The dual chamber single plate implant – its use in neovascular glaucoma

A.C.B. Molteno FRCS, FRACO
Department of Ophthalmology, University of Otago, Dunedin, New Zealand

Abstract

The insertion of an artificial draining implant consisting of a silicone tube, opening onto the upper surface of a circular episcleral plate, will provide long-term drainage in cases of neovascular glaucoma. A simple modification of the episcleral plate, the addition of a subsidiary pressure ridge, allows the episcleral tissues to function as a temporary pressure-sensitive valve which limits the escape of aqueous in the early postoperative period. The surgical technique used with this modified implant is described, together with the results in the first 24 eyes in which it has been used.

Key words: Artificial implant, neovascular glaucoma, postoperative hypotony.

The author has previously reported the use of an artificial implant to treat severe and complex cases of glaucoma. This implant, which consists of a fine-bore silicone tube opening onto the upper surface of one or two large circular episcleral plates, is placed so that the silicone tube drains aqueous from the anterior chamber (AC) into a deeply buried bleb formed in the tissue covering the episcleral plate (see Figure 1). These implants have been used to treat a wide variety of different types of secondary glaucoma including neovascular glaucoma, in which good long-term results, with retention of useful vision in a significant number of cases, have been reported.[1,2,3] This article describes a modified implant, designed to regulate the escape of aqueous during the early postoperative period and thereby avoid hypotony. The surgical technique for its use and the results obtained in cases of neovascular glaucoma are described.

Principle of dual chamber single plate implant

The only difference between the modified implant and the standard single-plate implant used hitherto is the addition of a pressure ridge to the upper surface of the episcleral plate. This additional ridge is joined to the circumferential ridge at the edge of the plate and encloses an area of 10.5 mm² around the opening of the silicone tube. When this modified implant is placed in position on the globe and covered by a thick flap of Tenon's tissue, the pressure ridge, together with the smooth flexible tissue of Tenon's capsule, acts as a pressure-sensitive valve which regulates the escape of aqueous into the main bleb cavity during the early postoperative period. The intraocular pressure at

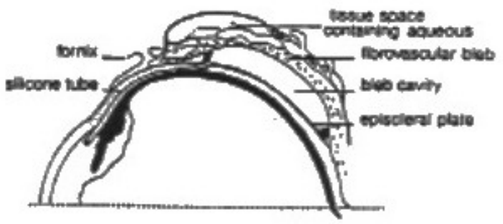

Fig. 1. – Principle of simple single plate Molteno implant. A section through the eye shows how the tube drains from the angle of the anterior chamber through the deeper layers of the sclera to open onto the upper surface of a circular episcleral plate which has a ridge around the edge and is curved to fit the sclera. The passage of aqueous into the space between the plate and the overlying tissues results in the formation of a large unilocular bleb.

Reprint requests: Dr A.C.B. Molteno, Department of Ophthalmology, Medical School, P.O. Box 913, Dunedin, New Zealand.

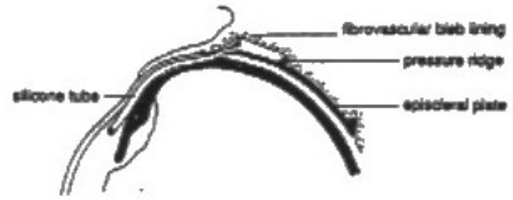

Fig. 2. – Principle of dual chamber single plate Molteno implant. A section through the eye shows how the pressure ridge together with the overlying tissue prevent aqueous from draining into the main bleb cavity in the immediate postoperative period.

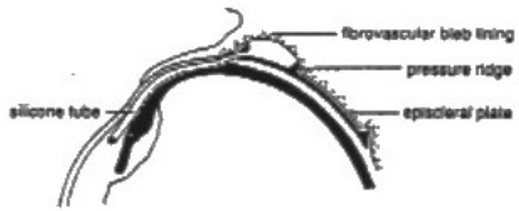

Fig. 3. – Principle of dual chamber single plate Molteno implant. A section through the eye shows the tissues over the anterior bleb becoming distended by aqueous to allow a controlled escape of aqueous into the main bleb cavity a few days after operation.

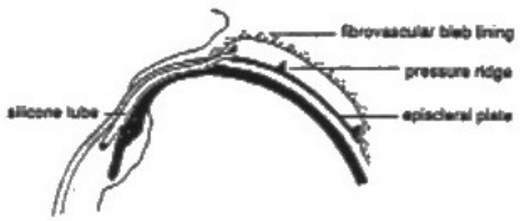

Fig. 4. – Principle of dual chamber single plate Molteno implant. A section through the eye shows how the formation of a large unilocular bleb lifts the tissues off the pressure ridge to allow free communication between the interior of the eye and the main bleb cavity. This occurs approximately seven days after operation.

which aqueous crosses the pressure ridge depends on several factors:

1. The tension with which the Tenon's tissue is sutured over the implant at the time of operation.
2. The intensity of any inflammatory swelling of the tissue which occurs during the early postoperative period.
3. The area enclosed by the pressure ridge.

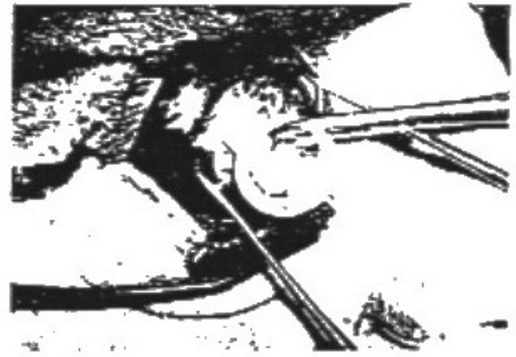

Fig. 5. – Photograph to show the dual chamber implant with the pressure ridge forming a small antechamber into which the translimbal tube opens.

4. The height and precise contour of the pressure ridge.

This valve action is temporary since the tension and inflammation in the overlying tissues decreases within a few days of operation. However, by this time the bleb has formed a definite inner fibrous lining which becomes distended by aqueous and which offers sufficient resistance to the further flow of aqueous to maintain the intraocular pressure. See Figures 2, 3, 4, 5.

Case selection

Patients presenting with established neovascular glaucoma who retained vision of bare light perception or better were offered drainage by implant where it formed an appropriate part of a treatment package which included pan-retinal photocoagulation, peripheral retinal cryo-ablation and medical measures to treat any underlying disease.

Preparation for operation

In addition to the usual prophylactic antibiotic drops and skin preparation, medical measures to lower the intraocular pressure were used in accordance with the patient's general state: These included topical Gutt. adrenaline 1%, or alternatively Gutt. phenylephrine 10% or 2.5% in patients with cardiovascular problems. Systemic acetazolamide was given either orally or intravenously in doses from 250 to 500 mg. If necessary these measures were supplemented by mannitol, by intravenous infusion, in a dose of 200 to 500 ml of 20% solution given half an hour prior to commencing the operation.

Fig. 6. – Photograph to show the episcleral plate of the implant sutured in position on the sclera with its anterior edge approximately in line with the insertions of the rectus muscles.

Anaesthesia

Where the general state of the patient permitted, general anaesthesia was preferred. In these cases care was taken to administer sufficient atropine to block the oculocardiac reflex, which is particularly easily elicited when operating on eyes with acute neovascular glaucoma. In those patients who were unsuitable for general anaesthesia, local anaesthesia was administered. However, in these cases care was taken to obtain the assistance of an anaesthetist who monitored the cardiovascular system and administered any sedation that was required during the anaesthetic. Local anaesthesia and akinesia was obtained by the retrobulbar injection of 3 or 4 cc of 2% lignocaine with adrenaline in a dilution of 1:180,000. In administering this retrobulbar injection great care was taken to handle tissue gently and to inject slowly to avoid causing undue pain and further stimulating the oculocardiac reflex. In addition local anaesthetic was injected in order to

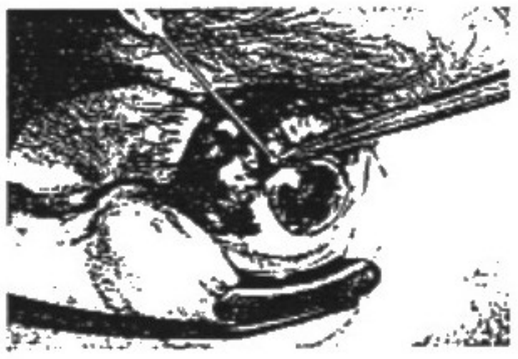

Fig. 7. – Photograph to show the use of a 22 gauge needle to form a track through the limbal tissues into the AC.

Fig. 8. – Photograph to show the tube of the implant passing beneath the scleral flap via the needle track into the AC.

block the facial nerve and prevent contraction of the orbicularis oculi muscle.

Surgical Technique

After retracting the lids with a speculum, the superotemporal quadrant of the sclera was exposed by incising the conjunctiva at the limbus and retracting the tissue towards the fornix, after supporting the globe by two squint hooks passed beneath the insertions of the superior and lateral rectus muscles. A battery operated cautery was used to outline a rectangular lamellar scleral flap with its base at the limbus and its corners close to the ends of the insertions of the adjacent superior and lateral rectus muscles. After incising the sclera within the cauterised area to a depth of one-third or one-half of its thickness, the flap was dissected up to the limbus and the episcleral plate of the implant placed on the sclera so that the anterior edge of the plate was situated at the posterior edge of the bed of the flap. The plate was firmly sutured to the sclera with two 7-0 silk sutures (Figure 6). The next step was to place the silicone tube radially across the cornea and cut the excess off at a point 3 mm inside the limbus. This cut was made obliquely so that the bevel of the tube faced anteriorly. Once the tube was suitably trimmed a sharp-pointed 22 gauge needle fitted to a 2 cc syringe was used to puncture the limbal tissues and enter the AC under cover of the lamellar scleral flap. This puncture was made in a direction corresponding to the plane of the iris, taking great care that it actually entered the anterior chamber rather than passing between the mesodermal and neurectodermal leaves of the iris (Figure 7). As soon as the needle was withdrawn the silicone tube was fed down the needle track into the AC (Figure 8). It was necessary to insert the tube quickly as the

Table 1. Control of IOP in cases of neovascular glaucoma drained by implants with six months to six and a half years follow-up (average 3.4 years) in the case of the 1982-84 series, and six months to four years (average 2.9 years) in the case of the 1985-87 series

	Simple single plate implants (24 eyes 1982-84)	Dual chamber single plate implants (24 eyes 1985-87)
Outcome		
Fail		
IOP > 2.67 kPa (> 20 mmHg) on Rx*	2	2
Phthisis bulbi	2	1
Control		
IOP < 2.67 kPa (< 20 mmHg) on Rx	5	8
Cure		
IOP < 2.67 kPa (< 20 mmHg)	15	13

*Rx = adrenaline and timolol drops ± acetazolamide.

needle track tended to close down and prevent passage of the soft and flexible silicone tube. If the tube did not pass easily, the needle track was dilated by reintroducing the needle. In certain cases difficulty was encountered when the tube entered Fuch's cleft in the iris instead of the AC. When this occurred air was injected via a Rycroft cannula to deepen the anterior chamber. After this, the needle track was redilated and the tube inserted into the anterior chamber. Once the tube was in position, the lamellar scleral flap was replaced and reinforced by a square of donor sclera sutured firmly in position.

The flap of Tenon's tissue and conjunctiva, which regulates the escape of aqueous during the early postoperative period, was drawn forward so as to completely cover the episcleral plate of the implant and the donor sclera. In those cases where the tissues were of normal thickness and elasticity, the flap was sutured so as to just cover the limbus. However, in old and frail patients in whom the conjunctiva and episcleral tissues were very thin and weak, the tissues were drawn forward to cover the pressure ridge of the implant with more substantial tissue. In both cases the flap was sutured at the limbus by two 7-0 silk sutures which were firmly anchored in the episcleral tissue after which any redundant thin and tattered conjunctiva was resected back to the margin of the cornea. In all cases the operation was concluded by the injection of a mixture of cephalosporin, gentamycin and methylprednisolone acetate beneath the conjunctiva in a quadrant away from the site of the implant.

Post-operative management

All patients were mobilised immediately after operation and all cases received a standard topical regime consisting of atropine 1%, adrenaline 1% or phenylephrine 2.5% and betamethasone with neomycin drops 0.1% three times a day.

The medication was continued until the eyes were white and quiet. Those patients with potentially useful vision received additional systemic medication to control bleb fibrosis. This regime, which has been reported in detail previously, consisted of a combination of prednisone, fluphenamic acid and colchicine given by mouth for four to six weeks after operation.[3]

Follow-up

All cases were seen at least once daily while in hospital and examined with a Haag Streit slit-lamp where their intraocular pressures were measured using a Goldmann applanation tonometer. Patients were discharged from hospital as soon as the AC was fully formed after which they were followed up as outpatients.

Initially patients were seen at intervals of a few days to a week, but after the first two visits were seen at intervals of two weeks during the first six weeks. Thereafter, patients were seen at monthly to three monthly intervals until the drainage system had stabilized after which they were seen every three months for the first year after operation. Subsequently, patients were seen every six to twelve months.

Postoperative course

The anterior chambers of the majority of cases were well formed on the first postoperative day while rapid regression of iris new vessels and absorption of fibrinous exudate occurred. The intraocular pressures of the uncomplicated cases remained in the 0.8 to 2.93 kPa (6 to 22 mmHg) range during the first seven to ten days until a definite bleb had formed. During the next five weeks, temporary elevation of intraocular pressure to a peak of between 3.33 and 5.33 kPa (25 and 40 mmHg) was observed in approximately half the cases. Once this hypertensive stage was passed, the eyes were characterized by a distended thick-walled bleb over the plate of the implant with a quiet anterior segment, marked to moderate regression of iris new vessels

and intraocular pressures which fell to a range of 1.33 to 2.67 kPa (10 to 20 mmHg) without medication, or were controlled with medication in those eyes which retained some vision (Table 1).

Complications

The major complications encountered in this series included two cases in which the anterior chamber remained flat for three and nine days respectively. In both cases the anterior chamber reformed spontaneously and it is of interest to note that the intraocular pressures were maintained throughout the period of collapse of the anterior chambers at levels of between 0.8 and 1.2 kPa (6 and 9 mmHg). Another major complication was breakdown of the tissues over an implant in a very ill man with chronic respiratory insufficiency who was maintained on long-term systemic steroids. In this case the implant was removed and reinserted via a pars plana incision after carrying out an anterior vitrectomy and lensectomy. This only eye retains vision of hand movements and has maintained a normal intraocular pressure without supplementary medication for the past nine months!

A minor complication which was noted in five cases was a delay of between one and three days in the drainage of aqueous through the tube. This was associated with a persistent elevation of IOP to as much as 4.67 kPa (35 mmHg) and was probably caused by blood clot trapped between the exit of the tube and the pressure ridge of the episcleral plate. This was treated conservatively with acetazolamide by mouth until spontaneous drainage was established.

Discussion

Early stages of bleb formation – valve action of implant

The valve mechanism of the dual chamber implant uses the inflamed tissue of Tenon's capsule as a flexible pressure-regulating element working against the pressure ridge of the implant. This arrangement has the advantage of making the valve cavity and the opening of the tube self-cleaning as they were exposed to the proteolytic enzymes and phagocytic cells derived from the overlying tissues. The pressure at which aqueous escapes into the main bleb cavity depends on the tension and tissue turgor of Tenon's tissue during the early postoperative period. However, in spite of wide individual variation in the surgical tension and degree of inflammation in this tissue the 'valve' has rapidly cleared itself and then maintained an IOP within

Table 2. Visual outcome in cases of neovascular glaucoma treated by implant with six months to six and a half years follow up (average 3.4 years) in the case of the 1982-84 series, and six months to four years (average 2.9 years) in the case of the 1985-87 series

	Simple single plate implants (24 eyes 1982-84)	Dual chamber single plate implants (24 eyes 1985-87)
Visual result		
No PL	4	4
PL-HM	11	13
1/60-5/60	1	3
6/60-6/24	6	2
6/18-6/9	2	2

PL = perception of light; HM = hand movements.

the 0.8 to 2.93 kPa (6 to 22 mmHg) range in all cases during the first week after operation. The maintenance of a near normal IOP during this period is important in preventing further leakage or rupture of intraocular blood vessels and thereby preserving what vision remains.

Comparison with earlier model implant

In evaluating the behaviour of this implant, it is useful to compare the result with those of eyes with neovascular glaucoma drained by the simple single plate implant used previously by the author. Comparison between the 24 eyes drained by implants during the period 1982 to 1984 the present series shows that in the former series more than 80% of eyes exhibited postoperative shallowing of the anterior chamber with 44% having a period of actual collapse of the anterior chamber. Furthermore, the mean time for this group before full reformation of the anterior chamber was 7.3 days. With the modified dual chamber implant the corresponding figures are 7.5% flattening of the anterior chamber with a shallowing of the anterior chamber being recorded in 35% of cases and the mean time before full reformation of the anterior chamber being 1.9 days.

Apart from the more rapid reformation of the AC after insertion of the dual chamber implant, the postoperative behaviour of the two types of implant is the same; with a hypertensive stage of bleb inflammation lasting five to six weeks after operation. In both types of implant the hypertensive stage is followed by a stable stage with a distended thick-walled bleb and an IOP that varied according to the patient's age, the severity of the glaucoma

Table 3. Postoperative behaviour and control of IOP in cases of neovascular glaucoma treated by implants (follow-up six months to six and a half years) (average 3.4 years) in the case of the 1982-84 series, and six months to four years (average 2.97 years) in the case of the 1985-87 series.

Postoperative course	Simple single plate implants (1982-84)	Dual chamber single plate implants (1985-87)
Flat AC	44%	9%
Mean IOP day 2	1.07 kPa (8 mmHg)	2.13 kPa (16 mmHg)
Range	0-2.4 kPa (0-18 mmHg)	0.8-2.93 kPa (6-22 mmHg)
Mean time to reform AC	7.3 days	1.9 days
Control of IOP	83%	87%

and whether or not medication had been given to control bleb fibrosis.

The overall results in terms of control of IOP do not differ significantly between the two groups. See Table 1. However, the groups are not strictly comparable, since the first group is restricted to somewhat more favourable cases of neovascular glaucoma that were thought to have some slight potential for vision. The second group on the other hand contains all cases of neovascular glaucoma that were seen, including eyes with the barest light perception and one eye with no light perception. These cases were included in order to evaluate the new implant under extreme conditions. See Table 2.

Despite the inclusion of these eyes, the overall incidence of postoperative flattening of the AC has been lower and the postoperative course smoother than was the case using the simple single plate implant in 'selected' cases. See Table 3. These findings lead the author to recommend that the dual chamber type of implant should be used in preference to the simple single plate implant when draining established cases of neovascular glaucoma.

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