Safety and Efficacy of Ahmed Valve on Intractable Glaucoma in Saudi Population

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Abstract:

PURPOSE: The study aims to assess the efficacy and safety of Ahmed glaucoma valve implant in eyes with intractable glaucoma and to evaluate the risk factors for failure.

METHODS: A retrospective evaluation of 83 patients (117 eyes) with intractable glaucoma who underwent silicone Ahmed glaucoma valve implant was done in a tertiary care center in Riyadh, Saudi Arabia, between January 2014 and December 2016. Complete success was defined as intraocular pressure (IOP) ≤21 mmHg without medication after a minimum follow-up of 6 months.

RESULTS: Eighty-three patients (117 eyes) with intractable glaucoma were evaluated. After a mean follow-up duration of 20.8 ± 3.1 (12–24) months, the overall success rate was achieved in 104 eyes (88.9%). Thirty-six eyes (30.8%) had a complete success rate, whereas 68 eyes (58.1%) had a qualified success rate. Thirteen eyes (11.1%) failed to achieve controlled IOP. The postoperative probability to fail was found to be increasing with time from 0.9% (0.9) in the 1st month to 11.1% (9.9) after 1 year. Complications included a hypertensive phase in 25 eyes (21.4%), encapsulation in 10 eyes (8.5%), hyphema in 7 eyes (6%), hypotony in 2 eyes (1.7%), and blood clots in the implanted tube in 2 eyes (1.7%). The presence of hyphema, scleral patch, and coronary heart diseases was found to increase the risk of failure after Ahmed valve implantation (P = 0.006, 0.040, and 0.014, respectively).

CONCLUSIONS: Ahmed glaucoma valve implant was safe and effective in treating cases of intractable glaucoma.

Keywords: Ahmed glaucoma valve, complications, intractable glaucoma, intraocular pressure

Introduction

Surgical treatment of glaucoma compromises a wide spectrum of different procedures. The success rate of trabeculectomy in aphakic, uveitic, neovascular, and postpenetrating keratoplasty glaucoma is still low and not satisfactory.¹⁻⁴ The Tube Versus Trabeculectomy Study demonstrated a higher success rate of tube shunt surgeries compared to trabeculectomies with mitomycin C (MMC) during 5 years of follow-up.⁵ Glaucoma drainage devices are considered to shift the aqueous humor from the anterior chamber to the subconjunctival, sub-Tenon’s space. These devices help to control intraocular pressure (IOP) in previously failed eye surgery and in eyes with unhealthy conjunctiva due to scarring from prior surgical procedures.⁶ Different glaucoma device implants are accessible in the market; some of them have a resistance mechanism to assure better flow control and limit overdrainage postoperatively. Valve

How to cite this article: Osman EA, Alkheraiji NF, Abouammoh MA, Mousa A, Al-Obeidan S. Safety and efficacy of ahmed valve on intractable glaucoma in Saudi population. Middle East Afr J Ophthalmol 2020;27:40-6.
Ahmed valve contains a design with flow restriction to reduce the incidence of hypotony. The valve body has a specially tapered chamber, with a large inlet to a small outlet, to create a Venturi flow effect and to provide resistance to aqueous flow.

The aim of this study is to investigate the efficacy, safety, complication rate, and potential risk factors for failure after surgery.

Methods

The records of patients who were diagnosed with intractable glaucoma that was characterized by being uncontrolled after applying maximum tolerated antiglaucoma medications with or without previous failed surgery who underwent Ahmed glaucoma implant surgery as a primary or secondary operation at King Abdul-Aziz University Hospital, King Saud University, Riyadh between January 2014 and December 2016 were retrospectively reviewed. The study was approved by the Institutional Review Board, College of medicine, King Saud University. The current study complies with the tenets of the Declaration of Helsinki for research involving humans. Informed consent was obtained from all individual participants included in the study. Patients who had repeated Ahmed valve surgery were excluded.

The ophthalmic evaluation included LogMAR visual acuity charts, measurement of IOP by Goldmann applanation in adults and Tono‑Pen in children, biomicroscopic evaluation, and cup–disc ratio (CDR). A chart review collected the age, gender, ethnicity, systemic comorbidity, subtype of glaucoma, and laterality of glaucoma.

The collected data were statistically analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA) and MedCalc 9.0 (MedCalc Software, Mariakerke, Belgium). Descriptive analysis was conducted to describe different variables. The significance level was set as $P < 0.05$; in addition, 95% of corresponding confidence intervals (CIs) were calculated. Complete success was defined as IOP $\leq 21$ mmHg without medication after a minimum follow-up of 6 months. A qualified success was defined as IOP $\leq 21$ mmHg with a single topical medication. Failure was defined by IOP of 21 mmHg or more, and two or more topical medications were needed to control the IOP in two consecutive visits. The Chi-square test was conducted to identify potential risk factors for failure, whereas binary logistic regression was used to investigate the significance of variables in a multivariate mode.

Surgical technique

After local or general anesthesia and complete sterilization, the conjunctival peritomy was made 2–3 mm posterior to the limbus between superior and lateral recti (or inferior), and cautery was performed. MMC (0.2 mg/ml) was applied under the conjunctival flap and over the episclera for 3 min, followed by irrigation of the area with a balanced salt solution. Priming of silicone AGV tube and plate model FP7 (Rancho Cucamonga, CA 91730, USA) was done. The plate was fixed to the sclera 8–10 mm posterior to the limbus using 2 interrupted 9-0 Prolene sutures. The tube was cut with the bevel facing anteriorly, and after the viscoelastic material was injected into the anterior chamber, the tube was placed through a corneoscleral track created using a 23G needle. The tube was sutured to the episclera with an 8-0 Vircryl. A patch graft 4 mm × 4 mm (tutoplast dura/pericardium/sclera/cornea in glycerine/fascia lata) was fixed over the tube using 8-0 nylon sutures. Subconjunctival injection of dexamethasone and gentamicin was performed. Surgical procedure was performed by the authors based on the standardized guideline approved by the glaucoma unit. Postoperatively, topical ofloxacin eye drops four times/day for 2 weeks and topical prednisolone eye drops four times/day that were usually tapered over 4–6 weeks. Follow-up visits were scheduled for 1 day, 1 and 2 weeks, and 1, 3, 6, and 12 months after the surgery and every 6 months thereafter.

Results

Ninety-two patients were originally recruited in the current retrospective cohort study, which eventually ended up by involving 117 eyes of 83 patients in the analysis after excluding repeated implant surgery cases. The mean (±SD) age of patients was 41 years (±29.6), ranging from 1 to 86 years, with males (48, 57.8%) exceeding females (35, 42.2%). The majority of the patients were Saudi citizens (71, 85.5%). There were 13 patients (15.7%) with a family history of glaucoma, and consanguinity was detected in 13 (15.7%) patients [Table 1].

Diabetes mellitus was the most common systemic comorbidity in this series affecting 28 (33.7%) patients, followed by hypertension (HTN) occurring in 16 (19.3%) patients, whereas bronchial asthma, coronary artery diseases, and dyslipidemia were found in 3%, 2%, and 2%, respectively. Assessment of the clinical manifestations at presentation showed that 49 (59%)
patients had refractory glaucoma in one eye and 34 (41%) patients had bilateral involvement. A higher incidence of refractory glaucoma was found in the left (62, 53%). Failed surgical congenital glaucoma cases were the most common subtype of glaucoma found in 36 patients (30.8%) with intractable disease, followed by failed combined surgery for chronic angle-closure glaucoma in 24 (20.5%) [Table 1].

The mean preoperative IOP was 32 (±10.7), ranging 8–62 mmHg. The mean number of antiglaucoma medications was 2.7 (±1.0), ranging 0–4, whereas the vertical CDR was found to be 0.7 (±0.2) and the LogMAR visual acuity was 1.4 (±0.9).

**Table 1: Demographic and clinical characteristics at presentation**

| Variable                          | Mean (SD), [Range] / Number (%) |
|-----------------------------------|---------------------------------|
| Age (years), mean (±SD), (range) | 41.0 (±29.6), (1-86)            |
| Gender, n (%)                     |                                 |
| Male                              | 48 (57.8)                       |
| Female                            | 35 (42.2)                       |
| Nationality, n (%)                |                                 |
| Saudi                             | 71 (85.5)                       |
| Others                            | 12 (14.5)                       |
| Family history of glaucoma        | 13 (15.7)                       |
| Consanguinity                     | 13 (15.7)                       |
| Systemic di, n (%)                |                                 |
| Diabetes mellitus                 | 28 (33.7)                       |
| Hypertension                      | 16 (19.3)                       |
| CHD                               | 2 (2.4)                         |
| Dyslipidemia                      | 2 (2.4)                         |
| BA                                | 3 (3.6)                         |
| Laterality of glaucoma, n (%)     |                                 |
| Bilateral                         | 34 (41.0)                       |
| Unilateral                        | 49 (59.0)                       |
| Eye, n (%)                        |                                 |
| OD                                | 55 (47.0)                       |
| OS                                | 62 (53.0)                       |
| Types of glaucoma, n (%)          |                                 |
| Primary congenital glaucoma       | 36 (30.8)                       |
| Primary closed-angle glaucoma     | 24 (20.5)                       |
| Secondary glaucoma                | 36 (30.8)                       |
| Neovascular glaucoma              | 14 (12.0)                       |
| Uveitic glaucoma                  | 13 (11.1)                       |
| Pseudoxfolliation glaucoma        | 5 (4.3)                         |
| Traumatic glaucoma                | 3 (2.65)                        |
| Steroid-induced glaucoma          | 1 (0.9)                         |
| Primary open-angle glaucoma       | 11 (9.4)                        |
| Aphakic glaucoma                  | 10 (8.5)                        |
| Glaucoma-specific indices, mean (±SD) |                           |
| IOP (mmHg)                        | 32 (±10.7)                      |
| Cup-to-disc ratio                 | 0.7 (±0.2)                      |
| Number of medications             | 2.7 (±1.0)                      |
| LogMAR visual acuity              | 1.4 (±0.9)                      |

SD: Standard deviation, CHD: Chronic heart disease, BA: Bronchial asthma, OD: Right eye, OS: Left eye, IOP: Intraocular pressure, LogMAR: Logarithm of the minimum angle of resolution

During surgery, pericardium patch was the predominant type of patches used in 63 (53.8%) eyes, followed by tutoplast in 12 (10.3%) eyes, scleral flap in 9 (7.7%) eyes, cornea in 3 (2.6%) eyes, and fascia lata in 2 (1.7%) eyes. The used tutoplast was dura mater tutoplast. Other patches are pericardium, cornea in glycerine, and sclera.

After Ahmed valve implant, the IOP was reduced from a mean preoperative value of 32 (±10.7), ranging 8–62 mmHg, to 16.2 (±5.7), ranging (7–39) mmHg, postoperatively, \( P < 0.001 \). Similarly, the mean number of antiglaucoma medications used was also significantly reduced from a preoperative mean value of 2.7 (±1.0), ranging 0–4, to 1.1 (±1.1), ranging 0–2, postoperatively, \( P = 0.046 \).

Although the mean LogMAR visual acuity has slightly improved from 1.4 (±0.9) to 1.3 (±0.9), such improvement was not statistically significant (\( P = 0.427 \)). The CDR deteriorated slightly from 0.7 (±0.2) to 0.8 (±0.2) (\( P = 0.036 \)) [Figure 1].

After a mean follow-up duration of 20.8 ± 3.1 (12–24) months, an overall success was achieved in 104 (88.9%) eyes. Thirty-six (30.8%) eyes had a complete success, and 68 (58.1%) eyes had a qualified success. Thirteen (11.1%) eyes failed after the procedure, and they needed at least two medications to control their IOP.

Complications included an increased IOP in 25 eyes (21.4%), encapsulation in 10 eyes (8.5%), hyphema in 7 eyes (6%), hypotony in 2 eyes (1.7%), and blood clots in the implanted tube in 2 eyes (1.7%) [Table 2].

The risk factors for failure of surgery were analyzed using a univariate statistical analysis. Hyphema, scleral patch types, and coronary heart diseases were found to be the risk factors for failure after Ahmed valve implantation (\( P = 0.006, 0.040, \) and \( 0.014, \) respectively) [Table 3].

**Figure 1:** A comparison between the preoperative (dark bar) and postoperative (light bar) glaucoma indices
Discussion

The current study attempts to provide evidence on the efficacy and safety of Ahmed glaucoma implant among the Saudi population. Our findings suggest that Ahmed valve implant has successfully and significantly reduced the increased intraocular patients among this consecutive series of patients to its safe threshold. Different techniques for tube insertion have been reported; otherwise, the majorities are inserted through an anterior chamber approach at our hospital, but there have been few instances where pars plana entry was used, notably after pars plana vitrectomy.\cite{6}

An overall successful outcome was achieved in 36 eyes (30.8%) as a complete success and 68 eyes (58.1%) as a qualified success after a mean follow-up duration of 20.8 ± 3.1 (12–24) months in our study. Out of 24 eyes with primary closed-angle glaucoma, an overall success rate was achieved in 23 eyes (95.6%). Similarly, out of the 36 eyes with secondary glaucoma, 33 eyes (91.7%) had an overall success rate. Ten eyes had aphakic glaucoma, 36 had primary congenital glaucoma, and 11 had primary open-angle glaucoma where an overall success rate was found to be 90% (9 eyes), 86.1% (31 eyes), and 72.7% (8 eyes), respectively. The higher failure rate in individuals with open-angle glaucoma cannot be contemplated as a clinically relevant risk factor for failure because of the variation in sample size between different types of glaucoma undergoing primary Ahmed tube insertion. However, the higher overall success rate in primary closed-angle glaucoma and secondary glaucoma subtypes might be attributed to an abundance of patients who are suitable for this procedure rather than other surgical interventions to control their IOP.

Qualified success was attained in 21 eyes (58.3%) and complete success in 10 eyes (27.8%).

In comparison to other studies performed, a cumulative probability of success of 78% at 12 months was achieved by Coleman et al.,\cite{7} whereas Ayyala et al.\cite{9} had a cumulative probability of success of 77% at 12 months. Huang et al.\cite{10} had a cumulative probability of success was at 1 year and 75% at 2 years after surgery. Taglia et al.\cite{11} experienced success rates at 1 year of 35% (15%–82%) for the Ahmed valve. In consistence with our study, Alasbali et al.\cite{12} published a study with 30 patients with refractory glaucoma, concluding that reduced IOP and the number of medications required to control refractory glaucoma, similar to our study. In our study, we used MMC as a routine in all patients that can help in improving the success rate and this matches with a study by Tien et al., who found a statistically significant difference in success rates between patients receiving MMC and those without (P = 0.011), with the MMC-treated group being 4.86 times more likely to have success as compared to the non-MMC group (95% CI: 1.45–16.34).\cite{13}

In our study, the probability of postoperative failure during follow-up in our series showed an increasing trend starting from 0.9% (0.9) in the 1st month to 11.1% (9.9) after 1 year. This increasing trend is quite common in repeated cases that use Ahmed valve implant as a second procedure of choice. Nevertheless, the failure rate of 11.1% is not considered high in such complicated glaucoma surgeries.

In the current study, during surgery, the pericardium patch was the predominant type of patches used in 63 (53.8%) eyes, followed by tutoplast in 12 (10.3%), sclera in 9 (7.7%), cornea in 3 (2.6%), fascia lata in 2 (1.7%), and healaflaw in 1 (0.85%). Majority of the studies are consistent with our study. Hwang and Kee\cite{14} illustrated that the surface area of expansion with pericardial membrane (Preclude) in AGV implant surgery had a significantly lower rate of HTN devoid of any postoperative complications. Quaranta et al.\cite{15} studied sutureless bovine pericardial patch in 20 cases that had not any of the following complications such as pericardial patch graft thinning, erosion of conjunctiva, tube exposure, or endophthalmitis in any of the cases. Spierer et al.\cite{16} used corneal tissue for 12 eyes; it was safe and effective, and there were no reported cases of rejection, tube exposures, wound dehiscence, or any drainage device-related complications.

In our study, although the mean LogMAR visual acuity has slight improvement from 1.4 (±0.9) to 1.3 (±0.9), such improvement did not reach the statistical significance level (P = 0.427). Kaya et al.\cite{17} reported a stable visual acuity which remained in most of the eyes during

### Table 2: Frequency of complications

| Complication                  | n (%) |
|-------------------------------|-------|
| Increased IOP                 | 25 (21.4) |
| Encapsulation                 | 10 (8.5) |
| Hyphema                       | 7 (6.0) |
| Blood clot in tube            | 2 (1.7) |
| Hypotony                      | 2 (1.7) |
| Hypotonic maculopathy         | 1 (0.9) |
| Endophthalmitis               | 1 (0.9) |
| Evisceration                  | 1 (0.9) |
| Exposed tube                  | 1 (0.9) |
| Leakage                       | 1 (0.9) |
| Retinal detachment            | 1 (0.9) |

IOP: Intraocular pressure

The conduct of multivariate analysis (binary logistic regression model) showed that in the presence of all risk factors, none of the associated variables were significant.

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In our study, although the mean LogMAR visual acuity has slight improvement from 1.4 (±0.9) to 1.3 (±0.9), such improvement did not reach the statistical significance level (P = 0.427). Kaya et al.\cite{17} reported a stable visual acuity which remained in most of the eyes during
follow-up. The mean visual acuity at baseline was 1.33 (±0.57) LogMAR units and at the last follow-up was 1.34 (±0.60) LogMAR units ($P = 1.00$).

Complications following implantation of Ahmed valves have been reported in the literature; the most prominent complications found in our study in the early as well as late postoperative periods were elevation of IOP and hypertensive phase, originally reported by Molteno and Dempster.\[18\] This can be explained by bleb fibrosis that might be stimulated by cells and collagen attracted by the endplates and subsequently elevation in the intraocular pressure. The higher rate of hypertensive phase in polypropylene type than polyethylene because of the nature of the endplates which are composed of rigid polypropylene may also play a role.\[9\] Reports on this hypertensive phase suggested that the peak occurred in the 1st month and stabilized by 6 months.\[19\] In our

### Table 3: Risk factors for failure

| Variable                  | Category                      | Success ($n=104)$, $n$ (%) | Failure ($n=13)$, $n$ (%) | Total ($n=117$), $n$ (%) | $P$  |
|---------------------------|-------------------------------|----------------------------|--------------------------|--------------------------|------|
| Age (years)               | ≤40                           | 47 (87.0)                  | 7 (13.0)                 | 54                       | 0.555|
|                           | >40                           | 57 (90.5)                  | 6 (9.5)                  | 63                       |      |
| Gender                    | Male                          | 60 (88.2)                  | 8 (11.8)                 | 68                       | 0.791|
|                           | Female                        | 44 (89.8)                  | 5 (10.2)                 | 49                       |      |
| DM                        | Yes                           | 35 (89.7)                  | 4 (10.3)                 | 39                       | 0.835|
|                           | No                            | 69 (88.5)                  | 9 (11.5)                 | 78                       |      |
| HTN                       | Yes                           | 19 (86.4)                  | 3 (13.6)                 | 22                       | 0.676|
|                           | No                            | 85 (89.5)                  | 10 (10.5)                | 95                       |      |
| CHD                       | Yes                           | 2 (100.0)                  | 0 (0.0)                  | 2                        | 0.014*|
|                           | No                            | 102 (88.7)                 | 13 (11.3)                | 115                      | 0.535|
| Dyslipidemia              | Yes                           | 3 (100.0)                  | 0 (0.0)                  | 3                        |      |
|                           | No                            | 101 (88.6)                 | 13 (11.4)                | 114                      |      |
| BA                        | Male                          | 60 (88.2)                  | 8 (11.8)                 | 68                       | 0.791|
|                           | Female                        | 44 (89.8)                  | 5 (10.2)                 | 49                       |      |
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*Statistically significant at 5% level of significance. DM: Diabetes mellitus, HTN: Hypertension, CHD: Congestive heart disease, BA: Bronchial asthma, VA: Vision, CDR: Cup-to-disc ratio, IOP: Intraocular pressure
cases, the second most common complication in the late postoperative period was encapsulation.

Hypertensive phase (HP) in our study occurred in 25 eyes (21.3%). Wu SC, in a study that included 19 eyes in 19 patients, had 12 patients (63.2%) who exhibited the HP. Nouri-Mahdavi and Caprioli\cite{20} presented 156 consecutive eyes (139 patients); HF occurred in 88 eyes (56%), Resolution of the HP in 19 of 68 eyes (28%). Ayyala et al.\cite{21} included 85 patients in their study; 70 cases (82%) exhibited HP. Jung et al.\cite{22} presented 44 patients (84.6%) out of 52 patients with hypertensive after AGV implantation. In our study, shifting to silicone implant may have attributed to the lesser percentage of hypertensive phase.

In our study, 7 eyes (6%) developed hyphema in the early postoperative days and 2 cases had obstruction of the tube with a blood clot; hyphema was found to increase the risk of failure after Ahmed valve implantation ($P = 0.006$ and 0.014, respectively). In our institute, we avoid this complication by ensuring a proper entry channel for tube passage to avoid excessive manipulation during this step and by injecting viscoelastic material into the anterior chamber to act as a tamponade. Hyphema in the early postoperative days is particularly seen in cases of neovascular glaucoma. Wu et al.\cite{19} reported one eye with hyphema (5.3%). Ayyala et al.\cite{21} reported hyphema as a major complication associated with the valve implantation, and it reached up to 14 eyes (16.5%). Coleman et al.\cite{17} reported blockage of the tube in 6 eyes (10%). Huang et al.\cite{18} had tube obstruction in 17 eyes (11%), which was the most common complication.

Two of our cases developed hypotony, and one of them developed maculopathy. Huang et al.\cite{18} reported a transient hypotony in 13 eyes (8%) after the operation. Theoretically, eyes receiving Ahmed valve should not develop hypotony. Kee et al.\cite{23} presented 32 patients who were divided into 16 patients with partial ligation and 16 patients without ligation. Early postoperative hypotony was observed more in nonligation group. Bochmann et al.\cite{21} predicted the risk of hypotony following AGV implantation by testing intraoperative opening and closing pressure.

Comparing pediatric versus adult population, infections were found to more common in young after tube shunt surgery.\cite{24} According to studies performed on children who underwent tube surgery, tubal erosion has been reported to be up to 11.1%.\cite{25,26} In our study, one of our patients (0.9%) developed endophthalmitis, which eventually ended with evisceration.

As regard postglaucoma drainage device surgery, conjunctival complications may occur, such as conjunctival dehiscence and exposed tube. This can be avoided by careful conjunctival closure.

In our study, we had one case (0.9%) of conjunctival erosion and tube exposure; tutoplast (dura mater) was applied and conjunctival was sutured. Ayyala et al.\cite{21} had tube exposure in 6 cases (7%) of their series.

In the current study, majority of the success cases were a qualified success supporting the investigation done by Pakravan et al.\cite{27} By dividing their patients into two groups, early and late initiation of antiglaucoma medications after AGV implant was investigated. They concluded that the group of early treatment had better outcomes as regards IOP reduction, hypertensive phase, frequency, and success rate, which may be explained by reducing the levels of inflammatory mediators in aqueous humor around the plate and decreasing hydrostatic pressure within the capsule.\cite{26}

The current study may have faced a number of limitations, including being a retrospective study, involving different glaucoma subtypes, and recruiting patients in a range of age groups as well as some variation in patients’ characteristics.

### Conclusions

Ahmed glaucoma valve implant is safely effective in lowering the IOP in intractable glaucoma cases, as demonstrated in this study. The rate of complications can be reduced by taking extreme cautious measures during surgery. The presence of hyphema and scleral patch type may be potential risks of failure after Ahmed valve implantation.

### Acknowledgment

The authors would like to thank Mrs. Hagar Aboelfath, Department of Ophthalmology, King Abdul-Aziz University Hospital, KSU for her help in editing the manuscript. The authors also acknowledge the support of the Glaucoma Research Chair, Department of Ophthalmology, College of Medicine, King Saud University, for enabling the current data and facilitating the process of analysis and reporting. Also many thanks go to Mrs. Priscilla Gikandi, Research Assistant, Department of Ophthalmology, KSU.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### References

1. 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;10:547-53.

2. Rodrigues GB, Abe RY, Zangalli C, Sodre SL, Donini FA, Costa DC, et al. Neovascular glaucoma: A review. Int J Retina Vitreous 2016;2:26.

3. Leen MM, Witkop GS, George DP. Anatomic considerations in the implantation of the Ahmed glaucoma valve. Arch Ophthalmol 1996;114:223-4.

4. Lim KS, Allan BD, Lloyd AW, Muir A, Khaw PT. Glaucoma drainage devices; past, present, and future. Br J Ophthalmol 1998;82:1083-9.

5. Gdede SJ, Schiﬀman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL, et al. Treatment outcomes in the Tube Versus Trabeculectomy (TVT) study after ﬁve years of follow-up. Am J Ophthalmol 2012;153:899-8000.

6. Riva I, Roberti G, Oddone F, Konstas AG, Quartan LA. Ahmed glaucoma valve implant: Surgical technique and complications. Clin Ophthalmol 2017;11:357-67.

7. Coleman AL, Hill R, Wilson MR, Choplin N, Kotas-Neumann R, Tam M, et al. Initial clinical experience with the Ahmed Glaucoma Valve implant. Am J Ophthalmol 1995;120:23-31.

8. Pakravan M, Esfandiari H, Yazdani S, Doozandeh A, Dastborhan Z, Gerami E, et al. Clinical outcomes of Ahmed glaucoma valve implantation in pediatric glaucoma. Eur J Ophthalmol 2019;29:44-51.

9. Ayyala RS, Michelini-Norris B, Flores A, Haller E, Margo CE. Comparison of different biomaterials for glaucoma drainage devices: Part 2. Arch Ophthalmol 2000;118:1081-4.

10. Huang MC, Netland PA, Coleman AL, Siegner SW, Moster MR, Hill RA. Intermediate-term clinical experience with the Ahmed Glaucoma Valve implant. Am J Ophthalmol 1999;127:27-33.

11. Taglia DP, Perkins TW, Gangnon R, Heatley GA, Kaufman PL. Comparison of the Ahmed Glaucoma Valve, the Krupin Eye Valve, and the double-plate Molteno implant. J Glaucoma 2002;11:347-53.

12. Alasbali T, Alghamdi AA, Khandekear R. Outcomes of Ahmed valve surgery for refractory glaucoma in Dhahran, Saudi Arabia. Int J Ophthalmol 2015;8:560-4.

13. Tien M, Yip L, Wong EP, Yong V, Wong H, Lim BA. The effect of adjuvant mitomycin C in Ahmed glaucoma valve surgery for refractory glaucoma. Invest Ophthalmol Vis Sci 2013;54:4771.

14. Hwang JM, Kee C. The effect of surface area expansion with pericardial membrane (principle) in Ahmed glaucoma valve implant surgery. J Glaucoma 2004;13:335-9.

15. Quaranta L, Riva I, Floriani IC. Outcomes of using a sutureless bovine pericardial patch graft for Ahmed glaucoma valve implantation. Eur J Ophthalmol 2013;23:738-42.

16. Spierer O, Rachmiel R, Lazar M, Alba M, Vassano D. Double use of corneal graft for Descemet stripping automated endothelial keratoplasty and coverage of glaucoma drainage device tube. J Glaucoma 2012;21:490-2.

17. Kaya M, Ozbek Z, Yaman A, Durak I. Long-term success of ahmed glaucoma valve in refractory glaucoma. Int J Ophthalmol 2012;5:108-12.

18. Molteno AC, Dempster AG. Methods of controlling bleb ﬁbrosis around drainage implants. In: Glaucoma: Proceeding of the Fourth International Symposium of the Norther Eye Institute; 1989. Manchester: Vision and Visual Health Care; 1998.

19. Wu SC, Huang SC, Lin KK. Clinical experience with the Ahmed glaucoma valve implant in complicated glaucoma. Chang Gung Med J 2003;26:904-10.

20. Nouri-Mahdavi K, Caprioli J. Evaluation of the hypertensive phase after insertion of the Ahmed Glaucoma Valve. Am J Ophthalmol 2003;136:1001-8.

21. Ayyala RS, Zurakowski D, Smith JA, Monshizadeh R, Netland PA, Richards DW, et al. A clinical study of the Ahmed glaucoma valve implant in advanced glaucoma. Ophthalmology 1998;105:1968-76.

22. Jung KI, Park H, Jung Y, Park CK. Serial changes in the bleb wall after glaucoma drainage implant surgery: Characteristics during the hypertensive phase. Acta Ophthalmol 2015;93:e248-53.

23. Bochmann F, Kipfer A, Tarantino J, Kaufmann C, Bachmann L, Thiel M. Intraoperative testing of opening and closing pressure predicts risk of low intraocular pressure after Ahmed glaucoma valve implantation. Eye (Lond) 2014;28:1184-9.

24. Chen TC, Bhatia LS, Walton DS. Ahmed valve surgery for refractory pediatric glaucoma: A report of 52 eyes. J Pediatr Ophthalmol Strabismus 2005;42:274-83.

25. Autrata R, Helmanova I, Oslejskova H, Vondracek P, Rehurek J. Glaucoma drainage implants in the treatment of refractory glaucoma in pediatric patients. Eur J Ophthalmol 2007;17:928-37.

26. Mahdy RA. Adjunctive use of bevacizumab versus mitomycin C with Ahmed valve implantation in treatment of pediatric glaucoma. J Glaucoma 2011;20:458-63.

27. Pakravan M, Rad SS, Yazdani S, Ghahari E, Yaseri M. Effect of early treatment with aqueous suppressants on Ahmed glaucoma valve implantation outcomes. Ophthalmology 2014;121:1693-8.