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Argon Laser Trabeculoplasty in Narrow Angle Glaucoma

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Summary

A prospective trial of argon laser trabeculoplasty (ALT) in narrow angle glaucoma (NAG) was undertaken. In eyes with NAG the mechanism of the glaucoma could be a combination of pupil block with subsequent irido-trabecular adhesion and trabecular damage with an increase in outflow resistance. To achieve relief of pupil block, eyes were randomly assigned to treatment with short pulsed laser iridotomy (LI) with the YAG or Dye lasers, or surgical peripheral iridectomy (PI). Alternatively, argon laser iridoplasty (IP) was performed to widen the anterior chamber angle sufficiently to permit ALT. Fifty-two eyes were treated and follow-up was from 12 to 22 months. A high rate of failure to control IOP with topical medication and progression of visual field loss occurred in all treatment groups.

Iridoplasty followed by ALT was particularly unsuccessful as, in 50 per cent of cases, progressive synechial closure of the anterior chamber angle occurred following treatment.

In eyes treated with PI/LI and ALT, the IOP control was improved in 12 per cent, unchanged in 30 per cent and remained uncontrolled in 58 per cent. By 15 months follow-up, a satisfactory outcome (IOP<21mmHg on topical medication, visual field and acuity stable) was obtained in 24 per cent of the 33 eyes treated with PI/LI and ALT. Thirty-one of these eyes showed visual field loss. Of the 10 eyes that did not receive ALT following PI or LI, 90 per cent had a satisfactory outcome. Eight of these eyes showed little or no visual field loss.

The authors conclude that iridoplasty followed by ALT is an unsuitable treatment for eyes with NAG. We further conclude that ALT is unlikely to be of benefit in eyes with NAG and visual field loss, even after pupil block has been relieved. Relief of pupil block alone may help eyes with early NAG without visual field loss.

Eyes with narrow angle glaucoma usually have a dual mechanism responsible for the raised intraocular pressure—relative pupil block and chronic outflow obstruction. The medical management of these eyes is complicated by the inappropriateness of topical sympathomimetics, which may cause angle crowding and, in the long term, of topical pilocarpine which may cause further shallowing of the anterior chamber (AC) and exacerbate creeping closure of the drainage angle.[1] A decision to operate in such cases is complicated by choosing whether relief of relative pupil block would be sufficient or whether drainage surgery would be more appropriate.[2]

The benefits of argon laser trabeculoplasty in open angle glaucoma (OAG) and of laser iridotomy for the relief of pupil block include

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the relative safety of these procedures, patient preference and the economic savings of out-patient laser rather than in-patient surgery.

The three main aims of this trial were:

(1) to determine whether by first relieving pupil block and then performing argon laser trabeculoplasty an effective and simple out-patient procedure exists for the management of narrow angle glaucoma.
(2) to compare surgical iridectomy with laser iridotomy to determine whether the shock wave and tissue debris released in the course of short-pulsed laser iridotomy influenced the final outcome of IOP control.
(3) to determine whether eyes with NAG may be treated successfully by first widening the AC angle by argon laser iridoplasty[3] and then performing ALT.

Material and Methods

A diagnosis of narrow angle glaucoma which was suitable for inclusion in the trial was made in patients whose eyes showed the following features:

(1) Axial AC depth of $\leq$ 2.5mm.
(2) Field loss detected on the Friedmann Visual Field Analyser of at least two adjacent spots 0.4 log units above threshold or one spot 0.6 log units above threshold.
(3) Glaucomatous cupping of the optic disc.
(4) A narrow anterior chamber angle, considered capable of occlusion, with or without peripheral anterior synechial closure of the anterior chamber angle visible on Zeiss-4 mirror indentation gonioscopy.
(5) All patients entered into this study had an intra-ocular pressure (IOP) > 21mmHg despite maximum tolerated medical treatment.

A small number of eyes with IOP > 21mmHg, AC depth < 2.0mm and peripheral anterior synechiae (PAS), without frank glaucomatous cupping or visual field loss, mostly fellow eyes of patients with established narrow angle glaucoma, were included as these were eyes at risk of developing progressive synechial closure and glaucomatous disc damage.

Patients were randomly assigned according to a computer generated random number sequence to the following treatment groups:

(1) Surgical iridectomy followed by argon laser trabeculoplasty (ALT).
(2) Laser iridotomy using either of two short-pulsed lasers, the Q-switched Neodymium: Yttrium Aluminium Garnet (Nd: YAG) laser or the pulsed Dye laser, followed by ALT at an interval of at least one month.
(360° ALT post-iridotomy/ectomy was not to be performed if the AC angle remained extensively closed by PAS, or if a satisfactory fall in IOP followed the relief of pupil block alone.)
(3) Argon laser iridoplasty followed by ALT.
After nine months of this trial no more patients were assigned to iridoplasty as it had become evident that progressive synechial closure of the drainage angle was occurring with this treatment (*vide infra*).

Treatment

Informed consent was obtained and the reasons for and possible alternatives to the treatment each patient would receive were explained. As this was a clinical trial of differing treatment options, assurance was given that any further treatment that appeared necessary during the course of the trial would be given as needs indicated. Argon laser iridoplasty was performed with the Laser Tek (Spectra Physics) argon laser to 180° of the basal iris and this was followed immediately by argon laser trabeculoplasty to the same half of the AC angle. Post-laser, the patients' usual glaucoma medication was continued in addition to guttae prednisolone 0.3 per cent q.i.d. for two weeks. The other 180° of the iris and AC angle were treated approximately one month later. The laser parameters used for argon laser iridoplasty and ALT are given in Table I.

Surgical peripheral iridectomy (PI) was performed as an in-patient. The method involved a clear-cornea incision. The patient was discharged off pilocarpine, taking guttae chloramphenicol and guttae prednisolone 0.3 per cent, both q.i.d., plus guttae timolol 0.25 per cent b.d., if necessary. ALT was performed between 2 and 6 months later, in two treatment sessions of 180°, with a month's interval between sessions.

Laser iridotomy (LI) was performed with the Q-switched Nd:YAG laser (Sirius Microruptor, Lasag AG, Thun, Switzerland) or the pulsed dye laser (Imperial College, London)—the techniques used have already been described.[4] The operating parameters of these lasers are given in Table II. Following laser iridotomy, the patients' glaucoma medication was continued, in addition to topical

Table I

Argon laser: Laser Tek: Spectra Physics
ALT → performed in two divided sessions of 180° each
all burns placed on anterior ½ trabecular meshwork (TM)
end point of burn taken as visible blanching of TM or bubble
spot size: 50 per cent of cases 50 micron spot
50 per cent of cases 100–150 micron spot
50 burns per 180° of TM
Power 0.4–1.0 watts depending on spot size
Time 0.1 sec for 50 micron burns, 0.2 seconds for burns > 50 microns
Iridoplasty → performed in two divided sessions of 180° each
25 burns, 0.2 second duration, 200 micron spot size and 0.7 watts applied to each 180° of the prominent last roll of the iris.

prednisolone 0.3 per cent or 1 per cent q.i.d. for two weeks. ALT was performed between one and four months post-iridotomy, again in two divided sessions.

Follow-up

Patients were closely followed up in the immediate post-operative period following all procedures, especially to detect post-laser pressure rises.[4] Thereafter, follow-up was at one month, then three monthly or more often if necessary. Follow-up period for the study was to be a minimum of 12 months. At each follow-up visit, intraocular pressure (IOP) was measured by Goldmann applanation tonometry, the axial AC depth was measured with a Haag-Streit pachometer, and the anterior chamber angle width and presence of PAS noted. The recurrence of pupil block was evidenced by narrowing of the AC angle and an increase in the forward convexity of the peripheral iris which was confirmed by AC slit-image photography.[4] If the IOP appeared satisfactory, patients were instructed to stop taking pilocarpine two days prior to their next visit. After one year's follow-up, most patients had repeated intraocular pressure measurements taken over a nine hour period (phasing of IOP), and those whose control appeared poor were admitted for in-patient phasing over a 36 hour period. Friedmann visual field analysis was performed at approximately six monthly intervals.

Throughout the study, topical medication was adjusted according to the IOP control. Where the IOP remained uncontrolled in the presence of severe or progressing visual field loss, the eye underwent filtering surgery (trabeculectomy), unless a poor surgical risk in which case systemic acetazolamide (Diamox) was added.

Table II

	YAG laser	*Dye laser*
Lasing material	Neodymium	Rhodamine 6 G
Wavelength	1064nm	600nm
Mode	Q-switched FM Fundamental MM Multi Mode	Short-pulsed
Timescale	12 nanoseconds	3 microseconds
Spot size	7μ FM 70 μ MM	150 μ
Delivery	Burst of 4 pulses	Single shot

Visual field analysis

All visual field analysis in this study was performed by an experienced field technician using the Friedmann Mark 2 Field Analyser. The following criteria were used to describe any field loss identified;

(a) Good. Field loss less than two adjacent spots 0.4 log units or one spot 0.6 log units above threshold.

(b) Early. Field loss greater than above, but less than four adjacent spots 0.6 log units above threshold.

(c) Bad. Field loss greater than four adjacent spots 0.6 log units above threshold.

Progression of visual field loss (VFL)

VFL progression was defined as the appearance of loss greater than four adjacent spots 0.6 log units above threshold in an area of previously normal field, or the progression from a relative to an absolute scotoma.

Results

Fifty-two eyes of 34 patients were included in the study.

The age range of the patients was from 46 to 80 years, average 63 years. The axial AC depth of the eyes was from 1.7mm to 2.5mm, average 2.1mm. Three patients (four eyes) did not complete a 12 month follow-up. One patient (one eye) died at nine months, one patient (one eye) failed to attend after the six month follow-up and one patient (two eyes) failed to attend after the eight month follow-up appointment.

8 eyes underwent iridoplasty followed by 360° ALT in each case.

15 eyes underwent PI, 10 followed by 360° ALT.

13 eyes underwent YAG LI, 11 followed by 360° ALT, one by 180° ALT.

16 eyes underwent Dye LI, six followed by 360°ALT, six by 180° ALT.

Group 1 Iridoplasty (IP) followed by ALT. Table III

This treatment option was removed from the study when it became evident that progressive synechial closure of the AC angle had occurred in 4 (50 per cent) of the eyes treated. A relative degree of pupil block was observed to be present in those eyes, evidenced by peripheral iris bombe and gonioscopic narrowing of the AC angle. Two of these four eyes required trabeculectomy, the other two iridectomy and topical medication.

Table III *Iridoplasty (IP) followed by ALT*

Case	*Age*	*ACD*	*ALT*	*Field*	*PAS △*	*Rx △*	*Outcome*	*Months*
1	64	2.2	360°	Early	↑	ISQ	PB → YAG LI	15
2	59	2.3	360°	Good	Nil	ISQ	VFL ↑	15
		2.3	360°	Good	Nil	ISQ	Stable	15
3	59	2.4	360°	Bad	↑	ISQ	PB → filter	9
4	70	1.8	360°	Good	↑	ISQ	PB → filter	13
5	70	2.5	360°	Early	↓	ISQ	VFL ↑	18

Age=age of patient; ACD=axial anterior chamber depth in millimetres; ALT=degrees of anterior chamber angle treated with ALT; Field=Friedman visual field at entry to trial; PAS △=change in PAS post-treatment, as assessed by Zeiss 4 mirror indentation gonioscopy; ↑ =increase; ↓ =decrease; Rx △=change in topical regimen at final outcome; Outcome=given in months post PI/LI/IP; Filter=trabeculectomy to achieve IOP control; Diamox=trabeculectomy only avoided by addition of acetazolamide in eye that was poor surgical risk; Stable=IOP controlled and visual field unchanged; VA ↓ =reduction in visual acuity by > 4 lines snellen; VFL ↑ = Visual Field Loss progression.

Table IV *Surgical peripheral iridectomy (PI) followed by ALT.*

Case	*Age*	*ACD*	*ALT*	*Field*	*PAS △*	*Rx △*	*Outcome*	*Months*
1	80	1.9	360°	Bad	Nil	ISQ	Stable	9
2	74	1.7	360°	Bad	Nil	↑	Diamox	18
3	50	2.2	360°	Bad	Nil	↑	VA ↓	18
4	59	2.0	360°	Early	Nil	ISQ	Stable	22
5	46	2.2	360°	Bad	↑	↑	Diamox	15
6	77	2.2	360°	Bad	↑	↓	Stable	16
7	80	1.8	Nil	Bad	Nil	↑	VA ↓	16
8	58	2.5	360°	Bad	↑	ISQ	Filter	8
9	56	1.8	Nil	Early	Nil	ISQ	Stable	8
10	59	1.9	Nil	Good	Nil	↓	Stable	12

Age=age of patient; ACD=axial anterior chamber depth in millimetres; ALT=degrees of anterior chamber angle treated with ALT; Field=Friedman visual field at entry to trial; PAS △=change in PAS post-treatment, as assessed by Zeiss 4 mirror identation gonioscopy; ↑ =increase; ↓ =decrease; Rx △=change in topical regimen at final outcome; Outcome=given in months post PI/LI/IP; Filter=trabeculectomy to achieve IOP control; Diamox=trabeculectomy only avoided by addition of acetazolamide in eye that was poor surgical risk; Stable=IOP controlled and visual field unchanged; VA ↓ =reduction in visual acuity by > 4 lines snellen; VFL ↑ = Visual Field Loss progression.

The remaining four eyes in this group maintained satisfactory IOP with topical medication, but three showed marked progression of visual field loss between 15 and 18 months follow-up.

Group 2 Surgical peripheral iridectomy followed by ALT. Table IV

Over the eight to 24 months follow-up, seven eyes were considered failures as IOP remained uncontrolled and field loss progressed. Two of these seven eyes underwent trabeculectomy, in three acetazolamide was necessary to achieve control, and in two topical medication was increased. Of the remaining eight eyes in Group 2, control of IOP was unaffected post-operatively in five eyes and in three eyes it was possible to reduce topical medication. The visual field in these eight eyes remained stable.

Group 3 YAG laser iridotomy followed by ALT. Table V

Five eyes in this group had uncontrolled IOP after treatment. Of these five, one eye showed late failure of patency of YAG iridotomy, redeveloping pupil block. This eye underwent trabeculectomy as the IOP was uncontrolled, and further visual field loss had occurred. Two other eyes with severe NAG required trabeculectomy to control the IOP, and two were controlled only with additional topical and systemic medication. In four eyes, topical medication remained unchanged after YAG LI/ALT, but over a 15 month follow-up period, their visual field loss showed marked progression. In four eyes the treatment was of benefit in that IOP control was achieved with a reduction of topical medication and no progression of visual field loss.

Group 4 Dye laser iridotomy followed by ALT. Table VI

Eight eyes in this group, all with advanced field loss, had uncontrolled IOP following laser treatment and seven required trabeculectomy between three and 15 months. The remaining eye would have required trabeculectomy, but for systemic acetazolamide. In the other eight eyes, the same pre-operative level of treatment had to be continued post-operatively.

In analysing the results of treatment in groups 2, 3 and 4, it is helpful to consider separately the ten eyes not subsequently treated with ALT. Eight of these eyes showed little glaucomatous damage and following PI or LI alone, their IOP control was satisfactory. Of the two with 'bad' field loss, ALT was not attempted because of extensive PAS persisting after PI/LI. One of these eyes remained stable, the other showed progressive field loss. Thus, in those eyes that did not require ALT, IOP control was improved in three, unchanged in six and continued difficult to control in one—a satisfactory result in 90 per cent of cases. Of the remaining 34 eyes that did receive ALT, 33 had a follow-up of 15 months or more. Of these, IOP control was improved in four eyes (12 per cent), unchanged in 11 (32 per cent) and remained uncontrolled in 19 eyes (58 per cent). Four eyes in which IOP control was unchanged following YAG LI/ALT, showed marked progression of visual field loss over a 15 month follow-up.

Visual acuity

Four eyes in the study had a reduction of visual acuity. Two eyes developed cataracts reducing visual acuity by more than four lines of Snellen following Dye laser iridotomy—at one year post treatment in a 77 year old patient, and at two years post treatment in a 70 year old patient. A similar reduction in vision was seen following surgical iridectomy in two eyes, at one year post surgery in a 50 year old, and at one year post surgery in an 80 year old.

PAS formation

Significant post-treatment progression of PAS was observed in four eyes in group 1, in four eyes in group 2, in four eyes in group 3, and in three eyes in group 4.

Table VII gives a summary of the outcome in treatment groups 2, 3 and 4 in those eyes followed up for 15 months or more. Control of IOP was improved in 4 eyes (12 per cent) unchanged in 10 eyes (30 per cent) and remained uncontrolled in 19 eyes (58 per cent). Those eyes with stable visual fields and visual acuities, and IOP less than 21 mmHg are shown in Table VIII. Three eyes (33 per

Table V *YAG laser iridotomy followed by ALT*

Case	*Age*	*ACD*	*ALT*	*Field*	*PAS* △	*Rx* △	*Outcome*	*Months*
1	64	1.8	360°	Bad	↑	ISQ	Filter	4
	64	1.8	360°	Bad	↑	ISQ	Diamox	8
2	67	1.9	360°	Bad	↑	ISQ	Filter	16
3	58	2.0	180°	Bad	Nil	↓	Stable	18
	58	2.0	Nil	Good	Nil	↓	Stable	18
4	53	2.3	180°	Good	Nil	ISQ	VFL ↑	15
	53	2.2	180°	Early	Nil	ISQ	VFL ↑	15
5	65	2.0	360°	Bad	↑	ISQ	PB → filter	9
	65	2.0	360°	Bad	Nil	ISQ	Diamox	9
6	68	1.9	360°	Early	Nil	ISQ	VFL ↑	15
	68	1.9	360°	Early	Nil	ISQ	VFL ↑	15
7	48	2.0	360°	Good	Nil	↓	Stable	15
	48	2.1	360°	Bad	Nil	↓	Stable	15

Age=age of patient; ACD=axial anterior chamber depth in millimetres; ALT=degrees of anterior chamber angle treated with ALT; Field=Friedman visual field at entry to trial; PAS △=change in PAS post-treatment, as assessed by Zeiss 4 mirror identation gonioscopy; ↑ =increase; ↓ =decrease; Rx △=change in topical regimen at final outcome; Outcome=given in months post PI/LI/IP; Filter=trabeculectomy to achieve IOP control; Diamox=trabeculectomy only avoided by addition of acetazolamide in eye that was poor surgical risk; Stable=IOP controlled and visual field unchanged; VA ↓ =reduction in visual acuity by > 4 lines snellen; VFL ↑ = Visual Field Loss progression.

Table VI *Dye laster iridotomy followed by ALT*

Case	*Age*	*ACD*	*ALT*	*Field*	*PAS* △	*Rx* △	*Outcome*	*Months*
1	76	2.0	180°	Bad	Nil	ISQ	Filter	3
	76	2.0	180°	Bad	Nil	ISQ	Filter	7
2	65	2.1	180°	Bad	Nil	ISQ	Filter	6
	65	2.1	180°	Bad	Nil	ISQ	Filter	10
3	77	2.4	180°	Bad	Nil	↑	Filter VA ↓	12
4	59	2.3	360°	Bad	Nil	ISQ	Stable	15
5	70	2.0	360°	Early	↑	ISQ	Filter	11
	70	2.0	360°	Early	Nil	ISQ	Stable	16
6	51	2.4	Nil	Good	Nil	ISQ	Stable	15
	51	2.5	Nil	Bad	Nil	ISQ	Stable	15
7	64	1.8	360°	Bad	Nil	ISQ	Filter	15
	64	1.6	360°	Bad	Nil	ISQ	Diamox	15
8	70	1.7	360°	Good	Nil	ISQ	VA ↓	18
9	46	2.15	180°	Bad	↑	ISQ	Diamox	6
10	67	1.9	Nil	Good	↑	ISQ	Stable	18
11	59	2.5	Nil	Good	↓	ISQ	Stable	18

Age=age of patient; ACD=axial anterior chamber depth in millimetres; ALT=degrees of anterior chamber angle treated with ALT; Field=Friedman visual field at entry to trial; PAS △=change in PAS post-treatment, as assessed by Zeiss 4 mirror identation gonioscopy; ↑ =increase; ↓ =decrease; Rx △=change in topical regimen at final outcome; Outcome=given in months post PI/LI/IP; Filter=trabeculectomy to achieve IOP control; Diamox=trabeculectomy only avoided by addition of acetazolamide in eye that was poor surgical risk; Stable=IOP controlled and visual field unchanged; VA ↓ =reduction in visual acuity by > 4 lines snellen; VFL ↑ = Visual Field Loss progression.

cent) had a successful outcome following PI/ALT, three (25 per cent) following YAG/ALT and two (17 per cent) following Dye/ALT—making a total successful outcome of eight eyes (24 per cent).

Discussion

Argon laser trabeculoplasty has become widely accepted as a generally safe and effective out-patient treatment for open angle glaucoma,[5,6,7,8] often helping to avoid the need

Table VII *IOP control at 15 months follow-up.*

No. of eyes		*Improved*	*Unchanged*	*Uncontrolled*
PI/ALT	9	1	2	6
YAG/ALT	12	3	4	5
Dye/ALT	12	nil	4	8
Total	33	4 (12 Per cent)	10 (30 Per cent)	19 (58 Per cent)

for filtering surgery.[7] However, ALT is unsuitable for patients with NAG as the inflammation produced may lead to PAS formation and progressive angle closure.[9] Wise reports that he has observed a tendency in medically treated eyes with OAG to develop creeping angle closure and therefore now performs AL iridotomies in 30 per cent of eyes he treats with ALT to deepen the peripheral AC and prevent the formation of PAS.[9]

In an ageing glaucomatous population as enlargement of the crystalline lens leads to progressive shallowing of the anterior chamber,[10,11] the prevalence of NAG must rise, thereby rendering less eyes suitable for ALT. In addition, pilocarpine may be responsible for narrowing the AC angle[1] and some patients may have unsuspected exfoliation syndrome[12]—in which there has been shown to be a high incidence of narrowing and closure of the AC angle.[13] Similarly, eyes with congenitally small anterior segments will be unsuitable for ALT as the drainage angle will be crowded by the peripheral iris.

Some eyes with raised IOP in which topical medication is inappropriate may therefore be unsuitable for ALT, and may require filtering surgery. However, filtration surgery requires in-patient treatment, and introduces the risk of infection, flat AC, malignant glaucoma and, in phakic patients, of worsening lens opacities.[14]

The benefits of relief of pupil block by iridectomy/iridotomy in eyes with chronic angle closure glaucoma are well known[15-19] and this is especially so in eyes with raised IOP with little in the way of glaucomatous damage.[18] Where cupping of the optic disc and visual field loss are present, however, iridectomy alone is unlikely to be successful in reducing the IOP to safe levels.[16,18] With the advent of LI, some authors, however, recommend argon LI in all cases of chronic angle closure as post-operatively, control may be more easily achieved with topical medication.[20,21,22]

Table VIII *Successful outcome at 15 months*

No. of eyes		*IOP<22. Stable VA & field*
PI/ALT	9	3 (33 Per cent)
YAG/ALT	12	3 (25 Per cent)
Dye/ALT	12	2 (17 Per cent)
Total	33	8 (24 Per cent)

This study sought to relieve any pupil block present in eyes with NAG, and then, if IOP was still raised, to improve outflow by performing ALT. Performing an iridotomy/iridectomy should relieve pupil block, widen the AC angle and prevent the progression of PAS.[18,19,22] ALT may then be performed on the more open angle without the risk of exacerbating PAS. A preliminary study of this treatment option showed a small fall in the IOP, additional to that produced by medical treatment, over a six to 12 month follow-up period.[23]

The results of treatment in the present study were, however, disappointing with a long-term success rate of 24 per cent. (Table VIII).

In the present study, the progressive synechial closure of the AC angle observed to follow iridoplasty/ALT in 50 per cent of cases led to the abandonment of this treatment. Irido-trabecular contact will result in permanent synechiae formation once the abrading action of contact has denuded the surface layer of cells covering these tissues. Laser damage to these surface cells will promote the tendency to adhesion between iris and TM.[24] The authors agree with the opinion of Wise that iridoplasty is an unsuitable method of deepening the peripheral AC prior to ALT as this deepening is only temporary.[9]

In groups 2, 3 and 4 relief of pupil block appeared to be most helpful in those eyes without visual field loss. Of the eight eyes without visual field loss none required ALT to keep the IOP controlled and none suffered further field loss. By 15 months follow-up of the 33 eyes that required ALT following PI/LI, 58 per cent came to filtering surgery or required the addition of systemic acetazolamide therapy. Thirty-one of these eyes had visual field loss.

Particularly disappointing in this study was the progression of visual field loss seen in the three eyes apparently successfully treated with iridoplasty and ALT, and four eyes with successful IOP control following YAG LI and ALT. As these patients continued to be treated with topical medication, it may be that their compliance was poor.[25] However, progression of field loss has also been reported following successful lowering of IOP after trabeculectomy[26] and also ALT.[27]

In eyes with OAG, ALT has been shown to be effective in reducing the IOP[6,7,8] with success rates as high as 85–90 per cent.[5] In this study, however, ALT resulted in improved IOP control in only 12 per cent of eyes. Several possible explanations may account for this difference:

(a) Difficulties with technique of ALT in eyes with NAG. Even though the angle was widened by IP/PI or LI prior to ALT, the target area remains less easily visualised than in an eye with OAG and the more oblique direction of the aiming beam may result in a less precisely focused spot.

(b) Differences in tissue response to ALT. To minimise the risk of PAS formation post-ALT in this study, the anterior TM was treated.[28] However, this may have resulted in further outflow obstruction due to the endothelial cellular proliferative changes which have been described by Van der Zypen *et al.* following anterior TM ALT.[29]

(c) The mechanism of outflow obstruction in NAG may differ from that of OAG. The exact mechanism of IOP reduction that is seen following successful ALT in OAG is conjectural, but tightening of the trabecular ring thereby opening up the collapsed spaces of the TM has been suggested.[30]

In those eyes that underwent ALT after LI or SI, 10 eyes (29 per cent) showed an increase of PAS over the period of follow-up. In the 10 eyes not treated with ALT, progression of PAS only occurred in one (10 per cent). Formation of PAS is a recognised complication of ALT in OAG[28] and despite widening of the AC angle after relief of pupil block, it may be that the laser energy deposited in the still relatively small space causes sufficient tissue damage to lead to PAS formation.

The study also served to compare the long term effects of surgical iridectomy with short-pulsed laser iridotomy. Surgical iridectomy is without danger to the endothelium[31] but carries the risks of infection, malignant glaucoma and worsening pre-existing cataract.[32] Although out-patient procedures, LI and ALT are not without complications. Significant elevations of IOP after LI are common in eyes with chronic angle closure glaucoma, may be prolonged and may require emergency in-patient treatment.[4] Endothelial damage may also follow short-pulsed LI, although, in the short term, this has not been shown to be clinically significant.[31] Significant elevations of IOP may also occur after ALT.[7,27] Therefore, in addition to the immediate risk to the eye from raised IOP, there may be long-term damage to the outflow system from tissue debris and shock-wave release associated with short-pulsed laser iridotomy. However, the treatment failure rate was very similar in Groups 2, 3 and 4 and therefore these theoretical disadvantages associated with LI do not seem to be prejudicial to the longer-term control of IOP. Because of the small number of eyes in each treatment group and the differing degree of glaucomatous damage in the eyes a statistical analysis of the results was not possible.

One potential danger of laser iridotomy in NAG eyes is failure to relieve pupil block. Where this occurs, whether due to late closure or inadequate size of the iridotomy, progressive angle closure will occur, exacerbated by the inflammation produced by the LI and ALT. This occurred in one eye in this study after YAG LI and may easily be overlooked in follow-up without frequent and careful gonioscopy. Failure of YAG LI has also been reported elsewhere[4,33] and in a series of 200

cases, Spaeth found nine per cent of YAG LIs required retreatment.[34]

Examination of Tables IV, V and VI shows that eyes with 'bad' visual field loss pre-treatment were the most likely to require filtering surgery to achieve control. The poorest results were obtained in the Dye LI/ALT group, but a greater proportion of eyes in this group had 'bad' visual field loss pre-treatment.

Four eyes in this study developed lens opacities—two after dye LI and two after PI. However, these lens opacities were not necessarily the result of treatment. Acute focal lens opacities have been reported following LI with the dye laser,[3] but no acute damage was observed in the two cases in this study and both patients were elderly with pre-existing nuclear sclerosis. Similarly, the cataracts that followed PI may not have been related to surgery. In one patient, as only one eye had received treatment and the progression to cataract was bilateral and symmetrical, this lens opacity was unlikely to be a result of surgery. The other patient to develop a cataract after PI was 70 years old and had pre-existing nuclear sclerosis.

Conclusions

(1) Argon laser iridoplasty followed by ALT is an unsuitable treatment for eyes with shallow anterior chambers and NAG.

(2) In eyes with normal visual fields that nevertheless have a diagnosis of NAG (shallow AC, raised IOP and early PAS) LI or SI is indicated. Relieving pupil block allows the safe use of medical therapy, reverses the trend to develop progressive angle closure and may in itself cause a fall in IOP.

(3) Eyes with established NAG (shallow AC, field loss, optic disc cupping and PAS) are unsuitable for treatment with ALT, even where successful relief of pupil block is achieved. To the high rate of failure to control IOP (58 per cent), must be added the morbidity of possible post-laser pressure rise and extension of PAS. Furthermore, such treatment requires much time to perform and close supervision in the immediate and long-term follow-up periods.

(4) In eyes with NAG with advanced glaucomatous damage of the optic nerve head and visual field loss, control of IOP after relief of pupil block remains difficult. Such eyes may be better treated by filtering surgery thus avoiding the delay and complications that may be encountered when a trial of PI or LI followed by topical medication is embarked upon.

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