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Outcomes of severe uveitic glaucoma treated with Baerveldt implant: can blindness be prevented?

Annelie N. Tan,[1,2] Michiel F. Cornelissen,[1] Carroll A. B. Webers,[1] Roel J. Erckens,[1] Tos T. J. M. Berendschot[1] and Henny J. M. Beckers[1]

[1]Maastricht University Medical Centre, University Eye Clinic, Maastricht, The Netherlands
[2]Department of Ophthalmology, Leiden University Medical Centre, Leiden, The Netherlands

ABSTRACT.

Purpose: **To evaluate long-term outcomes on efficacy and safety of severe uveitic glaucoma treated with a Baerveldt glaucoma implant (BGI).**

Methods: **A retrospective study of 47 eyes of 47 patients with uveitic glaucoma treated by a BGI between September 2002 and September 2015. Main outcome measures were intraocular pressure (IOP), number of glaucoma medications, course of the uveitis, visual acuity (VA) and complications.**

Results: **Mean IOP dropped from 30.6 ± 8.1 mmHg with 3.6 ± 1.1 glaucoma medications at baseline to 10.6 ± 4.3 mmHg with 1.0 ± 1.3 glaucoma medications after a mean follow-up of 63.6 ± 43.1 months. In the majority of cases, IOP remained stable during follow-up. However, especially in several patients with viral uveitis, episodes with IOP peaks were observed during a flare-up despite a functioning implant. These peaks remained below preoperative levels. During follow-up, 16 patients (34%) experienced a clinically significant VA loss, mainly because of late-stage glaucoma or hypotony maculopathy. Early postoperative complications were transient choroidal effusion (n = 5), shallow/flat anterior chamber (n = 4), hyphaema (n = 2) and suprachoroidal haemorrhage (n = 1). The most important late postoperative complication was hypotony maculopathy (n = 5), three of these in juvenile idiopathic arthritis (JIA) patients.**

Conclusion: **The BGI is an effective and safe treatment for patients with refractive secondary glaucoma due to uveitis. In a majority of patients, VA remains stable and a low and stable IOP is maintained over time with an acceptable number of complications. In particular, patients with viral uveitis and glaucoma should be closely monitored for IOP peaks that may occur during episodes of a flare-up of uveitis, whereas at the other end of the spectrum, patients with JIA seem much more prone to hypotony maculopathy.**

Key words: Baerveldt glaucoma implant – glaucoma – intraocular pressure – uveitic glaucoma

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Introduction

Despite its relative rareness, uveitis can lead to sight-threatening complications. Approximately 10% of uveitis patients will ultimately become blind. The most serious sight-threatening complication is glaucoma: 10–30% will develop secondary glaucoma, and eventually, one-third of patients with uveitic secondary glaucoma will become (severely) visually impaired or (in the worst scenario) blind. Juvenile idiopathic arthritis (JIA), Fuchs heterochromic cyclitis and herpetic uveitis have even higher reported rates of secondary glaucoma development (Moorthy et al. 1997; Merayo-Lloves et al. 1999; Neri et al. 2004; Siddique et al. 2013; Baneke et al. 2016). Long-term corticosteroid treatment may be needed to control the uveitis but can also lead to uncontrollable high IOP. The balance between uveitis activity and IOP rise is often difficult to manage with medications.

Medical treatment fails in approximately 25% of patients with uveitic glaucoma. These patients need surgical treatment to control IOP (Heinz et al. 2009; Siddique et al. 2013).

Trabeculectomy without antifibrosis medication such as mitomycin C or 5-fluorouracil has a poor outcome (Hill et al. 1993; Stavrou & Murray 1999). However, even with antifibrosis medication, reported qualified success rates vary greatly, ranging from 38% to 79% at 5 years (Towler et al. 2000; Kaburaki et al. 2009; Chawla et al. 2013; Iwao et al. 2014; Iverson et al. 2015). Postoperative inflammation influences surgical success greatly as fibrosis develops more rapidly in inflamed eyes (Shimizu et al. 2014). Therefore, maximum control of uveitis before surgery is warranted, and after surgery, careful suppression of the postoperative inflammation is extremely important for successful surgery. Glaucoma drainage implants have become an important surgical alternative to treat secondary glaucoma. Although these implants have initially only been used after failed trabeculectomy, in case of uveitic glaucoma they are increasingly used as a primary

surgical procedure (Joshi et al. 2005). The three most frequently used glaucoma drainage implants are the Ahmed valve glaucoma implant (New World Medical, Rancho Cucamonga, CA, USA), the Molteno glaucoma implant (Molteno Ophthalmic Ltd., Dunedin, New Zealand) and the BGI (Abbott Medical Optics Inc., Santa Ana, California, USA). Studies reporting on the outcome of the BGI for uveitic glaucoma are scarce. Because of its larger plate surface area, this implant may be more successful for IOP control on the long term compared to the smaller implants that may fail earlier due to subconjunctival fibrosis and scarring.

The aim of this study was to evaluate long-term efficacy and safety of the BGI for patients with uveitic glaucoma, in relation to the course of their uveitis.

Patients and Methods

A retrospective study for which we reviewed the medical charts of all patients diagnosed with (chronic) uveitis and treated with a BGI in the period between September 2002 and September 2015 at the University Eye Clinic Maastricht, the Netherlands. In case of bilateral uveitic glaucoma, the first operated eye was included in the analysis. Patients with a follow-up of at least 6 months were included. All patients gave their consent to use their medical data for scientific research. The study was conducted according to the principles of the Declaration of Helsinki (WMA, Brazil, October 2013).

The following data were collected: IOP, topical and systemic medications (prior to and after surgery), VA, visual fields (VF) when available, complications and subsequent ocular surgery. These data were collected at baseline (with baseline IOP as the mean IOP of two visits prior to surgery), 1, 3 and 6 months postoperatively and every year thereafter. Data on demographics, cause of uveitis, history of ocular surgeries, size of BGI and placement of the tube were collected as well. If patients were no longer followed in our clinic, the referring ophthalmologist was contacted to obtain data, after having received the patients' permission.

Surgical technique

A limbal- or fornix-based conjunctival flap was made in the superotemporal quadrant. A 250-mm^2 or 350-mm^2 plate BGI was placed 10 mm from the limbus, the 350 mm^2 with its wings underneath the lateral and superior rectus muscles. The plate was secured to the sclera with two nylon 8×0 sutures (Ethicon – Johnson & Johnson, Somerville, NJ, USA). The tube was sutured to the sclera with one nylon 8×0 suture and tied off with a Vicryl 7×0 suture (Ethicon – Johnson & Johnson). In case IOP lowering was immediately needed, one or two venting slits were made, or an orphan trabeculectomy was created. The anterior chamber was entered with a 23-G needle after which the Baerveldt tube was inserted close and parallel to the iris, with a preferred intraocular tube length of 3 mm. Several tubes (especially in more narrow anterior chambers) were placed transiridially through a peripheral iridectomy to secure a stable position and to prevent corneal endothelial cell loss (Tan et al. 2014, 2017). In three cases, a pars plana approach was chosen. Before closing the conjunctiva watertight with a running Vicryl 7×0 suture, the extraocular part of the tube was patched with donor sclera and sutured to the underlying sclera with four interrupted Vicryl 7×0 sutures.

Postoperative topical antibiotics were given for 10 days, and topical steroids (dexamethasone or prednisolone acetate) were started 4–6 times daily and slowly tapered over a period of 8–12 weeks. However, in most cases steroids were permanently continued bid or qd to control the underlying uveitis. If deemed necessary because of severe inflammation, oral prednisolone was added in the postoperative hypertensive phase. If patients were on oral immunosuppressive drugs preoperatively (e.g. methotrexate, prednisolone, adalimumab or infliximab), these were continued postoperatively at the discretion of the prescribing physician. If necessary, postoperative glaucoma medication was added to reach target IOP.

Outcome measures

Main outcome measures were IOP, number of postoperative glaucoma medications, VA loss, progression of VF loss, complications and uveitis activity. Three different definitions of success were used: postoperative IOP of $\geq$5 mmHg and $\leq$21 mmHg, or $\leq$18 mmHg, or $\leq$15 mmHg and a minimal IOP reduction of 30% from baseline. Failure was defined as two consecutive study visits without meeting the success criteria, with or without glaucoma medication (qualified success), starting after 3 months, with the first visit considered as the moment of failure. Total loss of vision, additional glaucoma surgery and removal of the BGI were also considered failures.

Statistical analysis

A linear mixed-model analysis (LMM) was used to analyse IOP, glaucoma medication, VA, VF progression and topical steroids. They were each fitted as a dependent variable with time as a factor and assuming a random intercept per eye. Success rates were determined by the Kaplan–Meier survival method. A p-value of 0.05 or less was considered statistically significant.

Baseline VA was also compared to VA at the last recorded visit to determine whether patients had a clinically significant loss of VA. Clinically significant loss was defined as a decrease of >0.20 LogMAR from baseline (Lim et al. 2010). The medical charts of these patients were analysed in more detail to provide an explanation.

Results

Forty-seven eyes of 47 patients, mean age 51.8 $\pm$ 16.6 years, 57% male, and 49% right eyes, with a mean follow-up of 63.6 $\pm$ 43.1 months (range 6–144 months) were included. From these, twelve patients had bilateral uveitis. In two patients, a BGI was implanted in both eyes: the first operated eye was included in the study. Demographic data are shown in Table 1. A majority (72%) of patients had a history of one or more ocular surgeries: 70% cataract surgery, 28% one or more trabeculectomies (range 1–3), 21% pars plana vitrectomy, 9% encircling band and scleral buckle and one (2%) penetrating keratoplasty (PKP). The most important causes of uveitis were idiopathic (28%), Fuchs heterochromic iridocyclitis (17%), sarcoidosis (15%) and JIA (7%). The tube

Table 1. Demographic characteristics.

	n (%)
Patients	47
Male	27 (57)
Female	20 (43)
Eyes	47
Right	23 (49)
Left	24 (51)
Age	
Mean ± SD, years	51.8 ± 16.6
Range, years	15–83
Follow-up	
Mean ± SD, months	63.6 ± 43.1
Range, months	6–144
Cause of uveitis	
Unknown	14 (30)
Fuchs uveitis syndrome	8 (17)
Sarcoidosis	6 (13)
JIA	4 (9)
Bechterew's disease	3 (6)
HSV	4 (9)
Syphilis	1 (2)
Polyarthritis	1 (2)
Rheumatic disorder	1 (2)
UGH syndrome	1 (2)
Bartonella	1 (2)
Cytomegalovirus	1 (2)
Sarcoidosis + Bechterew	1 (2)
Rubella	1 (2)
Lens status	
Phakic	14 (30)
Aphakic	3 (6)
Pseudophakic	30 (64)
Previous glaucoma surgery	
No. of patients with a TE	13 (28)
1 × TE	11 (23)
2 × TE	1 (2)
3 × TE	1 (2)
Previous other surgery	
Pars plana vitrectomy	10 (21)
Encircling band	4 (9)
Cataract surgery	33 (70)
Penetrating keratoplasty	1 (2)
Type of BGI	
350 mm^2	41 (87)
250 mm^2	3 (6)
Pars Plana 350 mm^2	3 (6)

SD = standard deviation; JIA = juvenile idiopathic arthritis; HSV = herpes simplex virus; TE = trabeculectomy; BGI = Baerveldt glaucoma implant.

was placed in the anterior chamber in 43 cases, of which 10 tubes were placed transiridial. In three eyes, a pars plana approach was chosen: in one case, the tube was placed in the ciliary sulcus. In two cases, an orphan trabeculectomy was performed. Three patients received a 250-mm^2 Baerveldt plate, once because of inadequate conjunctiva quality, twice because of the diagnosis JIA. All surgeries were performed by a single surgeon (HB).

IOP and glaucoma medication

Mean IOP dropped from 30.6 ± 8.1 mmHg at baseline to 10.6 ± 4.3 mmHg (65% reduction) at the last follow-up visit ($p < 0.001$, paired *t*-test) (Fig. 1). Patients with hypotony maculopathy were excluded from this analysis. Seventy-nine per cent of patients reached an IOP of ≤15 mmHg and ≥5 mmHg. IOP kept decreasing significantly until the sixth month (all $p < 0.011$, LMM). Thereafter, no further significant reduction was recorded and IOP remained stable.

The number of glaucoma medications decreased from 3.6 ± 1.1 at baseline to 1.0 ± 1.3 at the last follow-up visit ($p < 0.001$, paired *t*-test), with 53% of patients totally off medications. Medication use decreased sharply until the third postoperative month (all $p < 0.011$, LMM). Thereafter, a statistically non-significant tendency for a further reduction was noticed. No patient used more glaucoma medications postoperatively compared to preoperatively, 40% used fewer topical medications, and the remaining 7% used the same number of topical medications but were off oral acetazolamide.

Until the third postoperative month, there was a high need for topical steroids. In three patients with significant ocular inflammation, oral prednisolone was also added for several months until the inflammation subsided.

In seven eyes, despite the BGI, IOP fluctuations (peaks >5 mm than mean IOP over the years) kept occurring during bouts of uveitis: four (57%) with viral uveitis (HSV, CMV and rubella), one with Bartonella and two with idiopathic uveitis. In the other eyes, IOP remained low and stable, with little fluctuation over the years.

Success rate

With an upper limit of 21 mmHg, qualified success for 1 and 5 years was 89% (95% CI: 0.80–0.98) and 75% (95% CI: 0.60–0.90), respectively (Fig. 2). The reasons for failure after 5 years of follow-up in this group were hypotony maculopathy ($n = 5$), loss of light perception ($n = 4$) and removal of the implant ($n = 3$). With an upper limit of 18 mmHg, the qualified success was 87% (95% CI: 0.77–0.97) and 74% (95% CI: 0.59–0.89), respectively. With an upper limit of 15 mmHg, the qualified success rate dropped to 67% (95% CI: 0.53–0.81) and 51% (95% CI: 0.35–0.67).

Uveitis disease activity and systemic medication

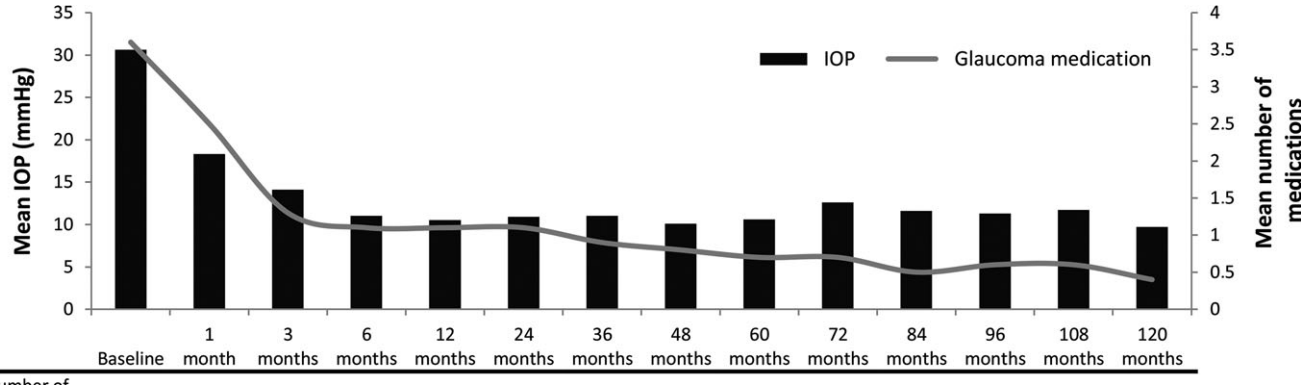
Seventeen patients (36%) used systemic immunosuppressive agents preoperatively to control their uveitis and/or underlying disease. Six used oral steroids, five adalimumab, three methotrexate, one infliximab and two acyclovir (Table 2). In the period after BGI implantation, five other patients were treated with oral steroids to suppress excess ocular inflammation and prevent a flare-up. One patient started with adalimumab postoperatively and once valacyclovir was given. Thus, a total of 24 patients (51%) used systemic immunosuppressive or antiviral agents postoperatively: 11 (46%) used corticosteroids, 10 (42%) used biologicals, and three (13%) used antiviral medication. Additionally, in most cases topical steroids were used as a maintenance therapy (87% at 1 year); however, 8.5% experienced a flare-up within the first year and had to use topical steroids 4–6 times a day (none of them had viral uveitis). Over the next years, the yearly flare-up rate fluctuated from 2.9% to 17.1%. IOP remained stable in these eyes despite the high topical steroid use, with the exception of patients with viral uveitis who still had IOP fluctuations with peaks.

Of the 24 patients with systemic immunosuppressive agents, only two with viral uveitis and one with Bartonella experienced large IOP fluctuations. Thus, the other five patients with IOP peaks did not use any type of systemic medication.

Visual acuity (VA) and visual field progression

Using mixed-model analysis, a statistically significant loss of VA was recorded only after 9 years ($p = 0.022$). Mean VA loss after 9 years was 0.86 LogMAR (95% CI: 0.12–1.60).

At the last follow-up visit, VA had remained stable in 23 patients and was improved in eight patients after cataract surgery, as compared to baseline. Sixteen patients (34%) experienced a clinically significant VA loss at the last follow-up visit (Table 3), starting after a mean follow-up of 41 ± 32 months.



	Baseline	1 month	3 months	6 months	12 months	24 months	36 months	48 months	60 months	72 months	84 months	96 months	108 months	120 months
Number of patients	47	47	47	47	41	39	34	29	23	19	17	13	8	7
IOP (mmHg) mean ± SD*	30.6 ± 8.1	18.3 ± 9.5	14.1 ± 7.6	11.0 ± 4.3	10.5 ± 4.8	10.9 ± 4.9	11.0 ± 4.3	10.1 ± 4.2	10.6 ± 2.9	12.6 ± 5.0	11.6 ± 5.0	11.3 ± 3.7	11.7 ± 5.2	9.7 ± 5 .8
Medications mean ± SD†	3.6 ± 1.1	2.5 ± 1.8	1.3 ± 1.4	1.1 ± 1.2	1.1 ± 1.3	1.1 ± 1.3	0.9 ± 1.0	0.7 ± 1.1	0.7 ± 1.1	0.7 ± 1.1	0.5 ± 0.8	0.6 ± 1.0	0.6 ± 0.9	0.4 ± 0.8
Pt. with 0 med. (%)	2	23	45	49	44	49	47	62	65	63	71	69	63	71

Fig. 1. Mean IOP and mean number of glaucoma medications over a period of 10 years. [a]Patients with hypotony maculopathy were excluded. [b]Oral glaucoma medication was counted as one extra medication.

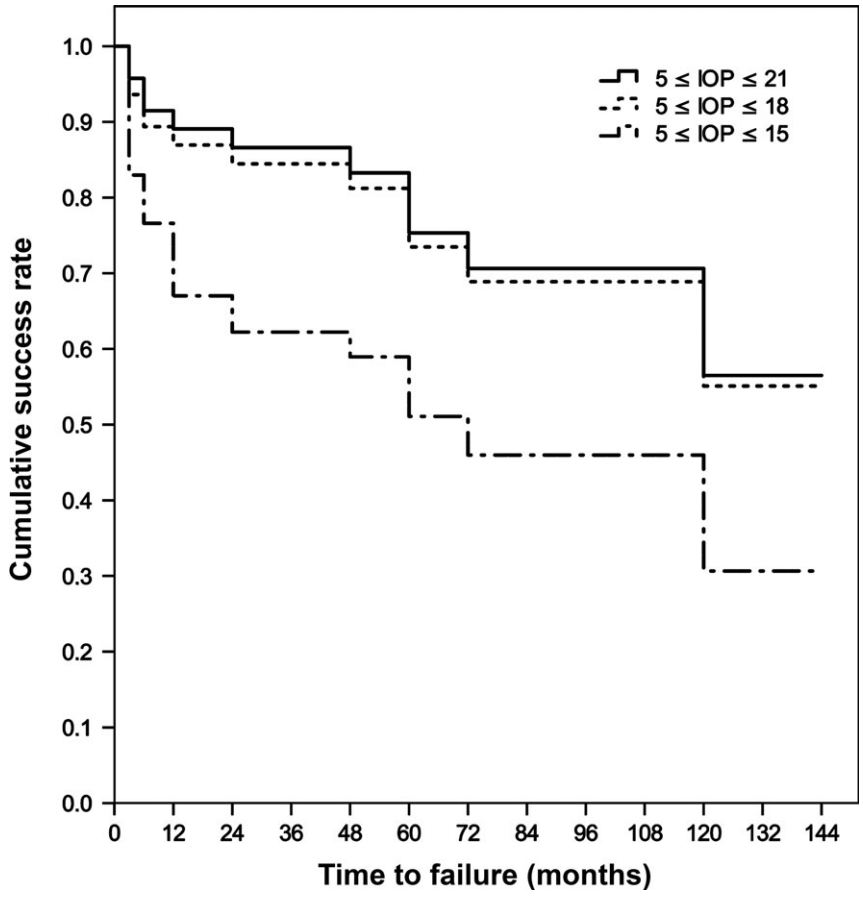


Fig. 2. Cumulative qualified success rates. Qualified success was defined as an IOP ≥5 mmHg and ≤21, 18 or 15 mmHg, a reduction of more than 30% from baseline, with or without glaucoma medications and without subsequent glaucoma surgery, loss of light perception or removal of the implant.

From these, four ultimately went blind. Three patients were preoperatively already severely visually impaired (ranging from hand motion to light perception in late-stage glaucoma). The fourth eye went blind from a postoperative suprachoroidal haemorrhage. The main reasons for VA deterioration for the other patients were hypotony maculopathy ($n = 5$), progression of VF loss despite a stable control of IOP in late-stage glaucoma ($n = 4$), and exacerbations of uveitis with uncontrolled IOP ($n = 3$; twice HSV uveitis, once Bartonella). One eye had a postoperative exacerbation of idiopathic uveitis for which oral steroids were started, and this is probably the reason of VA loss; however, no IOP fluctuations were recorded in this case. For one eye, no reason could be found. All 16 patients were pseudophakic ($n = 13$) or aphakic ($n = 3$).

Table 2. Systemic medication at baseline.

	n (%)
Oral prednisolone	6 (13)
Infliximab	1 (2)
Adalimumab	5 (11)
Methotrexaat	3 (6)
Acyclovir	2 (4)
Total number of patients	17 (36)

Twenty-two patients had at least one preoperative (maximum 12 months before surgery) and two postoperative VF tests with the 30-2 protocol of the Humphrey VF analyser (HFA; Carl Zeiss Meditec, Jena, Germany). Due to the differences in postoperative time of the VF testing for these patients, the postoperative period was divided into periods of 2 years. Mean preoperative mean deviation (MD) for these patients

Table 3. Visual acuity at baseline and at last visit.

	Baseline (n = 47)	Last visit (n = 47)
Mean VA (LogMAR)	0.60 ± 0,66	0.90 ± 1.20
VA range (LogMAR)	0.00 to 3.20	−0.08 to 3.51
		n (%)
Better VA*		8 (17%)
Same VA		23 (49%)
Worse VA		16 (34%)
	n (%)	n (%)
≤0.18 LogMar (20/30)	14 (30%)	14 (30%)
>0.18 < 1.30 LogMar	26 (55%)	22 (47%)
≥1.30 LogMar (20/400)	7 (15%)	11 (23%)†

VA = visual acuity; SD = standard deviation.
Last visit is defined as the mean of all last recorded visual acuity of each patient with a mean follow-up of 63.6 months.
* Difference of more than 0.2 LogMAR with baseline VA.
† Four blind eyes.

was −13.25 (95% CI: −16.73 to −9.76). The MD dropped to −15.76 (95% CI: −20.75 to −10.78) during the first two postoperative years. During the two consecutive postoperative years thereafter, the MD remained relatively stable with a mean of −15.98 (95% CI: −20.90 to −11.05). After 4 years of follow-up, only nine patients had at least one VF test. However, the difference between preoperative and postoperative VF tests was never significant (LMM, $p > 0.275$).

Complications

Table 4 lists early (within 3 months) and late (after 3 months) postoperative complications. A total of 11 patients (23%) had a serious complication (defined as a complication for which a reoperation was needed or with a clinically significant VA loss (Gedde et al. 2012; Budenz et al. 2016)).

Thirteen patients (28%) had one or more early complications, the most serious being a suprachoroidal haemorrhage that needed to be drained. Five eyes developed mild choroidal effusion, which spontaneously resolved in all cases. A shallow or flat anterior chamber, for which reformation with viscoelastics was needed, was seen in six eyes. Because of partial conjunctival dehiscence, one eye needed extra conjunctival suturing. In three eyes, a spontaneously resolving hyphaema occurred.

Fourteen patients (30%) experienced one or more late complications. To repair persistent hypotony, the tube was tied off in three eyes, which was successful only once. The most severe late complication was hypotony maculopathy (n = 5), in three of these cases occurring in patients with JIA. One painful blind eye with preexistent corneal decompensation was eviscerated. Because of tube erosion, a new scleral patch graft revision was needed in two cases. In one of them, the BGI plate eroded again and was finally removed. An encapsulated bleb developed in one eye with an encircling band and scleral buckle. This was resolved by removing all scleral material and placing a new BGI via the pars plana. In one case, cornea decompensation occurred after BGI implantation. Two cases with previous corneal decompensation underwent PKP, once a PKP was performed after a patient developed a herpetic corneal ulcer.

Table 4. Complications divided into early (<3 months) and late (>3 months) onset.

	<3 months n (%)	>3 months n (%)
Persistent mild diplopia*	7 (15)	
Choroidal effusion	5 (11)	0 (0)
Shallow/flat anterior chamber	4 (9)	2 (4)
Hypotony maculopathy	0 (0)	5 (11)
Corneal decompensation†	0 (0)	4 (9)
Tube endothelial touch	0 (0)	2 (4)
Conjunctiva/wound dehiscence	1 (2)	0 (0)
Tube erosion	0 (0)	2 (4)
Suprachoroidal haemorrhage	1 (2)	0 (0)
Cystoid macula oedema	0 (0)	1 (2)
Encapsulated bleb	0 (0)	1 (2)
Cornea ulcer	0 (0)	1 (2)
Hyphaema	2 (4)	1 (2)
Total number of patients‡	13 (28)	14 (30)
Number of patients with serious complications§	11 (23)	

* Only one patient needed an intervention; strabismus surgery.
† Three with preexisting corneal decompensation.
‡ Some patients had more than one complication.
§ Serious complication was defined as a complication for which a reoperation was needed or with VA loss (>0.20 LogMAR).

Discussion

Our study shows that the treatment of uveitic glaucoma is challenging, but in most patients with uveitic glaucoma, the BGI maintains a low and stable IOP over many years, with a significant reduction in glaucoma medications.

Only a few studies have reported on the long-term results of the BGI in uveitic glaucoma. Besides the long follow-up, the strengths of our study are the size of the study population and the extensive analysis of VA and complications. To analyse the retrospective collected data as efficiently as possible, we used linear mixed-model analysis (LMM). The advantage of this model is that all available data are included in the analysis. Still, due to the nature of retrospective studies and the heterogeneity of the study population, the results have to be interpreted with caution.

An important finding in this study is that IOP was substantially reduced and remained stable with a reduction between 59% and 68% during a ten-year follow-up period. However, IOP fluctuations can still occur after BGI implantation in a number of patients with uveitic glaucoma, for which mainly patients with viral uveitis seem to be at risk. However, IOP peaks during bouts of uveitis did not reach preoperative levels. Lewkowicz et al. (2015) also reported higher IOP in patients with viral uveitis compared to nonviral uveitis.

A successful control of the uveitis and its underlying disease seems to be

of crucial importance in the success of treatment of uveitic glaucoma. In recent years, systemic therapy has improved a lot after the introduction of biologicals as an addendum to the treatment armamentarium. In our study, 46% of patients who used systemic medication preoperatively used corticosteroids and 42% used biologicals. These medications seem very beneficial to prevent vision loss from IOP peaks; however in a few patients, the underlying uveitis seems to have been the reason for further visual deterioration despite stable IOP.

Our results compare to the one-year results of other studies that reported an IOP reduction between 57% and 69% after 1 year (Ceballos et al. 2002; Iverson et al. 2015). Iverson et al. reported a stable reduction over a period of 5 years as well. The IOP reduction for the Molteno glaucoma implant in uveitis patients seems slightly lower than for the BGI. At 1 year, the reported IOP reduction ranges from 50% to 56% (Molteno et al. 2001; Vuori 2010). Molteno et al. also reported an IOP reduction after 10 years of follow-up of 54% from baseline. There are four studies with a follow-up of 2 years or more with the Ahmed valve implant, reporting an IOP reduction ranging from 46% to 67% (Da Mata et al. 1999; Ozdal et al. 2006; Rachmiel et al. 2008; Bettis et al. 2015). Thus, the BGI probably results in a larger reduction in IOP than the other glaucoma drainage implants, possibly through its larger plate size. Recently, a large meta-analysis in a general glaucoma population compared the Ahmed valve with the BGI and reached the same conclusion (Wang et al. 2015). However, this study reported more complications in the Baerveldt group.

In most studies, success rate is defined as an IOP of 21 mmHg or lower. In our study, and in most other studies, the majority of patients have advanced glaucoma. Therefore, we believe that the aim of the BGI should be a low target pressure to prevent progression. Thus, a stricter upper limit of 18 mmHg or even 15 mmHg seems a more realistic definition of success. For the sake of comparison, we included a success rate with an upper limit of 21 mmHg. Still, it is difficult to compare these data because of differences in baseline characteristics, in particular the number of previous surgeries and the cause of uveitis. Our qualified success rate at 1 year (89%) is similar to those of Ceballos et al. and Iverson et al.; 92% and 91% at 1 year, respectively. At 5 years, a success rate of 75% was recorded, which is similar to the one we found (Iverson et al. 2015). In the Iverson study, 26% of patients continued their systemic uveitis medication. Caballos et al. do not mention systemic medication in their study. The qualified success at 1 year for the Ahmed valve implant ranged from 50% to 100% (Da Mata et al. 1999; Ozdal et al. 2006; Papadaki et al. 2007; Rachmiel et al. 2008; Bettis et al. 2015). The success rate for the Molteno implant at 1 year ranged from 79% to 97% (Hill et al. 1993; Valimaki et al. 1997; Broadway et al. 2001; Molteno et al. 2001; Vuori 2010). Molteno et al. (2001) reported a success rate of 87% and 77% at, respectively, 5 and 10 years. The short-term success rates are quite similar for the three implant types. It seems that the Molteno implant has a better long-term success rate, but this is only based on a single study.

Only a few articles report on VA loss, all with slightly different definitions. In the study of Ceballos et al. (2002), 21% of the patients had a profound loss of VA. Fifteen to 40% of patients with a Molteno glaucoma implant experienced VA loss (Hill et al. 1993; Valimaki et al. 1997). Five studies report the VA loss for the Ahmed valve implant. The percentage of patients with VA loss ranges from 0% to 26% (Gil-Carrasco et al. 1998; Da Mata et al. 1999; Ozdal et al. 2006; Papadaki et al. 2007; Rachmiel et al. 2008). In our study, 16 patients (34%) had a clinically significant VA loss at the last recorded visit. This number appears slightly higher than reported for the Ahmed valve implant. Most of this can be accounted for by the longer follow-up in our study, as mean VA loss only became significant after 9 years. Multiple earlier surgical procedures influenced this number as well, together with severe baseline pathology (other than uveitis), progression of VF loss in several patients and several cases with postoperative complications (hypotony maculopathy and suprachoroidal haemorrhage). A recent study of Pathanapitoon et al. showed that 41% of patients with uveitic glaucoma became blind at least in one eye, which was significantly higher compared to the uveitis eyes without secondary glaucoma (18%). A total of 69% of these eyes underwent glaucoma surgery (Pathanapitoon et al. 2017).

With regard to VF progression, we have to be careful to draw conclusions due to the lack of sufficient data. The majority of patients performed at least one VF test at baseline, from only 22 patients at least two postoperative VF tests were available for analysis. The main reasons for this were end-stage glaucoma, further follow-up by the referring ophthalmologist, or a short follow-up period. However, we observed a tendency towards a drop in MD (−3.40 dB) in the first 2 years after implantation, with a stabilization thereafter. From existing literature, we could not corroborate this finding with earlier work. In a preliminary study by the group of Jansonius (F.G. Junoy Montfolio, R.P.H.M. Müskens and N.M. Jansonius, abstract presented at 210th meeting of the Dutch Ophthalmological Society, Maastricht 2016), it was suggested that an increase in inflammation caused by the BGI may cause visual field progression in the early postoperative phase. If this is confirmed, this further underlines the need to sufficiently suppress inflammation, especially in uveitic eyes.

The complications recorded in this study are similar to those in two large prospective studies, the Tube Versus Trabeculectomy (TVT) study (Gedde et al. 2012) and the Ahmed Baerveldt Comparison (ABC) study (Budenz et al. 2016). At 5 years, the serious complication rate for the BGI was 22% and 29% in the TVT and ABC study, respectively. In our study, 23% had a serious complication. An important difference in late postoperative complication is the number of patients with hypotony maculopathy. Both studies reported approximately 1% hypotony maculopathy in the Baerveldt group. We recorded 11% ($n = 5$) hypotony maculopathy patients, three of them with JIA. A 250 mm^2 was tried for two patients with JIA, but one patient still developed a hypotony maculopathy with this smaller implant.

Hypotony is a known complication, even without surgery: with 10% per year of patients with JIA, this patient category is especially at risk (Thorne et al. 2007). Because of its chronic asymptomatic character, undertreatment is

possible, and ciliary body atrophy can occur (Foster 2003). Our patients with JIA underwent BGI surgery late in the course of the disease. A more aggressive and earlier medical and surgical approach of these patients may possibly lead to a better outcome (Foster et al. 2000; Kotaniemi & Sihto-Kauppi 2007).

In conclusion, the BGI has shown to be a long-term effective and safe treatment for refractive secondary glaucoma due to uveitis. Continued systemic immunosuppressive treatment seems beneficial to prevent a flare-up and uncontrolled IOP. The main reasons for postoperative vision loss in this population most probably are severe disease at baseline, uncontrolled uveitis/inflammation despite stable IOP, continued IOP fluctuations with IOP peaks (e.g. in viral uveitis), whereas at the other end of the spectrum, especially patients with JIA seem much more prone to hypotony maculopathy.

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Correspondence:
Henny J. M. Beckers, MD, PhD
University Eye Clinic
PO Box 5800
6202 AZ Maastricht
The Netherlands
Tel: +31 43 387 53 42
Fax: +31 43 387 53 43
Email: henny.beckers@mumc.nl

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