Long-term follow-up of Molteno drains used in the treatment of glaucoma presenting in childhood

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CLINICAL STUDY

Abstract

Purpose and methods **This study reviews the long-term follow-up (mean 11.2 years, range 9 months to 16 years 9 months) of Molteno drains used in the treatment of glaucoma presenting in childhood, in 34 eyes of 25 patients.**

Results **Intraocular pressure control was achieved in 85% of eyes, and vision (where measurable) was maintained in 57% of eyes. Seventy-one per cent of eyes required further surgical intervention. Thirty-two per cent of these cases were for drain-related problems, which may be avoidable with the use of current surgical techniques. The remaining interventions were for associated ocular defects, and for problems caused by multiple surgical procedures and periods of high intraocular pressure during early childhood.**

Conclusions **Today the implants are used at an earlier stage in the disease process to try to obtain early and definitive IOP control and so help to optimise the long-term visual prognosis.**

Key words Childhood glaucoma, Follow-up, Molteno drain

The use of Molteno drains in glaucoma presenting in childhood is usually reserved for eyes that have failed previous surgical procedures or are unlikely to respond to such procedures. In this study we have examined the long-term follow-up of a group of eyes that received Molteno drains for glaucoma presenting in childhood. The eyes in this series that were initially treated were complex cases that had often undergone multiple previous surgical procedures and the drains were inserted as a final attempt to control intraocular pressure (IOP). The initial drains were also performed as a two-stage procedure. As techniques developed with time, the drains were inserted as a one-stage procedure with the use of a Vicryl tie. Some of the eyes in this series formed the basis of a previous report.[1]

Primary congenital glaucoma is often managed surgically with either goniotomy or trabeculectomy and encouraging success rates (over 90%) have been reported in selected cases with both these procedures,[2–7] but more than one procedure may be required. Primary trabeculectomy for congenital glaucoma has been shown to have a good success rate[8–10] and is considered the treatment of choice by some authors.[11] The use of beta-irradiation[12] with trabeculectomy or antimetabolites[13,14] may improve the success rate of trabeculectomy even further; however, a note of caution has been raised with their use in juvenile patients.[15] The combined procedure of trabeculotomy–trabeculectomy also has good reported success rates.[9]

Other studies have reported less successful outcomes with trabeculectomy performed in children and young people.[16–20] Secondary glaucoma such as glaucoma associated with Sturge–Weber syndrome[21] or aniridia[22] or glaucoma secondary to surgery for congenital cataracts, and primary glaucoma in which initial goniotomy or trabeculotomy procedures have failed, may prove more difficult to treat. Where these initial procedures fail, further treatment options for control of glaucoma include cyclocryotherapy[23–26] (which may be associated with significant complications) and the use of drainage implants such as the Molteno drain.[1,28–37]

Subjects and methods

Patients with glaucoma presenting in childhood before the age of 10 years who received a Molteno drain before the age of 30 years and who were operated on within this department, were identified from a data base of Molteno drains. A case note review of these eyes was then performed to establish their long-term follow-up, with particular reference to IOP control, visual acuity, and complications and further surgery. Where patients had left the area, their current ophthalmologist was contacted for follow-up. One eye was lost to

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Table 1. *Pre-operative status and surgery*

Eye	Diagnosis	R/L	Age	Previous treatment	IOP (mmHg) Pre-op	IOP (mmHg) Range	Treatment	Visual acuity	Surgery Plates	Surgery Buckle	Surgery SFT
1	Cleavage defect, aphakic	L	22y 9m	Cyclodialysis ×3 Cyclodiathermy ×1 Iridectomy ×2	20	20–48	Acet, Adren	PL	2	No	No
2	Congenital glaucoma	L	21y 1m	Scheie's ×1	35	24–35	Acet, Adren, Carb	6/12	2	Yes	Yes
3	Congenital glaucoma, aphakic	R	2y 5m	Goniotomy ×2 Trabeculectomy ×4 Cyclodiatherapy ×1 Lens extraction ×1	37	37–45	Acet	CS	2	Yes	Yes
4	Congenital glaucoma, aphakic	L	2y 5m	Goniotomy ×2 Trabeculectomy ×4 Cyclodiatherapy ×1 Lens extraction ×1	37	32–50	Acet, Tim	CS	2	Yes	Yes
5	Congenital glaucoma	R	26y	Goniotomy ×2 Trephine ×1 Scheie's ×1 Sphincterotomy ×1	40	15–40	Acet, Adren, Isoptocarb	6/36	2	Yes	Yes
6	Congenital glaucoma	L	26y	Goniotomy ×1 Scheie's ×1 Goniopuncture ×1	32	20–39	Acet, Adren, Isoptocarb	6/60	2	Yes	Yes
7	Congenital glaucoma	R	6y 5m	Goniotomy ×3	23	18–28	Acet, Adren	6/18	2	Yes	No
8	Aphakic, rubella, microphthalmic	R	10y 1m	Lens extraction ×1 Scheie's ×1 Cyclodialysis ×1 Cyclocryotherapy ×1 Cyclodiathermy ×1	36	36–59	Acet, Adren, Pilo	CF	2	Yes	Yes
9	Aphakic, rubella, microphthalmic	L	10y 1m	Lens extraction ×1 Cyclodialysis ×1 Trabeculectomy ×2 Cyclodiathermy ×1 Scheie's ×1	60	35–60	Acet, Pilo, Adren	3/60	2	Yes	Yes
10	Rubella, aphakic, microphthalmic	R	20y	Lens extraction ×1 Capsulotomy ×1	32	27–32	Acet, Tim	6/60	2	Yes	Yes
11	Rubella, aphakic, microphthalmic	L	20y	Lens extraction ×1 Capsulotomy ×2	29	28–34	Acet, Tim	6/60	2	Yes	Yes
12	Aphakic	R	16y 10m	Lens extraction ×2 Goniotomy ×3 Scheie's ×2 Sclerectomy ×1	33	33–50	Acet, Adren, PI	PL	2	No	Yes
13	Aphakic	L	16y 10m	Lens extraction ×1 Goniotomy ×2 Scheie's ×3 Sclerectomy ×2	20	12–35	Acet, Adren, PI	2/60	2	No	Yes
14	Uveitic, aphakic	R	24y	Trabeculectomy ×1 Trephine ×1 Scheie's ×1	24	34–50	Acet, Pilo, Adren	6/9	1	Yes	Yes
15	Congenital glaucoma	R	13y 4m	Goniotomy ×3 Trabeculectomy ×1	24	15–25	Acet, Adren	6/60	2	Yes	Tes
16	Congenital glaucoma	L	13y 4m	Goniotomy ×3 Trabeculectomy ×1	20	15–23	Acet, Adren	6/60	2	Yes	Yes
17	Rubella, aphakic	L	15y 6m	Lens extraction ×1 Needling ×1 Capsulotomy ×1 Iridectomy ×1	25	17–40	Adren, PhI	6/36	2	Yes	Yes
18	Congenital glaucoma	R	13y 8m	Goniotomy ×1	36	35–36	Acet, Adren	PL	2	No	Yes
19	Congenital glaucoma	L	12y 5m	Goniotomy ×2 Trabeculectomy ×1	18	14–35	Acet, Tim, Pilo	HM	2	No	Yes

Table 1–*Cont*

Eye	Diagnosis	R/L	Age	Previous treatment	IOP (mmHg) Pre-op	IOP (mmHg) Range	IOP (mmHg) Treatment	Visual acuity	Surgery Plates	Surgery Buckle	Surgery SFT
20	Sturge–Weber syndrome	R	10y 7m	Nil	29	19–30	Tim, Pilo, Adren	6/6	2	No	Yes
21	*Congenital glaucoma*	*R*	*2 days*	*Nil*	*37*	*37*	*Nil*	*NM*	*1*	*No*	*No*
22	Congenital glaucoma	L	2 days	Nil	35	35	Nil	NM	1	No	No
23	Neurofibromatosis	R	4 days	Nil	29	29	Nil	NM	1	No	No
24	Aphakic, microphthalmic	R	3y 2m	Lens extraction ×1 Capsulotomy ×2	35	20–35	Acet, Tim	PC1/2M	2	No	Yes
25	Aphakic, microphthalmic	L	3y 2m	Lens extraction ×1	35	12–35	Acet, Tim	PC1m	2	No	Yes
26	Congenital glaucoma, dislocated lens	R	15y 11m	Trabeculectomy ×1	38	14–43	Acet, Prop	6/18	2	No	No
27	Congenital glaucoma, dislocated lens	L	16y 6m	Nil	18	13–46	Acet, Prop	6/9	2	No	No
28	Sturge–Weber syndrome	L	11y 10m	Nil	30	20–30	Acet, Pilo	6/60	2	No	No
29	Aphakic	L	1y 1m	Lens extraction ×1 Capsulotomy ×1	34	18–37	Betoptic	CS	1	No	No
30	Sturge–Weber syndrome	R	4m	Nil	35	30–35	Nil	CS	1	No	No
31	Aniridia, aphakic	L	26y	Trabeculectomy ×1 Lens extraction ×2	25	25	Acet, Tim, Pilo	1/60	2	No	No
32	Aniridia	R	14y 2m	Trabeculectomy ×1	35	35	Acet, Tim, Pilo	3/60	2	No	Yes
33	Aniridia	L	14y 2m	Trabeculectomy ×3	25	25	Acet, Tim, Pilo	1/60	1	No	Yes
34	Congenital glaucoma	R	9y 6m	Nil	31	31–60	Acet, Adren	6/60	2	No	No

IOP is shown as the immediate pre-operative reading and the range of readings prior to Molteno drain insertion (second stage in two-stage procedures).
R, right; L, left; y, years; m, months; Acet, acetazolamide; Tim, timolol; Pilo, pilocarpine; Prop, propine; Adren, Adrenaline; Carb, carbechol; Isoptocarb, isoptocarbechol; PhI, phospholine iodide; NM, not measured; CS, can see; CF, count fingers; PL, perception of light; HM, hand movements; PC, picture cards; SFS, systemic fibrosis suppression.

follow-up, but had 4 years' follow-up available and is included in the study. Data were available on 34 eyes of 25 patients.

Pre-operative status

Of the 25 patients, 16 had associated ocular findings in addition to glaucoma including: 10 patients (15 eyes) with aphakia; 3 patients (3 eyes) with Sturge–Weber syndrome; 1 patient (1 eye) with neurofibromatosis; 3 patients (5 eyes) with rubella syndrome; 3 patients (6 eyes) with microphthalmia; 1 patient (2 eyes) with dislocated lenses; 1 patient (1 eye) with a cleavage defect; 1 patient (1 eye) who was uveitic; and 2 patients (3 eyes) who were aniridic. The number of previous surgical procedures that each eye had undergone ranged from 0 to 8 (mean 3.0). Patient age at time of first Molteno drain ranged from 2 days to 26 years. Pre-operative IOPs were recorded as immediate pre-operative IOP (prior to the first stage in a two-stage procedure) and the range recorded as the IOPs in the 6 weeks prior to surgery. Mean pre-operative IOP was 31.0 mmHg and the range is shown in Table 1. Pre-operatively 4 patients (5 eyes) were not on any treatment; 18 patients were on systemic acetazolamide; and the mean number of topical medications per eye was 1.3 (range 0–3). Visual acuity (where recorded) ranged from 6/6 to perception of light. These data are shown in Table 1.

Surgical procedures

Thirty-eight Molteno drains were placed in 34 eyes, with 2 eyes having their drains replaced and 2 eyes having additional drains inserted. As first procedures, 27 eyes had a double plate drain inserted (19 eyes as a two-stage procedure without a Vicryl tie; 5 as a one-stage procedure with a Vicryl tie; 2 as a one-stage procedure without a Vicryl tie; and 1 as a one-stage procedure using a pressure ridge dual chamber drain with Vicryl tie). Seven eyes received a single plate drain (1 as a two-stage procedure without a Vicryl tie; 1 as a two-stage procedure with a pressure ridge dual chamber drain and Vicryl tie with tube to the posterior chamber via the pars plana; 3 as a one-stage procedure without a Vicryl tie; and 2 as a one-stage procedure with a pressure ridge dual chamber drain).

The surgical technique used has been described previously and differs slightly for one- and two-stage procedures. Briefly, the conjunctiva and Tenon's capsule were lifted at the limbus and dissected posteriorly.

Table 2. *Pre-operative surgical procedures (mean number per eye) in eyes that received an antifibrosis regime versus eyes that did not*

	Antifibrosis regime (22 eyes)	No antifibrosis regime (12 eyes)
No. of previous drainage operations (trabeculectomy, Scheie, sinusotomy, sclerectomy)	1.6	0.2
No. of goniotomies or goniopuncture	1.0	0.2
Cyclodialysis, cyclodiathermy, cyclocryotherapy	0.3	0.3

Double plate drains were sutured to the sclera with a 7/0 silk suture either side of the superior rectus muscle, with single plate drains being sutured to either the nasal or temporal side of the muscle. In the two-stage procedure, the tube was then placed under a triangular partial-thickness scleral flap, with the end of the tube being placed under the medial rectus muscle. In the one-stage procedure, a partial-thickness scleral flap was lifted to the limbus and the tube (after trimming to length) was placed into the anterior chamber via a paracentesis created with either a 22 or 23 gauge needle. In the cases in which it was used, a 5/0 Vicryl tie was then tied around the tube and its occluded lumen confirmed by attempting to irrigate balanced salt solution down the tube. The scleral flap was then replaced and sutured with either a 7/0 silk or 8/0 vicryl suture. In the two-stage procedure, after 4–6 weeks the conjunctiva and Tenon's capsule were lifted and the tube retrieved from under the rectus muscle. It was then placed into the anterior chamber in the same manner as for the one-stage procedure. At the end of the procedure, a sub-conjunctival injection of steroid and antibiotic was given. In addition, 14 eyes received a 360° buckle at the same time as the first procedure, to reduce the risk of later retinal detachment.

Post-operative medication

Post-operative medication consisted of topical steroids, adrenaline and atropine in all cases. In 22 of the most severely damaged eyes the antifibrosis regime of prednisolone, fluphenamic acid and colchicine previously described by Molteno[1] was used (diclofenac was substituted for fluphenamic acid in one case). The regime was given for 4–6 weeks after the second-stage operations or when the Vicryl tie dissolved and aqueous started to drain into the preformed bleb systems consisting of fibrous tissue enclosing the episcleral plates of the implants.

The criteria for choosing cases for fibrosis suppression medication included: (1) failure of previous drainage operations, (2) the presence of uveitis, (3) congested eyes with a very high IOP and (4) terminal disease with grossly enlarged eyes. The differences between eyes receiving fibrosis suppression and those not are shown in Table 2.

Results

IOP outcome

Follow-up ranged from 9 months to 16 years 9 months (mean 11.2 years). IOP outcome was defined as complete success if the IOP was < 22 mmHg without treatment, partial success if the IOP was < 22 mmHg with treatment, and as a failure if the IOP was > 21 mmHg or the eye was phthisical. By our definition, the IOP was controlled in 85% of cases. This included eye 23 in which the raised IOP was cured prior to enucleation for cosmetic reasons. Two eyes that failed had an IOP of 22 and 23 mmHg respectively, and although this was a failure by our definition, we felt that clinically the eyes were reasonably well controlled. If these two eyes are included, then 91.2% of eyes were cured or controlled (Table 3). Eighty-two per cent of the most severely damaged eyes that received the antifibrosis regime were controlled, compared with 92% of eyes that did not. Eighty-seven per cent of eyes that had had up to three previous surgical procedures, were controlled, compared with 82% of eyes that had had more than three procedures.

Visual outcome

Final visual acuity range from 6/9 to no perception of light, and was comparable with pre-operative levels in 28 eyes. We defined visual outcomes as maintained if the vision was within 1 Snellen line, deteriorated if acuity was 2 or more lines worse than the pre-operative level, and lost if the eye was blind or enucleated. By this definition, in eyes in which vision was comparable, 57% maintained their pre-operative vision. Sixty-seven per cent of eyes that had up to three previous surgical procedures maintained their pre-operative vision, compared with 40% of eyes that had had more than three procedures.

Fifty per cent of eyes maintained their vision and had the IOP controlled. If the two eyes that had IOPs of 22 and 23 mmHg are included, this figure rises to 57%.

Complications and further surgery

Two eyes (one with Sturge–Weber syndrome) had a choroidal detachment and flat anterior chamber in the early post-operative period that resolved spontaneously. Three eyes developed a corneal ulcer, and 2 eyes had an episode of iritis. Seven eyes developed band keratopathy. Twenty-four of the 34 eyes (71%) required further surgery (Table 4), with 10 eyes (29%) having more than one procedure over the follow-up period. Two eyes had their Molteno drains replaced and 2 eyes had additional Molteno drains inserted; the combined follow-up for these eyes is shown in Table 3. Three eyes had the tube shortened (as it was in the visual axis), and 3 eyes had the tube repositioned into the posterior chamber for corneal problems (2 following two attempts to reposition the tube in the anterior chamber). One eye had the

Table 3. *Post-operative status*

Eye	Follow-up	IOP (mmHg)	Treatment	Acuity	Outcome	
					IOP[a]	Acuity[b]
1[c]	13y 4m	14	Acet, Tim	NPL	PS	Lost
2	16y 6m	16	Acet, Tim	6/36	PS	Deteriorated
3	12y	15	Nil	PL	CS	NC
4	12y	Ph	Nil	NPL	Fail	Lost
5	15y 4m	20	Acet, Tim	3/60	PS	Deteriorated
6	15y 4m	20	Acet, Tim	HM	PS	Deteriorated
7	15y 8m	20	Nil	6/60	CS	Deteriorated
8[c]	2y 3m	15	Acet, Tim	NPL	PS	Lost
9	15y 7m	18	Tim	1/60	PS	Deteriorated
10	14y 10m	23	Acet, Adren	6/60	Fail	Maintained
11	14y 10m	19	Acet, Adren	6/60	PS	Maintained
12	15y 6m	17	Nil	PL	CS	Maintained
13	15y 6m	17	Tim	6/60	PS	Maintained
14	16y 9m	13	Nil	6/24	CS	Deteriorated
15	14y 11m	Ph	Nil	NPL	Fail	Lost
16	14y 11m	16	Tim	6/48	PS	Maintained
17	13y 4m	18	Tim, Prop	6/36	PS	Maintained
18	14y 8m	16	Nil	HM	CS	Maintained
19	4y	20	Nil	HM	CS	Maintained
20	12y 9m	22	Adren	6/9	Fail	Maintained
21	10y 4m	11	Nil	6/12	CS	NC
22	9y 8m	11	Nil	1/60	CS	NC
23[c]	9m	10	Nil	NPL	CS	NC
24	10y 10m	18	Nil	6/24	CS	Maintained
25	10y 10m	16	Tim	6/24	PS	Maintained
26[c]	4y	Ph	Nil	NPL	Fail	Lost
27	10y	12	Tim	6/12	PS	Maintained
28	10y 6m	20	Tim	HM	PS	Deteriorated
29	3y 3m	12	Tim	6/20	PS	NC
30	13y 3m	21	Tim	CF	PS	NC
31	9y 6m	15	Tim	1/60	PS	Maintained
32	7y 10m	16	Acet	3/60	PS	Maintained
33	7y 10m	18	Acet	1/60	PS	Maintained
34	3y 3m	16	Adren	6/60	PS	Maintained

IOP, Intraocular pressure; y, years; m, months; Adren, adrenaline; Tim, timolol; Prop, propine; Acet, acetazolamide; CF, count fingers; HM, hand movements; NPL, no perception of light; Ph, phthisical.

[a]Complete success (CS) = IOP < 22 mmHg without treatment; partial success (PS) = IOP < 22 mmHg with treatment; Fail = IOP > 21 mmHg or phthisical.

[b]Maintained = acuity within 1 Snellen line of pre-operative level; deteriorated = acuity 2 or more lines worse than pre-operative level; Lost = blind or enucleated; NC = non-comparable.

[c]IOP readings taken prior to enucleation and visual acuity recorded as NPL.

connecting tube between two plates unblocked. Two eyes had patch grafts to prevent erosion of the tube through the conjunctiva. Five eyes had division of adhesions or synechiae. One eye has had an iridectomy and 1 a sphincterotomy. Five eyes had cataract extractions (1 combined with vitrectomy), and 5 eyes had undergone vitrectomy (1 for tube blockage, and 4 for pigment or blood in the vitreous). Two eyes had unsuccessful retinal detachment surgery, and 1 eye has a localised inferior retinal detachment that has not undergone surgery and retains a vision of 6/36. One eye has had three corneal grafts and retains 6/60 vision. Four eyes have been enucleated. One eye became blind and phthisical 7 years after tube insertion, following an intraocular haemorrhage of unknown origin.

Table 4. *Further surgery (number of eyes undergoing each procedure)*

Drain replaced	2	Vitrectomy	5
Drain added	2	Cataract extraction	5
Tube reposition			
AC	4	Retinal detachment	2
PC	3	Enucleation	4
Tube shortened	3	Synechiae division	5
Tube erosion	2	Iridectomy	1
Unblocking of		Sphincterotomy	1
interconnecting tube	1	Corneal graft	1

AC, anterior chamber; PC, posterior chamber.

Discussion

IOP control

In this study we have examined the long-term outcome (mean follow-up 11.2 years) of Molteno drains in the treatment of glaucoma presenting in childhood. Many of the eyes in this study had undergone multiple previous surgical procedures prior to drain placement, and today these eyes would receive their drains at an earlier stage in the disease process, which may influence their outcome. Despite this, 85% of eyes had their IOP cured or controlled on long-term follow-up. Previous reported studies have differing criteria for the definition of success and this makes comparison difficult. Also the surgical procedure (one- or two-stage) and the number of plates

Table 5. *Success of intraocular pressure (IOP) control in reported series, with the use of Molteno drains in glaucoma presenting in childhood*

Author	Year	No. of eyes	Follow-up (months)	Age (years)	Success	IOP definition
Goldberg[27]	1987	15	Up to 18	Up to 36	100%	< 20 mmHg ± Rx
Minckler[28]	1988	13	Mean 22.8	< 13	54%	≤ 21 mmHg ± Rx
Traverso[29]	1989	44	Median 11	?	70%[a]	≤ 19 mmHg ± Rx
Billson[30]	1989	23	Mean 41	Up to 46	78%	≤ 21 mmHg ± Rx
Munoz[31]	1991	53	Mean 18	< 12	68%	≤ 21 mmHg ± Rx
Hill[32]	1991	65	Mean 22.7	< 21	62%	≤ 21 mmHg ± Rx
Nesher[33]	1992	27	Mean 20	Up to 13	59%	≤ 21 mmHg ± Rx
Lloyd[34]	1992	16	Mean 49.1	< 13	44%	≤ 21 mmHg ± Rx
Netland[35]	1993	13	Mean 32	≤ 10	77%	≤ 21 mmHg ± Rx

Rx, therapy.
[a]Calculated at 1 year.

used (one or two) differs within and between studies. However, taking these limitations into account, these results compare favourably with other published series with shorter follow-up. These previous reports are summarised in Table 5. In this study, the selective use of the antifibrosis regime appears to have improved the results in the worst cases, since the number of previous surgical interventions did not influence the outcome of surgery in terms of IOP control. However, the varied aetiologies and small numbers preclude any definite conclusions from this series.

Visual outcome

In this study 57% of eyes (in which we were able to make a comparison) have maintained their vision at final follow-up. This is comparable with previous studies in which Minckler *et al.*,[28] Hill *et al.*[32] and Lloyd *et al.*[34] reported vision being maintained within 1 line of pre-operative levels in 100%, 68% and 63% of eyes respectively, and Munoz *et al.*[31] reported vision being the same or better in 76% of cases.

From the patient's perspective the visual outcome is the main indicator of success. In the eyes in which we were able to compare pre- and post-operative vision, 12 either deteriorated or lost their vision. In 1 eye, vision deteriorated after an episode of raised pressure that was resolved by unblocking the connecting tube between two plates. In an eye with initial poor vision (PL) the drain failed to control IOP and the eye became blind. Enucleation was precipitated in 1 eye by perforation of an infected corneal ulcer in an eye with fluctuating pressure control, poor vision, and a persistently (present before tube placement) oedematous cornea. Another eye was enucleated for pain secondary to bullous keratopathy. Two eyes, in which the vision had not deteriorated, had undergone multiple surgical procedures before and/or after Molteno drain placement and eventually became phthisical despite pressure control. Phthisis could be related to unsuccessful retinal detachment surgery occurring 7 months after drain placement in 1 eye. In 1 eye with a pre-operative vision of < 3/60 with advanced glaucoma and multiple previous procedures, vision deteriorated over 15 years of follow-up, despite control of IOP. In a further 4 eyes, vision deteriorated despite IOP control, with no obvious cause being found for the reduced vision. Therefore, of the 12 eyes that measurably deteriorated, in only 2 (the first 2 described here) can the deterioration be directly related to tube problems. In the other eyes it seemed to be the general condition of the eye and the number of previous surgical procedures that influenced the visual outcome. Unfortunately 1 eye in this series, with Sturge–Weber syndrome (whose pre-operative acuity was not recorded at the age of 4 months), was noted to have an acuity of 6/12 at the age of 5 years but then spectacle wear was discontinued and, despite control of IOP, the acuity has dropped to count fingers. Some of the loss of acuity may be attributable to treatable amblyopia. This case thus illustrates the importance of correcting refractive errors and treating amblyopia as part of the follow-up of these cases.

Further surgery and complications

In the series, 71% of eyes required further surgery with 29% having more than one procedure, and 32% being for drain-related problems. In Hill *et al.*'s study[32] 83% of cases required further surgery, as did 44% of cases in Nesher *et al.*'s series.

In 4 eyes the Molteno drain was either replaced or a further drain added to facilitate pressure control. Three of these eyes (75%) have maintained good pressure control at latest follow-up. In this series 7 eyes had the tube repositioned (for cornea-related problems) or shortened, and in 2 eyes the tube eroded through the sclera requiring patch grafts. One eye required vitrectomy due to vitreous blocking the tube. These complications, often requiring further surgery, occur in many reported series[28–36] and may be avoided by careful, accurate placement of the tube into the anterior chamber. The tube is best positioned parallel to the iris plane and just in front of it. The tube should also be bevelled anteriorly to help prevent blockage by iris. Where vitreous is present, for example in aphakic eyes, a good anterior vitrectomy should clear any residual vitreous from entering the end of the tube. It may also be appropriate in these eyes to place the tube through the pars plana into the posterior chamber with its tip visible in the pupil (but not in the visual axis), so as to avoid occlusion by iris and to remove the risk of corneal touch. One tube that had to be shortened in this study was initially placed in the eye of a 2-day-old baby with congenital glaucoma and on examination at day 10 was

noted to be in the visual axis. At over 10 years follow-up this eye has good IOP control and a vision of 6/12. In this study one eye had blockage of the interconnecting tube between two plates at 10 years post-operatively, when the eye was noted to have a raised IOP with one bleb distended while the bleb overlying the other plate was flat. This interconnecting tube was unblocked at surgery and the eye now has distended blebs over both plates and a controlled IOP.

Other surgical intervention was required in 19 eyes. These interventions included cataract extraction, retinal detachment repair, vitrectomy, enucleation, iridectomy, sphincterotomy and synechiae division; 1 eye underwent three corneal grafts. The need for these interventions reflects the presence of associated anomalies and the damage done by severe glaucoma and repeated surgical interventions during early childhood.

Conclusions

In summary, this series reports the long-term follow-up of Molteno drains used in eyes with glaucoma presenting in childhood, and shows that they can maintain good pressure control and visual function. Seventy-one per cent of eyes required further surgical intervention. Thirty-two per cent of cases were for drain-related problems, which may be avoidable with current surgical techniques. The remaining interventions were for associated ocular defects, and for problems caused by multiple surgical procedures and periods of high IOP during early childhood. Today we use the implants earlier in the disease process to try to obtain early and definitive IOP control and so help optimise the long-term visual prognosis.

References

1. Molteno ACB, Ancker E, Van Biljon G. Surgical techniques for advanced juvenile glaucoma. Arch Ophthalmol 1984;102:51–7.
2. Luntz MH. Congenital, infantile, and juvenile glaucoma. Ophthalmology 1979;86:793–802.
3. Anderson DR. Trabeculotomy compared to goniotomy for glaucoma in children. Ophthalmology 1983;90:805–6.
4. DeLuise VP, Anderson DR. Primary infantile glaucoma (congenital glaucoma). Surv Ophthalmol 1983;28:1–19.
5. Shaffer RN, Hoskins HD. Goniotomy in the treatment of isolated trabeculodysgenesis (primary congenital [infantile] developmental glaucoma). Trans Ophthalmol Soc UK 1983;103:581–5.
6. Quigley HA. Childhood glaucoma: results with trabeculotomy and study of reversible cupping. Ophthalmology 1982;89:219–26.
7. McPherson SD, McFarland D. External trabeculotomy for developmental glaucoma. Ophthalmology 1980;87:302–5.
8. Burke JP, Bowell R. Primary trabeculectomy in congenital glaucoma. Br J Ophthalmol 1989;73:186–90.
9. Elder MJ. Combined trabeculotomy–trabeculectomy compared with primary trabeculectomy for congenital glaucoma. Br J Ophthalmol 1994;78:745-8.
10. Joseph A. Trabeculectomy in congenital glaucoma. Indian J Ophthalmol 1981;29:81–2.
11. O'Connor G. Combined trabeculotomy–trabeculectomy for congenital glaucoma. Br J Ophthalmol 1994;78:735.
12. Miller MH, Rice MSC. Trabeculectomy combined with beta-irradiation for congenital glaucoma. Br J Ophthalmol 1991;75:584–90.
13. Whiteside-Michel J, Leibmann JM, Ritch R. Initial 5-fluorouracil trabeculectomy in young patients. Ophthalmology 1992;99:7–13.
14. Zalish M, Leiba H, Oliver M. Subconjunctival injection of 5-fluorouracil following trabeculectomy for congenital and infantile glaucoma. Ophthalmic Surg 1992;23:203–5.
15. Herschler J. Commentary. Ophthalmic Surg 1992;23:205.
16. Gressel MG, Heuer DK, Parrish RK. Trabeculectomy in young patients. Ophthalmology 1984;91:1242–6.
17. Beauchamp GR, Parks MM. Filtering surgery in children: barriers to success. Ophthalmology 1979;86:170–9.
18. Debnath SC, Teichmann KD, Salamah K. Trabeculectomy versus trabeculotomy in congenital glaucoma. Br J Ophthalmol 1989;73:608–11.
19. Sturmer J, Broadway DC, Hitchings RA. Young patient trabeculectomy: assessment of risk factors for failure. Ophthalmology 1993;100:928–39.
20. Cadera W, Pachtman MA, Cantor LB, Ellis FD, Helveston EM. Filtering surgery in childhood glaucoma. Ophthalmic Surg 1984;15:319–22.
21. Iwach AG, Hoskins HD, Hetherington J, Shaffer RN. Analysis of surgical and medical management of glaucoma in Sturge–Weber syndrome. Ophthalmology 1990;97:904–9.
22. Wiggins RE, Tomey KF. The results of glaucoma surgery in aniridia. Arch Ophthalmol 1992;110:503–5.
23. Caprioli J, Strang SL, Spaeth GL, Poryzees EH. Cyclocryotherapy in the treatment of advanced glaucoma. Ophthalmology 1985;92:947–54.
24. Bellows AR, Grant WM. Cyclocryotherapy in advanced inadequately controlled glaucoma. Am J Ophthalmol 1973;75:679–84.
25. Al Faran FM, Tomey KF, Al Mutlaq FA. Cyclocryotherapy in selected cases of congenital glaucoma. Ophthalmic Surg 1990;21:794–8.
26. Aminlari A. Cyclocryotherapy in congenital glaucoma. Glaucoma 1981;331–2.
27. Goldberg I. Management of uncontrolled glaucoma with the Molteno system. Aust NZ J Ophthalmol 1987;15:97–107.
28. Minckler DS, Heuer DK, Hasty B, Baerveldt G, Cutting RC, Barlow WE. Clinical experience with the single plate Molteno implant in complicated glaucomas. Ophthalmology 1988;95:1181–8.
29. Traverso CE, Tomey KF, Al-Kaff A. The long-tube single plate Molteno implant for the treatment of recalcitrant glaucoma. Int Ophthalmol 1989;13:159–62.
30. Billson F, Thomas R, Aylward W. The use of two-stage Molteno implants in developmental glaucoma. J Pediatr Ophthalmol Strabismus 1989;26:3–8.
31. Munoz M, Tomey KF, Traverso C, Day SH, Senft SH. Clinical experience with the Molteno implant in advanced infantile glaucoma. J Pediatr Ophthalmol Strabismus 1991;28:68–72.
32. Hill RA, Heuer DK, Baerveldt G, Minckler DS, Martone JF. Molteno implantation for glaucoma in young patients. Ophthalmology 1991;98:1042–6.
33. Nesher R, Sherwood MB, Kass MA, Hines JL, Kilker AE. Molteno implants in children. Glaucoma 1992;1:228–32.
34. Lloyd MA, Sedlak T, Heuer DK, Minckler DS, Baerveldt G, Lee MB, Martone JF. Clinical experience with the single plate Molteno implant in complicated glaucomas: update of pilot study. Ophthalmology 1992;99:679–87.
35. Netland PA, Walton DS. Glaucoma drainage implants in paediatric patients. Ophthalmic Surg 1993;24:723–9.
36. Airaksinen PJ, Aisala P, Yuulonen A. Molteno implant surgery in uncontrolled glaucoma. Acta Ophthalmol (Copenh) 1990;68:690–4.
37. Freedman J, Rubin B. Molteno implants as a treatment for refractory glaucoma in black patients. Arch Ophthalmol 1991;109:1417–20.