Single stage insertion of the Molteno tube for glaucoma and modifications to reduce postoperative hypotony

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SUMMARY Severe glaucoma was controlled in all 13 cases following insertion of a Molteno drain in a single stage procedure. One eye required a repeat operation. A modified technique to minimise early postoperative hypotony and prevent flat anterior chambers is described

Standard filtering operations often have poor results in neovascular glaucoma,¹ other severe cases of secondary glaucoma, and in cases complicated by unfavourable factors including aphakia,² previous failed drainage surgery,^{3,4} or the youth of the patient.^{5,6} Cyclodialysis and cyclocryotherapy, techniques designed to reduce aqueous fluid production, have well recognised complications which include long term hypotony.^{7,8} Both are widely regarded as giving poor visual results.

The use of artificial implants to maintain aqueous fluid drainage dates from 1906.⁹ In 1969 Molteno first reported his work with an implant consisting of a silicone tube attached to an episcleral plate.¹⁰ The design was subsequently modified by lengthening the tube, allowing the plate to be sutured to the post-equatorial sclera.¹¹ Two interconnected episcleral plates, giving a total area of 270 mm², have been shown to provide the optimum total bleb area. In many cases of neovascular glaucoma, however, the ciliary body is severely damaged, and a single plate is therefore preferable.¹² Good results have been obtained with this system.¹³⁻¹⁸

Materials and methods

Patients were selected for Molteno tube surgery when medical therapy was no longer satisfactory and conventional surgery had already failed or was unlikely to have any reasonable chance of success. The eyes were divided into four groups relating to the cause of the raised intraocular pressure (Table 1). Previous intraocular surgery had been performed on

eight eyes. Five eyes with neovascular glaucoma had previously received panretinal photocoagulation (Tables 2-5).

The implant consists of a silicone tube with 0.6 mm outside and 0.3 mm inside diameter attached to one or two 13 mm diameter polymethylacrylate (PMMA) plates. Single plate implants were used for cases of neovascular glaucoma.

The plates were attached and tubes inserted in a one-stage procedure. Where two plates were used, the adjoining tube was passed underneath the superior rectus muscle. The plate(s) were secured in a postequatorial position with the tube lying radial to the limbus. A large partial thickness scleral flap, hinged at the limbus, was created to cover the entire length of the tube. In some cases cover was achieved with two separate flaps. The tube length was shortened to approximately 2 to 3 mm beyond the limbus,

Table 1 Patients receiving Molteno tube implants

Treatment group	Diagnosis	Number of eyes treated	Number of procedures
I	Central retinal vein occlusion with neovascular glaucoma	4	5
II	Proliferative diabetic retinopathy with neovascular glaucoma	3	3
III	Aphakic glaucoma	3	3
IV	Miscellaneous:		
	Coats disease/neovascular glaucoma	1	1
	Heterochromic iridocyclitis	1	1
	Post endophthalmitis/chronic angle closure	1	1
	Total	13	14

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Table 2 Treatment group I (CRVO-NVG)

	Age	Sex	Panretinal argon laser photocoagulation	Preoperative visual acuity	Postoperative visual acuity	Preoperative intraocular pressure	Preoperative ocular medication	Postoperative intraocular pressure	Postoperative ocular medication
1	84	M	No	CF	HM	32	Timoptol Atropine	70	
2	84	M	No	HM	CF	70	—	16	—
3	90	M	No	HM	CF	42	Timoptol Atropine	19	Timoptol
4	77	M	Yes	6/60	PL	40	—	6	—
5	74	M	No	CF	CF	26	Acetazolamide Timoptol	24	—

CRVO=central retinal vein occlusion. NVG=neovascular glaucoma. CF=counting fingers at 0.5 m. HM=hand movements. PL=perception of light.

Table 3 Treatment group II (PDR/NVG)

	Age	Sex	Panretinal argon laser photocoagulation	Prior surgery	Preoperative visual acuity	Postoperative visual acuity	Preoperative intraocular pressure	Preoperative ocular medication	Postoperative intraocular pressure	Postoperative ocular medication
1	66	F	Yes	Extracapsular cataract extraction	HM	PL	42	Acetazolamide	6	—
2	63	M	Yes	Vitrectomy and lensectomy	6/60	6/60	28	Timoptol Acetazolamide	18	—
3	69	F	Yes	Intracapsular cataract extraction, vitrectomy	CF	PL	33	Timoptol Acetazolamide	16	—

PDR=proliferative diabetic retinopathy. NVG=neovascular glaucoma.

Table 4 Treatment group III (aphakic glaucoma)

	Age	Sex	Prior procedure	Preoperative visual acuity	Postoperative visual acuity	Preoperative intraocular pressure	Preoperative ocular medication	Postoperative intraocular pressure	Postoperative ocular medication
1	81	F	ICCE, ALT	6/5	6/9	24	Acetazolamide Timoptol	19	Timoptol
2	65	M	ICCE and IOL, ALT	6/5	6/5	28	Timoptol Pilocarpine	21	Timoptol Pilocarpine
3	69	F	ICCE	6/36	CF	24	Acetazolamide Timoptol Pilocarpine	19	Timoptol

ICCE=intracapsular cataract extraction. IOL=intraocular lens. ALT=argon laser trabeculoplasty.

Table 5 Treatment group IV (miscellaneous)

	Age	Sex	Diagnosis	Previous surgery	Preoperative visual acuity	Postoperative visual acuity	Preoperative intraocular pressure	Preoperative ocular medication	Postoperative intraocular pressure	Postoperative ocular medication
1	30	M	Coats disease, neovascular glaucoma	—	PL	PL	55	—	6	—
2	52	F	Heterochromic iridocyclitis	ICCE	6/6	6/9	38	Timoptol Acetazolamide	12	—
3	71	F	Postoperative endophthalmitis	ECCE and IOL, PK, trabeculectomy	HM	HM	45	Timoptol Acetazolamide	16	—

ECCE=extracapsular cataract extraction. PK=penetrating keratoplasty.

thus allowing for postoperative tube retraction. The tube was inserted into the anterior chamber through a narrow incision and the scleral flap(s) closed securely with interrupted 8/0 virgin silk sutures. The same suture was used for the conjunctiva.

In six cases a 3/0 polypropylene suture was passed through the tube (Fig. 1). The presence of the suture, which acts as a splint, greatly facilitates the insertion of the tube into the anterior chamber. The distal end of the suture was passed over the plate, under the superior and horizontal rectus muscles, and secured to sclera (Fig. 2). The proximal end of the suture remained in the tube. Removal six weeks later, under local anaesthesia, was through a small conjunctival incision over the distal end of the suture, well away from the drainage site.

In one case the Vicryl tie procedure was employed.¹⁹ A 6/0 Vicryl suture was tied round the tube under the scleral flap so as to occlude the lumen (Table 6).

All cases received preoperative chloramphenicol drops. The postoperative regimen was atropine drops 1% twice daily, adrenaline drops 1% three

Fig. 1 Single plate Molteno tube with 3/0 polypropylene suture.

Fig. 2 3/0 Polypropylene suture (arrow) is inserted half way down the Molteno tube, passed under the superior and horizontal rectus muscles, and secured to sclera.

times a day, and betamethasone drops four times a day for six weeks. Adrenaline drops were not used for more than one week on intracapsular aphakic eyes. Additional systemic medication was given to four patients: group III patient 2 and group IV patients 1 and 3 were given oral prednisolone 10 mg three times a day, colchicine 0.25 mg three times a day, and indomethacin 25 mg three times a day for five weeks. In group I, patient 5, unable to tolerate the full regimen, was given oral prednisolone 10 mg three times a day for three weeks.

Results

Tables 2–5 show that all cases, with the exception of case 1 in group I, achieved an intraocular pressure less than 25 mmHg. The mean fall in pressure was 23 mmHg. Four eyes, three of which had aphakic glaucoma, required additional antiglaucoma drops. The mean follow-up was 14 months, with a range of 6 to 27 months. In group I patient 5 died three months after the operation. All eyes retained vision, seven eyes showed a small deterioration, and two eyes a

Table 6 Operative procedures

Procedure	Number
Single plate Molteno tube	7
Single plate and 3/10 Prolene	3
Double plate and 3/0 Prolene	3
Double plate and Vicryl tie procedure	1

Table 7 Postoperative complications

Procedure	No.	Hyphaema	Vitreous haemorrhage	Vitreous face opacification
Open tubes	7	7	—	—
Tubes with 3/0 Prolene	6	5	1	2
Tube with Vicryl tie	1	1	—	—

Table 8 Postoperative complications

<i>Procedure</i>	<i>No.</i>		<i>Hypotony</i>	<i>Flat AC</i>	<i>Choroidal detachment</i>	<i>Corneal touch</i>	
					<i>Early Pers.</i>	<i>Early Pers.</i>	
Open tubes	7	4	4	2	1	4	1
Tubes with 3/0 Prolene	6	3	—	1	—	2	—
Tube with Vicryl tie	1	—	—	—	—	1	—

AC=anterior chamber. Pers.=persistent.

small improvement in visual acuity. There were no cases of infection.

Case 1 in group I developed profound hypotony, with choroidal detachment and a flat anterior chamber, after insertion of a single plate tube without an intraluminal 3/0 polypropylene suture. On the fourteenth day iris occluded the tube, resulting in a sharp rise in intraocular pressure. Attempts to clear the tube failed. The original implant was removed, and a single plate tube with a 3/0 polypropylene suture was inserted at a fresh site (recorded as group I case 2). Transient obstruction by iris was observed in one other case without a 3/0 polypropylene suture.

In the first case where the polypropylene was used postoperative retraction of the Molteno tube resulted in protrusion of the suture into the anterior chamber (case 2, group III). This required adjustment under local anaesthesia on day 4. In all subsequent cases the polypropylene sutures were withdrawn half way up the tube, before they were secured to the sclera, at the time of the initial operation. Other complications are summarised in Tables 7 and 8. Hypotony, defined here as an intraocular pressure less than 2 mmHg, was found in the early postoperative phase in seven eyes. Five of these eyes had neovascular glaucoma. Associated flat anterior chambers were found in four eyes, all with open tubes. No flat anterior chambers were found in eyes where the suture had been placed in the tube. One case of choroidal detachment and one case of corneal touch persisted beyond 10 days, both in eyes with open tubes.

During the first eight postoperative weeks there were six cases of raised intraocular pressure. The maximum reading was 35 mmHg, and all returned to normal by the end of this period. In two cases the polypropylene suture was removed early, at three weeks, in each case producing a significant drop in

pressure (group I, patient 4, and group IV, patient 2).

Postoperative hyphaema was present in 12 eyes, and all cleared in the first fortnight. There were no cases of obstruction of the tube with blood clot.

The two cases of vitreous face opacification occurred in the aphakic glaucoma group (group III, patients 1 and 2). In both cases treatment with the YAG laser resulted in vitreous entering the tube causing a rise in intraocular pressure. In patient 2 partial clearance was obtained with further YAG laser applications to the vitreous within and adjacent to the tube. Control of the intraocular pressure was regained with the use of additional topical treatment.

Discussion

In the absence of surgical damage to the ciliary body postoperative hypotony is often a consequence of continued excessive escape of aqueous fluid. In a series of 30 single-plate Molteno tubes, inserted in a one-stage procedure, seven flat anterior chambers were reported in the first postoperative week and one of these resulted in failure.¹⁶ In this series four out of 13 eyes had flat anterior chambers in the first week, and all achieved a satisfactory final result.

Obstruction of the tube by iris or vitreous occurring after single-stage insertion has been described and associated with excessive aqueous drainage.^{13,14} In this series two cases of obstruction by iris coincided with hypotony, and in one case this caused a serious rise in intraocular pressure, necessitating a repeat operation. Interestingly our two cases of vitreous entry into the tube occurred after YAG laser treatment, a previously unrecognised complication of this procedure.

Molteno advocates insertion of the tube in a two-stage procedure, permitting a thin layer of fibrous tissue to surround the plate, thereby creating some resistance to the passage of aqueous fluid. Good results were obtained, and the technique also reduced the incidence of hypotony and secondary obstruction of the tube with iris or vitreous.¹³ There are, however, two main disadvantages with a two-stage procedure: the condition of the eye may not permit such a delay and two major operations are required.

One alternative is temporarily to occlude the lumen of the tube by tying an absorbable suture round the outside. With a single loop of 5/0 Vicryl suture the tube has been shown to open up after an average of four weeks, with a few cases possibly taking up to eight weeks. Good results have been reported with this method.¹⁹ Molteno *et al.* have reported that, with a 22 gauge needle for entry into the anterior chamber, leakage of aqueous fluid outside the occluded tube ceased a few minutes after

insertion. Continued treatment with glaucoma medication was required until the tube reopened. This method has successfully eliminated the necessity of a second-stage operation, but the problem of potential delay in adequate control of intraocular pressure still remains.

The technique we have used in an attempt to overcome these problems is temporarily to partially occlude the lumen of the Molteno tube by inserting 3/0 polypropylene down its length. The presence of the suture, while permitting the flow of some aqueous fluid, greatly reduces the overall drainage and, if required, could be used to clear any obstruction of the tube by iris, vitreous, or blood. The intention is to provide immediate control of intraocular pressure, without profound hypotony, with simultaneous limited deposition of fibrous tissue round the episcleral plate. The polypropylene, acting as a splint, also facilitates insertion of the tube into the anterior chamber at the time of operation.

The numbers in the study are too few to demonstrate conclusively a modifying effect of the intraluminal 3/0 polypropylene suture. These first results, however, suggest that hypotony may be mitigated but not prevented. Aqueous drainage outside the tube is unaffected by the suture, and despite a narrow anterior chamber incision we believe in some cases contributes to the lowering of the intraocular pressure in the early postoperative phase. Hypotony is therefore not eliminated. In contrast to the open tubes, however, no flat anterior chambers were observed with the 3/0 polypropylene suture. In the two cases of early suture withdrawal a fall in intraocular pressure was observed, demonstrating an increase in aqueous flow. It is probable that a more complete fibrous lining to the bleb accounts for the absence of a pressure drop on withdrawal at six weeks.¹³

The histology of functioning and failed blebs is well recognised.^{11 20-25} Evidence exists for a role of aqueous fluid in fibroblast growth in tissue culture and in bleb fibrosis.²⁶⁻³⁰ In a monkey model aqueous aspirated from eyes that had previously undergone filtration surgery supported growth of tissue cultures of subconjunctival fibroblasts. This ability to support growth diminished with increasing postoperative interval. 92% of cultures were positive with aqueous samples removed at one week, 75% at four weeks, and 33% at eight weeks.²⁷ This duration is similar to the period of postoperative bleb inflammation and associated increased intraocular pressure observed by Molteno *et al.*²⁸

To minimise excessive bleb fibrosis Molteno advocates the use of a long tube in a two-stage or Vicryl tie procedure together with administration of oral prednisone, fluphenamic acid, and colchicine.^{11 13 19 28 31} Brown and Cairns did not find

improved results in patients given this systemic medication.¹⁶ In our series four patients received oral enteric coated prednisolone, indomethacin, and colchicine. The full regimen was tolerated in three of these patients. The numbers at this stage are too small to demonstrate the effect on final results.

Other studies to assess pharmacological modification of drainage surgery have been undertaken. In a randomised prospective trial, which excluded patients with aphakia or previous drainage surgery, Starita *et al.* showed the success rate of trabeculectomy to be improved by topical steroids, with no additional benefit from systemic steroids.³² Topical indomethacin has been shown to have an adverse effect.³³ Fourteen out of 15 eyes with increased risk of filtration failure had successful trabeculectomies following preoperative subconjunctival triamcinolone.³⁴ The place of 5-fluorouracil, while the drug appears to be potentially useful, remains to be established.³⁵⁻³⁸ The results of further studies on animals and humans are awaited.

Encouraging results, without the use of systemic medication, have been obtained with a tube attached to an encircling band.^{39 40} Schocket *et al.* point out that success depends on the formation of scar tissue. Fourteen out of 30 eyes in their series had flat anterior chambers and, significantly, all had neovascular glaucoma.³⁹ Drainage into a large surface area with a one-piece system incorporating a valve has been reported to have a much lower incidence of flat anterior chamber.⁴¹

The optimum early postoperative aqueous fluid flow rate and the optimum ratio of drainage area to fibrous well thickness, for tube systems used in glaucoma, remain to be determined.

We believe the results of single-stage insertion of the Molteno tube and the temporary presence of an intraluminal suture are encouraging.

While the use of the systemic antifibrosis regimen is inconclusive in this study, we accept that there is a need for vigorous suppression of inflammation and fibrosis in some cases of Molteno tube surgery.

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