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Glaucoma drainage implants in the treatment of refractory glaucoma in pediatric patients

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PURPOSE. *The aim of this study is to report the clinical course, effectiveness, and safety of glaucoma drainage implants (Molteno and Baerveldt devices) in primary and secondary childhood glaucomas refractory to conventional surgical treatments and medical therapy.*
METHODS. *This retrospective study included 76 children (76 eyes) younger than 18 years who underwent glaucoma drainage device (GDD) implantation in our clinic between 1990 and 2004. The mean age at time of surgery was 6.9±5.3 years (range: 4 months to 17.5 years). Intraocular pressure (IOP), visual acuity, corneal diameter, axial length, intraoperative and postoperative complications, and number of glaucoma medications were evaluated. Criteria for success were defined as IOP between 7 and 22 mmHg with or without glaucoma medications, no further glaucoma surgery, the absence of visually threatening complications, and no loss of light perception. Results were compared for children with primary and secondary glaucomas. The mean follow-up was 7.1±6.5 years (range: 1.6 to 15.2 years).*
RESULTS. *Mean preoperative and postoperative IOP was 33.6±11.4 mmHg and 17.1±6.5 mmHg ($p<0.001$), respectively. Kaplan-Meier survival analysis showed cumulative probability of success: 93% at 6 months, 91% at 1 year, 82% at 2 years, 76% at 3 years, 71% at 4 years, 67% at 5 years, and 65% at 6 years. There was no difference between patients with primary (n=31 eyes) and secondary glaucoma (n=45 eyes) in terms of cumulative success ($p=0.186$), final IOP, number of medications, or length of follow-up. On average, the GDI surgery was successful for a mean period of 6.7 years. Fourteen eyes of 76 (18.4%) failed: 10 eyes with uncontrolled IOP, 2 eyes with retinal detachment, and 2 eyes with no light perception. Statistical regression model did not show influence of gender and previous surgery. Lower age at the time of surgery was found to be associated with higher probability of treatment failure.*
CONCLUSIONS. *Molteno and Baerveldt glaucoma drainage implants surgery seems to be safe and effective treatment for primary and secondary pediatric glaucoma refractory to the initial surgical procedure and medical therapy. (Eur J Ophthalmol 2007; 17: 928-37)*

KEY WORDS. *Glaucoma drainage devices, Pediatric glaucoma, Primary developmental glaucoma, Secondary glaucoma*

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INTRODUCTION

The initial management of primary childhood glaucoma, congenital or infantile, consists of goniotomy or trabeculotomy, which have success rates of 75% to 90% (1-3). For most secondary glaucomas of childhood and primary pediatric glaucomas refractory to angle surgery, medical therapy is frequently unsuccessful. Traditionally, the next surgical option has been trabeculectomy (4-8). However, numerous studies have demonstrated disappointing suc-

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cess rates using standard trabeculectomy due to the healing response in children, which may lead to a higher rate of fibrosis and scarring. To reduce the scarring, antifibrotic agents such as mitomycin C have been utilized (9-16). Trabeculectomy with mitomycin C has a moderate probability of success, ranging from 40% to 90%, with lower success seen in younger children (10-12). The relatively high rate of endophthalmitis in younger patines after mitomycin trabeculectomies and poor visual outcomes with these infections in children (14, 15) has prompted the use of glaucoma drainage implants as an alternative surgical approach in these challenging pediatric patients (17). Cyclodestructive procedures have been used but require multiple retreatments and may be associated with phthisis bulbi (18-20). The glaucoma drainage device (GDD) implantation has been shown to be an effective treatment for refractory adult glaucomas (21-23). Several studies have examined the outcomes of the GDD implantation in children, and have evaluated the efficacy and safety of the Baerveldt glaucoma drainage implants (BGDI) and Molteno glaucoma drainage implants (MGDI) in pediatric patients (17, 24-29). The aim of this study is to describe the clinical course, effectiveness, and safety of the Molteno and Baerveldt glaucoma implants in groups of primary and secondary pediatric glaucomas refractory to conventional surgery, with a long-term follow-up.

MATERIALS AND METHODS

The medical records were reviewed to identify patients who had received a GDD in a 15-year period from 1990 to 2004 at the Department of Pediatric Ophthalmology, Masaryk University Hospital. All included patients had uncontrolled glaucoma, despite maximal medical therapy, and many had failed previous glaucoma surgery. For patients who underwent GDD implantation in both eyes, one eye was randomly selected for inclusion. Patients with less than 6-month follow-up were excluded. Information extracted from the medical records included number and types of prior surgery; preoperative intraocular pressure (IOP), visual acuity (VA), and number of glaucoma medicines; surgical technique; postoperative IOP, VA, and number of glaucoma medications; subsequent surgical procedures; and intraoperative and postoperative complications.

A similar operative technique was performed in all patients for placement of the GDD. There were Molteno double plate (270 mm^2) and Baerveldt plate (250 mm^2) drainage implants randomly used. All surgical procedures were performed by one of two glaucoma subspecialists using a similar technique. The quadrant of choice for the implant was the superotemporal, followed by the superonasal quadrant. After conjunctival peritomy and dissection of Tenon capsule, the bellies of the adjacent rectus muscles were identified. GDD's plate was placed 8 to 10 mm posterior to the limbus. The ligated tube was inserted into the anterior chamber parallel to the iris plane or in the vitreous chamber when the surgery was combined with a pars plana vitrectomy. The tube was secured to the episclera with 8-0 polyglactin and covered with a patch graft. The Tenon capsule and conjunctiva were separately sutured. Postoperatively, antibiotics were prescribed five times per day for 1 week, topical atropine 1% was used two times per day for 3 to 4 weeks in phakic patients, and topical steroids were administered five times per day for 6 to 8 weeks. In 10 patients, two-stage implantation was performed, using the technique described by Molteno et al (30). The plate was attached to the sclera in the initial surgical procedure, and the tube was inserted 4 weeks later.

Criteria for surgical success were defined as an IOP of 7–22 mmHg with or without glaucoma medications, no further glaucoma surgery, absence of visually threatening complications, and no loss of light perception. Preoperative and postoperative IOP and number of medications were compared using paired Student *t*-tests. These variables were compared between groups using nonpaired Student *t*-tests. Postoperative VA, IOP, and medication data were censored subsequent to failure. Categorical variables were compared using the chi-square test. Kaplan-Meier survival curves were used to calculate long-term probability success rates. Survival was compared for primary and secondary glaucomas using the log-rank sum test. Results were considered significant at $p<0.05$.

RESULTS

Seventy-six eyes of 76 patients were identified that fit the study inclusion criteria. The mean age of all these patients was 6.9±5.3 years (4 months to 17.5 years). Follow-up time ranged from 2.6 to 15.2 years, with a median follow-up of 7.1 years. The most common preoperative diagnosis was primary congenital or infantile glaucoma, followed by glaucoma associated with aphakia, Sturge-Weber syndrome, and ocular trauma. Table I shows the preoperative

and postoperative clinical characteristics of all patients, and provides information on the amount of follow-up, IOP, and number of glaucoma medications in use at last follow-up for each group, primary or secondary glaucoma. A total of 31 primary and 45 secondary childhood glaucomas were identified. In the secondary glaucoma group, diagnoses associated with secondary glaucomas included aphakia after extraction of congenital cataract (9); Sturge-Weber syndrome (7); ocular trauma (7); congenital rubella syndrome (6); Peters anomaly (5); aniridia (4); persistent hyperplasia of the primary vitreous (4); and juvenile rheumatoid arthritis (3). There were no significant differences in demographic or preoperative clinical characteristics between the two groups. The primary childhood glaucoma group had a somewhat younger mean age at implant surgery than the secondary glaucoma group, although the difference did not reach statistical significance (4.2 years vs 7.8 years, respectively; p=0.0935). The average length of follow-up for all patients was 7.1 and did not differ significantly between the two groups.

Surgery was performed in a single stage in 63 patients and in two stages in 13 cases. Sixty-four implants were placed in the superotemporal quadrant and 12 in the inferotemporal quadrant. Six patients underwent concurrent pars plana vitrectomy with or without lensectomy. Four patients had the tube placed in the pars plana rather than in the anterior chamber after vitrectomy.

Forty-two (55.2%) of the 76 patients had had one previous glaucoma surgery, and 25 (32.8%) had had two or more glaucoma surgeries before receiving the GDD. In 9 children (11.8%), the implantation of the GDD was the primary surgical procedure. Previous glaucoma and other ophthalmic surgeries of all the patients are listed in Table II. The most common previous surgeries were trabeculectomy, trabeculotomy, and goniotomy.

The mean number of ocular antiglaucomatous medications used preoperatively was 1.8 (range 1–4). Seventy-three percent of patients were being treated with beta-blockers (Tab. III).

Intraocular pressure

The mean preoperative IOP was 33.6±11.4 mmHg (range, 21–53 mmHg) for all patients and did not differ significantly between primary and secondary glaucoma groups. The mean postoperative IOP was 17.1±6.5 mmHg (range, 5–39 mmHg) and the median number of ocular hypotensives used was one at the time of the final visit (Tab. I).

The difference between pre- and postoperative IOP for the total group of eyes was statistically significant ($p<0.001$). Figure 1 shows preoperative IOP and IOP at last follow-up for all participants of this study group. The majority of patients had IOPs lower at last follow-up than preoperatively.

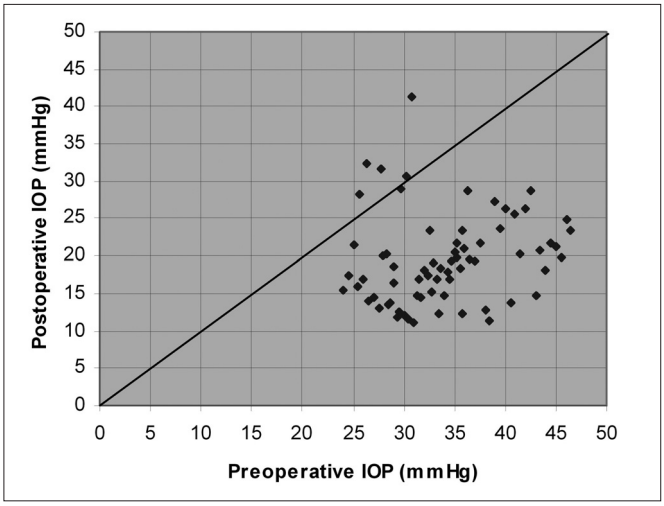

Fig. 1 - *Scatter chart demonstrating intraocular pressures (IOPs) before and after glaucoma drainage devices implantation in all the children on the final visit.*

Visual acuity

Preoperative VAs were available for 57 patients: 22 in the primary glaucoma group and 35 in the secondary glaucoma group. VA could not be measured preoperatively in 19 patients because of poor patient cooperation. Final postoperative VAs were available in 66 patients and were slightly better than preoperative values, possibly due to improved ability to measure in older children at last examination. Among those 57 patients who had VA measured both pre- and postoperatively, 28 had improved VA, 22 were unchanged, and 7 were worse. The distribution of preoperative VA was 20/20 to 20/80 in 13 patients, 20/100 to 20/800 in 30 patients, counting fingers to light perception in 14 patients. On the final visit, the distribution of postoperative VA was 20/20 to 20/80 in 19 patients, 20/100 to 20/800 in 26 patients, counting fingers to light perception in 12 patients (Tab. IV).

The cumulative probability of success

For the total group, the cumulative probability of success at 6 months and 1, 2, 3, 4, 5, and 6 through 10.4 years af-

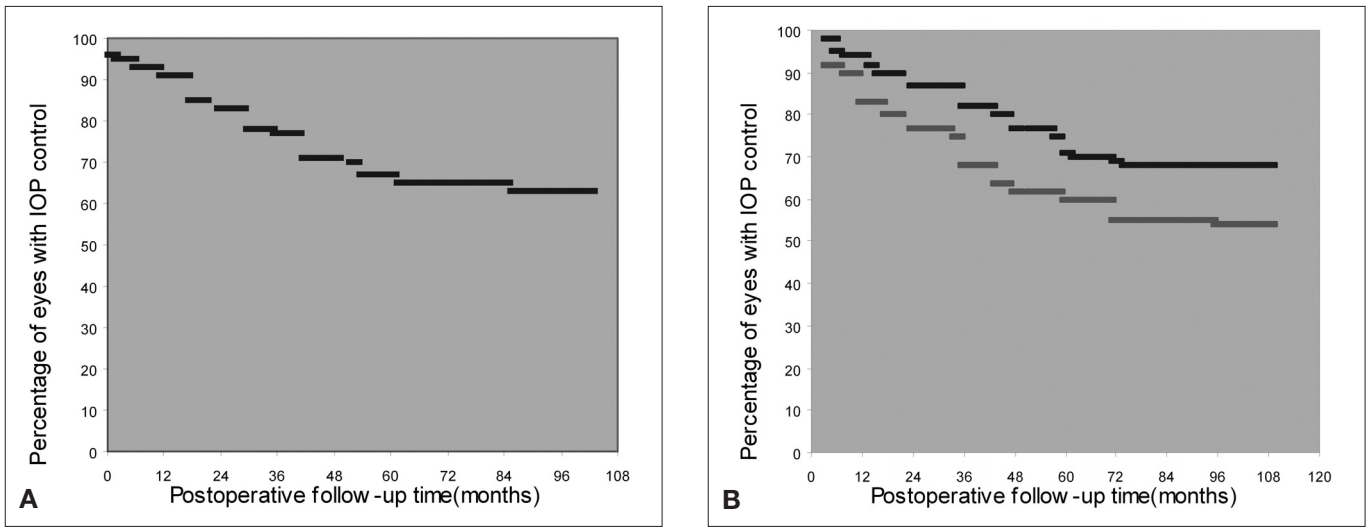

Fig. 2 - A) *Kaplan-Meier survival curve showing the probability of success of all patients after glaucoma drainage devices implantation over the study.* **B)** *Kaplan-Meier survival curve showing the probability of success of primary and secondary glaucoma patients after drainage device implantation over the study. Gray line = primary glaucoma cases. Black line = secondary glaucoma cases.*

ter Molteno and Baerveldt glaucoma drainage device implantation was 93.1%, 91.4%, 82.7%, 76.5%, 71.4%, 67.2%, and 65.3%, respectively. In the primary congenital and the secondary glaucoma groups, the cumulative success rate is summarized in Table V and Kaplan-Meier survival curves are demonstrated in Figure 2, a and b.

A log-rank test comparing survival curves by diagnostic group did not show any statistically significant difference in terms of survival between primary and secondary glaucoma (p=0.186). Of the 76 GDDs performed in this study, 62 (81.6%) were considered successful. Fourteen eyes (18.4%) were considered failures: 9 eyes had uncontrolled IOP, 3 eyes developed retinal detachment, and 2 failed because of loss of light perception.

A risk factor analysis

We evaluated whether success or failure of GDD implantation procedure was dependent on preoperative factors such as gender, age at surgery, previous surgeries, type

TABLE I - PREOPERATIVE AND POSTOPERATIVE CLINICAL CHARACTERISTICS OF PATIENTS WITH PRIMARY AND SECONDARY PEDIATRIC GLAUCOMA WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

	All patients (n=76)	Primary glaucoma (n=31)	Secondary glaucoma (n=45)	p value
Age, yr	6.9 ± 5.3 (0.3–17.5)	4.2 ± 3.6 (0.15–10)	7.8 ± 6.9 (0.5–17.5)	0.089*
Male/female	41/35	17/14	24/21	0.915†
Previous surgery	1.6 ± 1.2 (0–5)	1.8 ± 1.3 (0–5)	1.5 ± 1.2 (0–4)	0.713†
Number of glaucoma medications preoperatively	1.8 ± 1.5 (1–4)	1.6 ± 1.4 (1–4	1.9 ± 1.5 (1–4)	0.442*
Preoperative IOP (mmHg)	33.6 ± 11.4 (21–53)	35.3 ± 11.2 (23–56)	32.9 ± 9.7 (21–52)	0.581*
Follow-up, yr	7.1 ± 6.5 (1.6–15.2)	7.8 ± 6.7 (2.9–15.2)	6.5 ± 5.9 (1.6–13.8)	0.615*
Number of glaucoma medications postoperatively	1.1 ± 1.4 (0–3)	0.9 ± 1.2 (0–3)	1.3 ± 1.2 (0–3)	0.432*
Postoperative final IOP (mmHg)	17.1 ± 6.5 (5–39)	17.8 ± 6.9 (7–39)	16.8 ± 6.4 (5–36)	0.879*

Values are mean ± standard deviation (range).
*Two-sample t test.
†Chi-square test.
IOP = Intraocular pressure

of drainage implants (Molteno versus Baerveldt device), glaucoma type, preoperative IOP, or preoperative number of glaucoma medications (Tab. VI). There was no relationship between failure or success and all these analyzed factors, by a log-rank test used. When these data were reanalyzed stratified by type of glaucoma, primary compared to secondary glaucoma, there was no statistically significant result.

Complications

There were no intraoperative complications. In addition to the failures already noted, 21 of 76 eyes (27.6%) developed other complications. Three eyes had cataract formation requiring cataract extraction. Eight of the eyes developed tube-related complications: three eyes had tube blockage, three eyes had tube retraction, two eyes had exposure of the tube caused by graft retraction. Three eyes presented vitreous hemorrhage, two eyes had flat anterior chambers, two eyes developed serous choroidal detachment, two eyes had retinal detachment requiring scleral buckling. One eye presented with infected and exposed tube and this patient was treated for endophthalmitis (Tab. VII).

TABLE II - PREVIOUS GLAUCOMA AND OPHTHALMIC SURGERIES OF PEDIATRIC PATIENTS WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

Previous surgery	Number	%
Trabeculotomy	29	38.2
Trabeculectomy	27	35.5
Goniotomy	23	30.2
Combined trabeculotomy and trabeculectomy	18	23.6
Trabeculectomy with mitomycin C	17	22.3
Cyclocryotherapy, cyclophotocoagulation	13	17.1
Cataract extraction	8	10.5
Pars plana vitrectomy	6	7.8
Scleral buckling	6	7.8
Drainage tube implant	4	5.2
Penetrating keratoplasty	3	3.9

TABLE III - PREOPERATIVE AND POSTOPERATIVE (in the last visit) USE OF OCULAR HYPOTENSIVE MEDIACTIONS IN PEDIATRIC PATIENTS WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

Ocular hypotensive medications	Preoperatively, n (%)	Postoperatively, n (%)
Beta-blockers	56 (73.6)	32 (42.1)
Oral carbonic anhydrase inhibitors	31 (40.7)	6 (7.8)
Topical carbonic anhydrase inhibitors	33 (43.4)	18 (23.6)
Prostaglandins	27 (35.5)	13 (17.1)
Alpha-adrenergic	21 (27.6)	9 (11.8)

DISCUSSION

The treatment of primary congenital or infantile developmental glaucoma is generally surgical. Medical therapy has a limited role in the treatment of childhood glaucoma and is used as an adjunctive therapy postoperatively. Goniotomy ab interno and trabeculotomy ab externo are the initial surgical procedures for primary infantile glaucoma. Both procedures have been shown to have success rates ranging from 54% to 90%, with a low rate of complications (2, 5). Success rates vary according to the popula-

TABLE IV - PREOPERATIVE AND POSTOPERATIVE (on the final visit) VISUAL ACUITIES IN PEDIATRIC PATIENTS WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

Visual acuity	Preoperatively, n (%)	Postoperatively, n (%)
20/20	0	3 (5.2)
20/25	2 (3.5)	3 (5.2)
20/30	4 (7)	5 (8.7)
20/40	2 (3.5)	3 (5.2)
20/50	1 (1.75)	2 (3.5)
20/60	2 (3.5)	2 (3.5)
20/80	2 (3.5)	2 (3.5)
20/100	4 (7)	6 (10.5)
20/200	8 (14)	7 (12.3)
20/300	6 (10.5)	4 (7)
20/400	5 (8.7)	5 (8.7)
20/800	7 (12.3)	4 (7)
CF, FF	7 (12.3)	6 (10.5)
HM	5 (8.7)	4 (7)
LP	2 (3.5)	2 (3.5)
NLP	0	2 (3.5)

Total of 57 patients.
CF = Counting fingers; FF = Fix and follow; HM = Hand movements; LP = Light perception; NLP = No LP

TABLE V - OUTCOME AND THE CUMULATIVE PROBABILITY OF SUCCESS IN PEDIATRIC PATIENTS WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

Outcome	All eyes in the study	Primary glaucoma, n=31 eyes	Secondary glaucoma, n=45 eyes
Overall surgical outcome, n (%)			
Success	62 (81.6)	26 (83.8)	36 (80)
Failure	14 (18.4)	5 (16.2)	9 (20)
Cumulative success, %			
6 months (n=76)	93.1±3.6	92.7±4.9	94.9±3.1
1 year (n=76)	91.4±3.9	83.6±6.1	93.7±3.3
2 years (n=76)	82.7±4.8	76.9±7.5	87.3±4.5
3 years (n=73)	76.5±5.6	68.3±8.9	82.1±4.9
4 years (n=69)	71.4±7.2	65.4±10.2	77.4±6.1
5 years (n=61)	67.2±8.6	62.8±10.8	70.2±9.5
6 years (n=53)	65.3±9.7	57.5±11.7	68.9±10.3
Failure, n (%)			
Uncontrolled IOP (>22 mmHg)	10 (13.1)	4 (12.9)	6 (13.3)
Retinal detachment	2 (3.9)	0	2 (4.4)
Loss of light perception	2 (2.6)	0	2 (4.4)

IOP = Intraocular pressure

TABLE VI - A RISK FACTOR ANALYSIS FOR FAILURE IN PEDIATRIC PATIENTS WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

Factor of analysis	The cumulative probability of success at 1 year ± SD	p Value (log-rank test)
Gender		
Male	0.86±0.07	0.648
Female	0.97±0.05	
Age at surgery, yr		
<2	0.78±0.08	0.275
2–5	0.84±0.10	
>5	0.85±0.11	
Type of GDI		
Molteno	0.82±0.06	0.396
Baerveldt	0.90±0.07	
Number of previous surgeries		
0	0.73±0.12	0.805
1–2	0.79±0.09	
≥3	0.88±0.14	
Number of preoperative ocular hypotensives		
0–1	0.81±0.08	0.591
2–4	0.89±0.06	
Preoperative IOP (mmHg)		
≤30	0.82±0.11	0.743
31–40	0.87±0.10	
≥41	0.91±0.07	
Type of glaucoma		
Primary	0.83±0.06	0.186
Secondary	0.93±0.03	

GDI = Glaucoma drainage implant; IOP = Intraocular pressure; SD = Standard deviation

TABLE VII - POSTOPERATIVE COMPLICATIONS IN PEDIATRIC PATIENTS WHO UNDERWENT GLAUCOMA DRAINAGE DEVICES IMPLANTATION

Type of complication	No. (%)
Cataract formation	3 (3.9)
Tube obstruction	3 (3.9)
Tube retraction	3 (3.9)
Exposure of the tube	2 (2.6)
Vitreous hemorrhage	3 (3.9)
Flat anterior chamber	2 (2.6)
Serous choroidal detachment	2 (2.6)
Retinal detachment	2 (2.6)
Endophthalmitis	1 (1.3)
Overall	21 (27.6)

tion studied and the type of glaucoma. Some authors have proposed a combined trabeculotomy–trabeculectomy procedure as the initial surgery and report (6) an improvement of the success rate following the combined procedure for severe and moderate cases of primary congenital glaucoma. Secondary developmental glaucomas presenting in infancy, such as aniridia, Sturge-Weber syndrome, anterior segment dysgenesis, and glaucoma associated with aphakia, are typically unresponsive to primary angle surgery. When angle procedures fail, we are confronted with a choice of what procedure to do next.

Surgical options available to these children include trabeculectomy with or without adjunctive antifibrosis therapy, glaucoma drainage device surgery, or cyclodestructive procedures.

Some conclusions can be drawn based on the case series published to date. Trabeculectomy during the first year of life has a lower success rate than in older children (12, 13), the use of intraoperative mitomycin C (MMC) does not have a significantly better long-term outcome compared with historical controls without MMC, and finally the risk of bleb-associated complications following filtering surgery augmented with MMC is continuous into the future (14, 15).

GDDs offer the potential advantage over trabeculectomy of being technically feasible for use in the presence of conjunctival scarring or in buphthalmic eyes with very thin sclera. Because the bleb of the GDD is placed far posterior to the limbus, the long-term risk of infection is lower than with trabeculectomy. Potential disadvantages of GDDs include the risk of implant erosion or occlusion of the tube with vitreous.

No prospective, randomized trials comparing MMC trabeculectomy with GDDs in refractory congenital glaucoma have yet been performed. The retrospective case series published by Beck and coworkers (16) reviewed the outcomes of children aged 2 years or younger who had undergone implantation of a GDD (n=48; AGV or BGI) or MMC-augmented trabeculectomy (n=24) after the failure of primary angle surgery. The cumulative success rate for the GDDs (53±12%, standard deviation) was greater than that for MMC trabeculectomy (19±7%) after 6 years of follow-up ($p<0.0001$). This retrospective study is limited by the nonrandomized choice of the surgery type and the inclusion of secondary glaucoma. In the absence of large comparative trials, it is helpful to examine case series of GDDs alone to better predict the success rates and complications.

The success rates for control of IOP reported in studies with glaucoma drainage implants range from 50 to 95%, depending on the criteria for success, variable types of implants, and length of follow-up (17, 24, 25, 31, 32). Most patients eventually require adjunctive glaucoma medications for IOP control after surgery. Regardless of the IOP criteria used, declining success is seen with longer follow-up (17, 21) Beck et al (16) reported a short term success rate of 87% at 1 year that declined to 53% at 6 years.

Several implant types have been investigated, including the single- and double-plate Molteno implant, Ahmed implant, Krupin Schocket implant, and Baerveldt implant. Differences in patient populations, follow-up periods, surgical technique, and IOP criteria for success make comparison of these retrospective studies difficult. Most reported series suffer from relatively short follow-up. Longer follow-up almost always leads to reduced surgical success.

Our current study reports a relatively large series of GDDs in children with refractory glaucomas, with the longest follow-up and demonstrating significant IOP lowering, from 33.6 mmHg preoperatively to 17.1 mmHg after an average follow-up of 7.1 years. The success rate in our study is 82% at 2 years, decreased to 65% at 6 years, and is similar to those reported in other studies evaluating GDDs in pediatric patients with intermediate follow-up.

Two large case series of Baerveldt implants in refractory pediatric glaucoma were recently published. In a retrospective study of 62 patients, Budenz and colleagues (24) reported a cumulative success rate of 80% at 1 year, 67% at 2 years. They found no difference in success between patients with primary compared with secondary pediatric glaucomas. Rolim de Moura and coworkers (25) reported similar results in 48 patients with a median follow-up of 21 months. Cumulative success was 90% at 1 year, 84% at 2 years, and 58% at 4 years. In both series, failure was on the basis of uncontrolled IOP, retinal detachment, or loss of light perception.

It is difficult to compare the probabilities of success between the different glaucoma drainage devices in pediatric patients due to the lack of uniformity. Considerations such as buphthalmos, a tight orbit, or conjunctival scarring represent risk factors for surgical failure that are independent of GDD type. This difficulty is further compounded by situations in individual pediatric patients that require choosing one type of implant over another.

A recent systematic review of the literature by Hong et al (22) failed to show a significant difference among different GDDs in adults. Only one study comparing implants in pediatric patients has been performed. Beck et al (16) used both AGVs and BGIs in their patients; they reported no difference in success rate between the two GDD types in 32 children 2 years and younger with primary congenital glaucoma and a failed previous angle procedure (follow-up of 6 years). However, the choice of implant was not randomized.

In our present study, there was no significant difference in the probability of success between the Molteno ant the

Baerveldt implants (p=0.396).

The most common postoperative complications, tube-related problems such as tube retraction, tube exposure, tube blockage, tube-cornea or tube-iris touch, have been reported in numerous studies. Tube-cornea contact has been reported (24-26, 31, 33) in a range from 5% to 20%. In our series, it occurred in 7.8% of eyes. Surgical repositioning of the tube was necessary to resolve this complication without any loss of IOP control in the majority of these eyes. Children younger than 2 years at the time of surgery appear to be at higher risk for this complication (16). With regard to tube blockage and tube retraction, these complications are probably due to pliable or elastic and thinned corneoscleral tissue in pediatric eyes (17). Another tube-related complication is occlusion of the tube with vitreous in pediatric aphakic eyes. Anterior vitrectomy must be performed to avoid this late complication.

Flat anterior chamber and serous choroidal detachment have been noted after GDD surgery. In our study, two eyes had flat anterior chambers and two eyes had choroidal detachments, which resolved spontaneously. These incidences are comparable to other studies reported (17). In pediatric patients the reported incidence of hypotony and flat anterior chamber varies, ranging from 0% to 25% (17). In an attempt to avoid or minimize the risk of complications caused by hypotony, a two-stage implantation of GDD or temporary ligation of the tube may be implemented. This technique has been shown to be safe and effective in this group with postoperative choroidal effusions and suprachoroidal hemorrhage (34).

Two patients (2.6%) in the current series had retinal detachments (RD) decreasing the visual acuity despite RD surgery with pars plana vitrectomy. None of these occurred within 6 months of surgery, thus their relationship to the GDD surgery remain unclear. The implant was removed in both cases at the time of scleral buckling for a rhegmatogenous RD. Removal of the plate was required to allow placement of an encircling band.

Tube exposure and scleral plate erosion associated with endophthalmitis developed in one eye (1.3%) from our study group of children. This complication necessitated explantation of the device. Early and late postoperative endophthalmitis after GDD surgery has occurred at the rate of 0% to 5% (27, 28, 35). The culture-negative cases may have represented a severe noninfectious inflammatory response postoperatively, rather than infectious endophthalmitis. Young patients have a tendency toward a more exuberant inflammatory response with GDD surgery (25, 36, 37).

We noted no cases of ocular motility disturbance in our series. Because many of the patients in the current series were of preverbal age, had poor vision, or were monocular, the motility examination was used to assess for postoperative strabismus rather than complaints of diplopia. Motility disturbances have been described after placement of the Molteno (38) and Baerveldt implants (39). Strabismus after GDD surgery may be due to mechanical restriction of the rectus or oblique muscles by the implant and bleb or posterior fixation suture effect induced by scarring under the rectus muscle. Placement of GDD in the superotemporal quadrant may reduce the risk of this complication (17).

Late postoperative IOP elevation attributed to bleb encapsulation was observed in 9 eyes (11.7%) of our present study. This complication occurs at a rate of 6% to 20% (17) in pediatric glaucomas with different glaucoma drainage devices. If the IOP increases because of an encapsulated bleb, adjunctive medical therapy is recommended. If this therapy fails to control IOP, cyclophotocoagulation or excising a portion of the pseudocapsule around the plate may be useful (17).

In summary, GDD implantation is an effective and useful option in refractory pediatric glaucoma when previous conventional angle or filtration surgery with adjunctive medical therapy have already failed. Similar probabilities of success in primary and secondary pediatric glaucoma types were observed. Most complications associated with glaucoma drainage surgery are generally not devastating and IOP control can be maintained with additional surgical intervention. A large prospective randomized comparative clinical study may prove useful to establish long-term outcomes.

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