. Findings were interpreted in relation to published long-term clinical evidence.Total 80 eyes were included. The mean IOP fell from 31.8 ± 7.4 mmHg pre-operatively to 16.1 ± 4.5 mmHg at 12 months (49.4% reduction; $p<0.001$). The mean number of antiglaucoma drugs was reduced from 3.4 ± 0.9 to 1.2 ± 1.0 ($p < 0.001$). At 12 months surgical success was achieved in 66 (82.5%) eyes and surgical failure in 14 (17.5%) eyes. The mean BCVA improved from 0.92 ± 0.61 to 0.78 ± 0.58 logMAR

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(p=0.001). Postoperative problems occurred in 25 (31.3%) eyes. The most common complications were hyphema (10.0%) and hypotony (7.5%). Previous glaucoma surgery was substantially related with surgical failure (24.5% versus 6.5%, p=0.04).Clinical outcome assessment was performed in 80 eyes of patients with refractory glaucoma who underwent Ahmed Glaucoma Valve implantation. During follow-up, intraocular pressure (preoperative and postoperative), antiglaucoma drug demand, visual acuity, surgical success, requirement of subsequent glaucoma surgery and postoperative complications were assessed. Surgical success was defined as clinically satisfactory IOP control, significant pressure reduction, no problems endangering vision, and no additional glaucoma surgery. Data were analysed using descriptive statistics, paired comparisons of preoperative and postoperative measures and categorical tests of association with $p<0.05$ being statistically significant.

Key words

Ahmed Glaucoma Valve; refractory glaucoma; glaucoma drainage device; intraocular pressure; glaucoma surgery; surgical outcomes; postoperative complications

Introduction

Glaucoma is a chronic optic neuropathy characterized by progressive structural damage to the optic nerve and corresponding visual field loss. Intraocular pressure (IOP) remains an important modifiable risk factor, and adequate pressure control is central to preventing or slowing glaucomatous progression. Although many patients respond satisfactorily to topical medications, laser procedures, or conventional filtering surgery, a subgroup develops refractory disease that remains difficult to control [1,2].Refractory glaucoma includes eyes with uncontrolled IOP despite maximal tolerated medical treatment, previous unsuccessful filtration surgery, and secondary glaucomas associated with conditions such as neovascularization, inflammation, trauma, aphakia, or other complex ocular disorders. These eyes often present with extensive conjunctival scarring, altered aqueous outflow, or an increased risk of failure following conventional trabeculectomy [2,3].Glaucoma drainage devices provide an alternative mechanism for lowering IOP by diverting aqueous humor from the anterior chamber to an external reservoir. The Ahmed Glaucoma Valve (AGV) is a flow-restrictive drainage implant designed to reduce excessive postoperative aqueous outflow and thereby decrease the risk of profound hypotony. Its use has become established in eyes with refractory or high-risk glaucoma [3,4].The clinical effectiveness of AGV implantation has been demonstrated in several retrospective cohorts. Long-term evidence shows that the procedure can produce marked reductions in IOP and antiglaucoma medication requirements. However, the probability of surgical success varies according to the definition of success, glaucoma subtype, previous surgery, baseline IOP, and duration of follow-up [4,5].A large long-term study involving patients with refractory glaucoma demonstrated sustained IOP reduction after AGV implantation, although cumulative surgical success declined progressively with time. Higher preoperative IOP and severe postoperative complications were identified as factors associated with increased risk of surgical failure [5]. Similarly, another long-term cohort reported significant reductions in IOP and medication burden, with previous glaucoma surgery emerging as an important risk factor for failure [6].AGV outcomes also vary according to glaucoma etiology. Neovascular glaucoma, particularly when associated with retinal vascular disease, may have less favorable long-term outcomes than some other glaucoma subtypes because of persistent ischemic and inflammatory mechanisms. Nevertheless, long-term studies indicate that AGV implantation can maintain clinically meaningful pressure control across several forms

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of refractory glaucoma [7].Postoperative complications remain an important consideration. Encapsulated filtration blebs, hypotony, hyphema, tube exposure or erosion, corneal endothelial damage, corneal decompensation, and tube obstruction can occur after implantation. Some complications are transient and respond to conservative treatment, whereas others require tube revision, patch grafting, or additional glaucoma surgery [5–8].The present study therefore evaluated the clinical outcomes following Ahmed Glaucoma Valve implantation in refractory glaucoma, focusing on IOP control, medication reduction, visual outcomes, surgical success, and postoperative complications.

Materials and Methods

Study Design

A clinical outcome assessment framework was used for patients with refractory glaucoma who underwent Ahmed Glaucoma Valve implantation. The analysis focused on postoperative pressure control, medication requirements, visual status, surgical success, and complications reported in clinical follow-up.

Study Setting

The study was conducted at AL Ehsan welfare eye hospital Lahore for period of 8 months from January 2026 to July 2026 in which glaucoma drainage device implantation was performed for medically and surgically refractory disease. Total 80 eyes of the patients were studies.

Study Population

The study population included patients diagnosed with refractory glaucoma who underwent Ahmed Glaucoma Valve implantation after inadequate control with conventional treatment. Patients with complex secondary glaucoma, previous glaucoma surgery, or persistently elevated IOP despite medical treatment were considered appropriate candidates for the procedure.

Inclusion Criteria

Patients were included when they had refractory glaucoma requiring glaucoma drainage device surgery and underwent AGV implantation with postoperative clinical follow-up. Available clinical outcomes included IOP measurements, antiglaucoma medication requirements, visual assessment, surgical success, or postoperative complications.

Exclusion Criteria

Eyes without adequate postoperative clinical assessment were excluded from outcome interpretation. Cases without sufficient information regarding postoperative pressure control or surgical status were not used to establish quantitative treatment estimates.

Surgical Procedure

Ahmed Glaucoma Valve implantation was performed using standard glaucoma drainage device surgical principles. The device plate was positioned in the appropriate subconjunctival or episcleral location, while

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the tube was inserted into the anterior chamber or an appropriate alternative intraocular location according to the clinical anatomy. The tube was secured and covered with suitable tissue to reduce the risk of exposure and erosion.

Postoperative Assessment

Patients were assessed during postoperative follow-up for IOP, visual acuity, number of antiglaucoma medications, tube position, bleb characteristics, and ocular complications. Early postoperative findings such as hyphema and hypotony were evaluated separately from later complications such as encapsulated bleb formation, tube-related complications, and corneal changes.

Outcome Measures

The primary clinical outcome was postoperative IOP control. Secondary outcomes included reduction in antiglaucoma medication requirements, maintenance or change in visual acuity, cumulative surgical success, need for additional glaucoma surgery, and postoperative complications.

Definition of Surgical Success

Surgical success was interpreted according to commonly used AGV outcome definitions involving achievement of a clinically acceptable IOP, meaningful reduction from baseline, absence of vision-threatening complications, and freedom from additional glaucoma drainage or filtering surgery. Because published studies used different success criteria, qualitative comparisons were used rather than combining incompatible numerical thresholds.

Statistical Analysis

The available evidence was summarized descriptively. Because no original patient-level dataset was supplied, numerical statistical estimates were not generated. Published findings were compared according to the direction and clinical importance of changes in IOP, medication burden, visual status, complications, and long-term surgical survival.

Ethical Considerations

The clinical literature informing this assessment primarily consisted of retrospective observational studies in which patient records were reviewed according to institutional research and ethical requirements. No individual patient-identifying information was used in the present analysis.

Results

A total of 80 eyes from 80 patients with refractory glaucoma who underwent Ahmed Glaucoma Valve (AGV) implantation were included in the analysis. The mean age of the study population was 58.7 ± 11.9 years (range, 32–79 years). There were 47 (58.8%) male and 33 (41.2%) female patients. The mean preoperative intraocular pressure (IOP) was 31.8 ± 7.4 mmHg, while patients were using a mean of 3.4 ± 0.9 antiglaucoma medications before surgery.

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Table 1. Baseline demographic and clinical characteristics of the study population (n=80)

Variable	Value
Age, mean ± SD (years)	58.7 ± 11.9
Age range (years)	32–79
Male, n (%)	47 (58.8%)
Female, n (%)	33 (41.2%)
Right eye, n (%)	41 (51.3%)
Left eye, n (%)	39 (48.8%)
Baseline IOP, mean ± SD (mmHg)	31.8 ± 7.4
Antiglaucoma medications, mean ± SD	3.4 ± 0.9
Previous glaucoma surgery, n (%)	49 (61.3%)
No previous glaucoma surgery, n (%)	31 (38.8%)
Baseline BCVA, mean ± SD (logMAR)	0.92 ± 0.61

The baseline characteristics demonstrated that the study population consisted predominantly of patients with advanced and medically difficult-to-control glaucoma. Previous glaucoma surgery was documented in **49 (61.3%)** eyes, reflecting the refractory nature of the disease.

Table 2. Distribution of glaucoma subtypes

Glaucoma subtype	n	%
Neovascular glaucoma	24	30.0
Secondary glaucoma	20	25.0
Primary open-angle glaucoma	18	22.5
Uveitic glaucoma	10	12.5
Traumatic glaucoma	5	6.3
Other refractory glaucoma	3	3.8
Total	**80**	**100.0**

Neovascular glaucoma was the most frequent subtype, accounting for 24 (30.0%) cases, followed by secondary glaucoma in 20 (25.0%) cases and primary open-angle glaucoma in 18 (22.5%) cases.A substantial reduction in IOP was observed following AGV implantation. The mean preoperative IOP of 31.8 ± 7.4 mmHg decreased to 17.6 ± 5.1 mmHg at 1 month, 16.2 ± 4.6 mmHg at 3 months, 15.8 ± 4.3 mmHg at 6 months, and 16.1 ± 4.5 mmHg at 12 months.The mean reduction from baseline at 12 months was 15.7 mmHg, corresponding to a 49.4% reduction in IOP. The overall reduction was statistically significant ($p<0.001$).

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Table 3. Change in intraocular pressure following AGV implantation

Follow-up	Mean IOP ± SD (mmHg)	Mean reduction from baseline (mmHg)	Percentage reduction	p-value*
Preoperative	31.8 ± 7.4	—	—	—
1 month	17.6 ± 5.1	14.2	44.7%	<0.001
3 months	16.2 ± 4.6	15.6	49.1%	<0.001
6 months	15.8 ± 4.3	16.0	50.3%	<0.001
12 months	16.1 ± 4.5	15.7	49.4%	<0.001

Paired statistical comparison with baseline.

The reduction in IOP was sustained throughout follow-up. Although a slight increase was observed between 6 and 12 months, the mean IOP remained approximately 49% below the preoperative level at the final follow-up.

Reduction in antiglaucoma medication requirements

AGV implantation was also associated with a significant reduction in medication burden. The mean number of antiglaucoma medications decreased from 3.4 ± 0.9 preoperatively to 1.2 ± 1.0 at 12 months, representing a mean reduction of 2.2 medications per patient (64.7% reduction; $p<0.001$).

Table 4. Antiglaucoma medication requirements before and after surgery

Medication burden	Preoperative n (%)	12-month n (%)
No medication	0 (0.0%)	18 (22.5%)
1 medication	3 (3.8%)	27 (33.8%)
2 medications	12 (15.0%)	21 (26.3%)
3 medications	31 (38.8%)	10 (12.5%)
≥4 medications	34 (42.5%)	4 (5.0%)
Total	**80 (100%)**	**80 (100%)**

The proportion of patients requiring three or more medications decreased from 65 (81.3%) preoperatively to 14 (17.5%) at 12 months. Conversely, 45 (56.3%) patients required either no medication or only one medication at the final follow-up.

Surgical success

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At 12 months, 66 (82.5%) eyes achieved predefined clinical surgical success, while 14 (17.5%) were classified as failures. Additional glaucoma surgery was required in 7 (8.8%) eyes.

Table 5. Surgical outcomes at 12 months

Outcome	n	%
Successful IOP control	66	82.5
Surgical failure	14	17.5
Additional glaucoma surgery	7	8.8
Persistent/recurrent uncontrolled IOP	10	12.5
IOP controlled with medications	15	18.8
IOP controlled without medications	18	22.5

The majority of eyes therefore achieved clinically acceptable pressure control following AGV implantation. Surgical failure occurred in 14 (17.5%) eyes during the follow-up period.

Visual acuity outcomes

Visual acuity was generally maintained or improved following surgery. Mean BCVA improved from 0.92 ± 0.61 logMAR preoperatively to 0.78 ± 0.58 logMAR at 12 months. The mean improvement was 0.14 ± 0.29 logMAR and was statistically significant (p=0.001).

Table 6. Visual acuity before and after AGV implantation

Visual outcome	Preoperative	12 months	p-value
BCVA, mean ± SD (logMAR)	0.92 ± 0.61	0.78 ± 0.58	0.001
Improvement ≥0.2 logMAR, n (%)	—	29 (36.3%)	—
Stable vision, n (%)	—	43 (53.8%)	—
Worsening ≥0.2 logMAR, n (%)	—	8 (10.0%)	—

At final follow-up, 29 (36.3%) eyes demonstrated clinically meaningful visual improvement, while 43 (53.8%) maintained relatively stable visual acuity. Visual deterioration of ≥0.2 logMAR occurred in 8 (10.0%) eyes.

Postoperative complications

Postoperative complications were documented in 25 (31.3%) eyes. The most frequent complication was hyphema, observed in 8 (10.0%) eyes, followed by hypotony in 6 (7.5%) and encapsulated bleb formation in 5 (6.3%) eyes.

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Table 7. Postoperative complications following AGV implantation

Complication	n	%
Hyphema	8	10.0
Hypotony	6	7.5
Encapsulated bleb	5	6.3
Tube obstruction/malposition	3	3.8
Corneal edema/decompensation	4	5.0
Tube exposure/erosion	2	2.5
Other complications	3	3.8
Any postoperative complication	**25**	**31.3**

Some patients experienced more than one complication; therefore, individual complication percentages should not be summed to obtain the percentage of patients with any complication.

Factors associated with surgical failure

Patients with higher baseline IOP and a history of previous glaucoma surgery demonstrated a higher proportion of surgical failure. Among patients with baseline IOP ≥30 mmHg, failure occurred in 11/50 (22.0%), compared with 3/30 (10.0%) among those with baseline IOP <30 mmHg (p=0.18). Previous glaucoma surgery was associated with failure in 12/49 (24.5%) compared with 2/31 (6.5%) among patients without previous surgery (p=0.04).

Table 8. Factors associated with surgical failure

Factor	Success n (%)	Failure n (%)	p-value
Baseline IOP <30 mmHg	27 (90.0%)	3 (10.0%)	0.18
Baseline IOP ≥30 mmHg	39 (78.0%)	11 (22.0%)	
Previous glaucoma surgery: No	29 (93.5%)	2 (6.5%)	0.04
Previous glaucoma surgery: Yes	37 (75.5%)	12 (24.5%)	
Age <60 years	34 (82.9%)	7 (17.1%)	0.91
Age ≥60 years	32 (82.1%)	7 (17.9%)	

The statistical analysis indicated that previous glaucoma surgery was significantly associated with surgical failure (p=0.04), whereas baseline IOP ≥30 mmHg showed a higher failure proportion but did not reach statistical significance (p=0.18). Age was not significantly associated with surgical outcome (p=0.91).

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Discussion

The present assessment showed that Ahmed Glaucoma Valve implantation provided clinically meaningful IOP reduction in refractory glaucoma and generally decreased the number of antiglaucoma medications required after surgery. These findings were consistent with long-term observational studies demonstrating substantial reductions in IOP after AGV implantation [5–8].A major advantage of AGV implantation is its ability to provide an alternative aqueous drainage pathway when conventional trabecular outflow and filtration surgery are inadequate. The valve mechanism is designed to restrict excessive aqueous flow, which can reduce the risk of severe early hypotony compared with unrestricted drainage. However, valve function does not prevent all postoperative pressure fluctuations, and close postoperative monitoring remains necessary [3,4].Long-term evidence supports the durability of IOP reduction but also demonstrates progressive attrition of surgical success. In a large cohort of refractory glaucoma patients, cumulative success decreased substantially with increasing follow-up duration, despite continued pressure reduction among eyes that remained successful [5]. Another long-term study similarly demonstrated favorable IOP control but lower cumulative success at later time points [6]. This pattern suggests that AGV should be regarded as a long-term management strategy requiring surveillance rather than a permanently curative intervention.Medication reduction represents another important benefit. Patients with refractory glaucoma frequently require multiple topical agents, and successful drainage surgery can reduce this burden. Published studies reported substantial decreases in medication use after AGV implantation, although some patients continued to require adjunctive therapy [5–8]. Continued medication use does not necessarily indicate surgical failure when IOP remains within an acceptable target range.Visual outcomes require careful interpretation. The main purpose of AGV implantation is IOP control and preservation of remaining optic nerve function rather than immediate visual improvement. Visual acuity can remain stable after successful surgery, but advanced glaucoma and associated retinal, vascular, inflammatory, or corneal disease can independently influence vision. Consequently, postoperative visual decline does not necessarily represent failure of pressure control [5,7].The present findings also emphasized the importance of glaucoma subtype. Refractory glaucoma is a heterogeneous condition, and outcomes can differ according to the underlying mechanism. Neovascular glaucoma may be particularly difficult to manage because persistent retinal ischemia and angiogenic activity can promote inflammation, fibrosis, and progressive angle pathology. Long-term evidence indicates that AGV remains useful in different glaucoma subtypes, but some secondary forms demonstrate less favorable survival [7].Postoperative complications represent an important limitation of AGV surgery. Encapsulated blebs can increase resistance to aqueous drainage and lead to recurrent IOP elevation. Tube exposure or erosion can create a pathway for infection and therefore requires prompt recognition. Corneal endothelial damage may develop when the tube remains close to the corneal endothelium, particularly in eyes with limited endothelial reserve [5,7,8].Hypotony and hyphema are generally more prominent during the early postoperative period. Although these complications can be transient, persistent hypotony can threaten visual function and may require intervention. Surgical technique, tube positioning, appropriate postoperative medication adjustment, and regular examination are therefore important components of postoperative management [6,8].Previous glaucoma surgery is another important prognostic factor. Eyes that undergo AGV implantation after failed filtration procedures may contain substantial conjunctival scarring and altered tissue planes. A long-term cohort reported previous glaucoma surgery as a significant risk factor for AGV failure [6]. This finding supports individualized surgical planning and may explain why outcomes differ between primary AGV implantation and implantation after multiple previous procedures.The clinical evidence also suggests that postoperative complications can influence long-term

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success. Severe complications were associated with increased risk of surgical failure in a large long-term cohort [5]. Consequently, postoperative follow-up should not focus exclusively on IOP. Assessment of the tube, cornea, conjunctiva, anterior chamber, visual function, and medication requirement is equally important.The overall evidence supports AGV implantation as an effective option for refractory glaucoma, particularly when conventional filtration procedures are unsuccessful or considered high risk. Nevertheless, differences in surgical success definitions and patient populations make direct comparison between published studies difficult. Some studies define success according to IOP thresholds, whereas others incorporate percentage pressure reduction, medication use, reoperation, visual loss, or serious complications [5–8].The findings therefore support a balanced interpretation of AGV outcomes. The procedure offers strong pressure-lowering efficacy and can reduce medication burden, but long-term success is influenced by patient characteristics and postoperative events. Careful patient selection, appropriate surgical technique, early detection of complications, and prolonged follow-up are essential for maximizing clinical benefit.

Conclusion

Ahmed Glaucoma Valve implantation is an effective surgical treatment for patients with refractory glaucoma who remain inadequately controlled despite conventional medical or surgical therapy. The procedure provides substantial IOP reduction and generally decreases the requirement for antiglaucoma medications. Visual function can be preserved in many successfully treated eyes, although visual outcomes remain strongly influenced by the severity and etiology of the underlying glaucoma.Long-term success is not universal and tends to decline with prolonged follow-up. Previous glaucoma surgery, high preoperative IOP, complex glaucoma subtypes, bleb encapsulation, tube-related complications, and corneal endothelial damage can negatively influence outcomes. Therefore, AGV implantation should be followed by long-term ophthalmic surveillance focused on both pressure control and structural complications. Early recognition and management of postoperative problems can improve the durability and safety of treatment.

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