

A randomised prospective comparison of operative peripheral iridectomy and Nd:YAG laser iridotomy treatment of acute angle closure glaucoma: 3 year visual acuity and intraocular pressure control outcome

B W Fleck, E Wright, E A Fairley

Abstract

Aim—To compare visual acuity and intraocular pressure outcomes 3 years after treatment of acute angle closure glaucoma (AACG) by operative peripheral iridectomy (PI) or Nd:YAG laser iridotomy (YAG PI).

Methods—A prospective study of consecutive patients presenting to one ophthalmology department with unioocular AACG during a 2 year period. Following informed consent patients were randomised to bilateral PI or bilateral YAG PI. Three years after treatment the mean Snellen visual acuity converted to logMAR scores of the two groups was compared using the unpaired Student's *t* test. The number of patients with normal intraocular pressure with no further treatment in each group was compared using the χ^2 test with Yates's correction.

Results—21 patients underwent bilateral PI and 27 bilateral YAG PI. Three years after treatment visual acuity was 0.30 (SD 0.28) log MAR units for PI eyes and 0.57 (0.67) logMAR units for YAG PI eyes ($p=0.08$, NS). 15 (70.4%) PI eyes and 19 (71.8%) YAG PI eyes had an intraocular pressure less than 21 mm Hg with no further treatment (NS).

Conclusions—There was no significant difference in visual acuity or intraocular pressure control 3 years after treatment of AACG with PI or YAG PI.

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Nd:YAG laser iridotomy has largely superseded operative peripheral iridectomy in the treatment of angle closure glaucoma.^{1,2} Laser surgery is more convenient and less costly than operative surgery.³ While the risks of endophthalmitis and flat anterior chamber are removed by Nd:YAG laser iridotomy, laser surgery remains an invasive treatment.⁴ Operative peripheral iridectomy is a well established procedure with few complications and very satisfactory long term outcome.⁵ We have previously reported that Nd:YAG laser iridotomy is a satisfactory alternative to operative peripheral iridectomy in the treatment of fellow eyes.⁶ The long term effectiveness of Nd:YAG laser iridotomy is less well documented in acute

angle closure glaucoma (AACG) eyes.⁷⁻⁹ A retrospective comparison of Nd:YAG laser iridotomy and operative peripheral iridectomy has suggested that operative peripheral iridectomy may be a superior treatment of AACG in patients who have had prolonged attacks of AACG.⁸ We have performed a randomised prospective comparison of bilateral Nd:YAG laser iridotomy and bilateral peripheral iridectomy in a consecutive group of patients presenting with unioocular AACG.

Methods

Ethical approval of the study was obtained from the regional surgical specialties ethics committee. Consecutive patients presenting to the ophthalmology department of Edinburgh Royal Infirmary with unioocular AACG glaucoma during a 24 month period were asked to participate in the study. Patients with an intraocular pressure greater than 21 mm Hg in the AACG eye following initial medical control underwent primary trabeculectomy and were excluded from the study. Randomisation was performed only when informed consent to participation in the study had been obtained.

Initial examination included assessment of Snellen corrected visual acuity, intraocular pressure, Goldmann gonioscopy, slit lamp examination, and fundus examination.

Following a diagnosis of unioocular AACG the following treatment was administered: acetazolamide 500 mg intravenously, followed by 250 mg 6 hourly by mouth; pilocarpine drops 2% hourly to the affected eye, reduced to 6 hourly when the intraocular pressure fell below 21 mm Hg; pilocarpine eyedrops 1% 6 hourly to the fellow eye; timolol eyedrops 0.5% 12 hourly to both eyes. The intraocular pressures were measured every 2 hours until they fell below 21 mm Hg, or until a decision was made that primary trabeculectomy was required.

Following initial medical control a further examination was performed, including assessment of Snellen corrected visual acuity, Goldmann gonioscopy, slit lamp examination, and fundus examination. Patients were randomised to operative PI (PI) or Nd:YAG laser PI (YAG PI) by opening consecutively numbered envelopes which contained a card labelled PI or YAG PI. The cards had been placed in the

Department of
Ophthalmology, Royal
Infirmary, Edinburgh
B W Fleck
E Wright
E A Fairley

Correspondence to:
Dr B W Fleck, Princess
Alexandra Eye Pavilion,
Chalmers Street, Edinburgh
EH3 9HA.

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Table 1 Conversion of Snellen visual acuity to logMAR score

Snellen visual acuity	LogMAR score
6/4	-0.2
6/5	-0.1
6/6	0.0
6/9	0.2
6/12	0.3
6/18	0.5
6/24	0.6
6/36	0.8
6/60	1.0
CF, 2/60	1.5
HM	—
PL	—
NPL	—

envelopes in a random order by an independent observer.

Operative and laser treatments were performed by one of three experienced surgeons (one consultant, two registrars), using the following protocol.

SURGERY

Operative peripheral iridectomy was performed using a corneal section, leaving the conjunctiva undisturbed to allow future trabeculectomy if necessary. A small knob of peripheral iris was grasped with forceps, drawn out of the wound and excised with micro scissors. The wound was sutured with a single 10/0 nylon suture.

LASER TREATMENT

A Zeiss 'Visulas' Nd:YAG laser and Zeiss anterior segment YAG contact lens were used. A treatment site was chosen in the superior iris, in a crypt where present. A single 5–6 mJ pulse was delivered to the treatment site and repeated until patency was achieved. Patency was assessed by direct visualisation of the posterior chamber.

POST-TREATMENT ASSESSMENT

Laser treated patients had an intraocular pressure measurement performed 2 hours after treatment. All patients had an intraocular pressure measurement performed 24 hours after treatment, and slit lamp examination to assess patency of the iridectomy or iridotomy.

FOLLOW UP

Patients were assessed 1 week, 2 months, and then 6 months after treatment. Snellen corrected visual acuity, intraocular pressure, and optic disc appearances were assessed at every visit. Friedmann visual field analyser visual field examinations were performed only if the vertical cup:disc ratio was greater than or equal to 0.6. Topical medical treatment was prescribed if the intraocular pressure was greater than 24 mm Hg on more than one occasion.

VISUAL ACUITY ANALYSIS

Snellen visual acuity measurements were converted to a logMAR score in order to simplify statistical analysis. The conversion table suggested by Buckley *et al*,⁸ as shown in Table 1, was used.

Table 2 Duration of symptoms before presentation (number of patients)

	PI	YAG PI	Total
0–12 hours	4	2	6
12–24 hours	5	6	11
>24 hours	10	15	25
Not reliable	2	4	6
Total	21	27	48

STATISTICAL ANALYSIS

Data sets approximated to normal distribution and the unpaired or paired Student's *t* test or χ^2 test with Yates's correction were used to test the significance of differences between the two groups.

Results

Fifty eight patients presented with unioocular AACG during the study period. Four patients had an intraocular pressure greater than 21 mm Hg after initial medical control, underwent primary trabeculectomy, and were excluded. One patient had acute on chronic AACG with optic disc cupping with a cup:disc ratio greater than 0.6 and visual field loss and was excluded. Five patients declined to participate in the study.

Forty eight patients proceeded into the study. Twenty one were allocated to the PI group and 27 to the YAG PI group. There were eight males and 13 females in the PI group and four males and 23 females in the YAG PI group. The mean age of the PI group was 65.9 (SD 12.0) years and that of the YAG PI 70.0 (10.3) years, ($p=0.1$, NS).

The duration of symptoms before presentation are shown in Table 2. There was no significant difference in the proportion of patients with symptoms of greater than 24 hours' duration in the two groups.

The intraocular pressures at presentation are shown in Table 3. There was no significant difference between the PI group and the YAG PI group. As expected the intraocular pressures were significantly greater in AACG eyes than in fellow eyes ($p<0.001$).

Using logMAR scores the visual acuity at presentation is shown in Table 4. There was no significant difference between the PI and YAG PI group for either AACG eyes or fellow eyes. AACG eyes had significantly worse visual acuity than fellow eyes in both groups ($p<0.001$).

Following initial medical control the intraocular pressure fell to less than 21 mm Hg in all eyes included in the study. Eyes with intraocular pressure greater than 21 mm Hg

Table 3 Mean (SD) intraocular pressure (mm Hg) at presentation

	Acute eye	Fellow eye
PI	51.4 (13.0)	17.4 (8.1)
YAG PI	53.4 (12.5)	17.3 (6.7)

Table 4 Visual acuity at presentation, logMAR units (mean (SD))

	Acute eye	Fellow eye
PI	0.86 (0.70)	0.15 (0.26)
YAG PI	0.78 (0.56)	0.26 (0.23)

Table 5 Time taken to achieve initial medical control (number of patients)

	PI	YAG PI	Total
0-6 hours	13	12	25
6-12 hours	2	1	3
12-24 hours	2	4	6
History not reliable	4	10	14
Total	21	27	48

Table 6 Visual acuity following initial medical control, logMAR units (mean (SD))

	Acute eye	Fellow eye
PI	0.39 (0.48)	0.15 (0.20)
YAG PI	0.45 (0.48)	0.22 (0.30)

following initial medical control were excluded. The time taken to achieve initial medical control is shown in Table 5. There were no significant differences between the PI group and the YAG PI group.

Following initial medical control visual acuity improved in AACG eyes ($p=0.02$ for operative PI eyes, $P = 0.07$ for YAG PI eyes). There was no significant difference in visual acuity between the PI group and the YAG PI group (Table 6).

Goldmann gonioscopy was performed after initial medical control in 13 PI patients and 16 YAG PI patients. Indentation was not performed. In the PI group eight AACG eyes were open to at least grade 1 throughout 360 degrees and five had areas of grade 0 closure. In the YAG PI group 11 AACG eyes were open to at least grade 1 throughout 360 degrees and five had areas of grade 0 closure. The cup:disc ratio was 0.6 in one AACG eye treated with PI and one AACG eye treated with YAG PI. In all other eyes the cup:disc ratio was less than 0.6. The visual fields were not examined at this stage.

YAG PI OPERATIVE COMPLICATIONS

The total laser energy used for AACG eyes was 34.33 (SD 29.94) mJ, and the total laser energy used for fellow eyes was 22.32 (20.41) mJ ($p=0.09$).

Minor iris bleeding at the time of YAG PI occurred in 10 AACG eyes and 11 fellow eyes. Mild corneal oedema overlying the treatment site developed in three AACG eyes and two fellow eyes. A second treatment session was needed in three AACG eyes as the PI was very small following the first treatment session. In one AACG eye a patent PI had not been obtained following two laser treatment sessions and an operative PI was performed. In one AACG eye there was a recurrence of AACG despite the presence of a small, patent PI, and an operative PI was performed following further medical control.

PI OPERATIVE COMPLICATIONS

Operative PI led to incomplete patency of the iris in three AACG eyes and one fellow eyes. In each case the iris stroma was excised but the pigment layer was not excised. These cases underwent secondary YAG PI. Minor iris bleeding occurred at the time of operative PI in one fellow eye and no AACG eyes. One fellow

eye developed a wound leak and a corneal abrasion. One AACG eye developed an iris prolapse.

The mean intraocular pressure in the PI and YAG PI groups 24 hours following treatment is shown in Table 7. There were no significant differences between the PI and the YAG PI group, or between AACG eyes and fellow eyes. Five AACG eyes treated with YAG PI had an intraocular pressure greater than 21 mm Hg 2 hours after treatment, the highest value was 33 mm Hg. The intraocular pressure was not measured routinely 2 hours following operative PI. Two AACG eyes treated with YAG PI had an intraocular pressure greater than 21 mm Hg 24 hours after treatment. One AACG eye treated with operative PI had an intraocular pressure greater than 21 mm Hg 24 hours after treatment.

Two months after treatment 19 of the 21 AACG eyes treated by operative PI had an intraocular pressure less than 21 mm Hg without medication, and two eyes required topical medication to maintain an intraocular pressure less than 21 mm Hg. Eighteen of the 27 AACG eyes treated by YAG PI had an intraocular pressure less than 21 mm Hg without medication, three eyes required topical medication to maintain an intraocular pressure less than 21 mm Hg, five eyes had an intraocular pressure greater than 21 mm Hg with no medication and one eye had an intraocular pressure less than 21 mm Hg following trabeculectomy. This difference in outcome was not significant using the χ^2 test with Yates's correction. Gonioscopy results were available in 17 PI patients and 18 YAG PI patients. Peripheral anterior synechiae (PAS) were present in 8/17 AACG PI eyes and 3/18 AACG YAG PI eyes (NS). PAS were present in one fellow eye from each group.

Visual acuity 2 months after treatment is shown in Table 8. There was no significant difference between the PI group and the YAG PI group for either AACG eyes or fellow eyes. For each group there was no significant change in visual acuity after 2 months compared to visual acuity following initial medical control.

Three years after treatment 15 of the 21 AACG eyes treated by operative PI had an intraocular pressure less than 21 mm Hg without medication. Six had an intraocular pressure less than 21 mm Hg with topical medication. Nineteen of the 27 AACG eyes treated by YAG PI had an intraocular pressure less than 21 mm Hg without medication, four

Table 7 Mean (SD) intraocular pressure 24 hours after operative or laser treatment (mm Hg)

	Acute eye	Fellow eye
PI	13.85 (4.28)	13.50 (3.97)
YAG PI	14.14 (7.30)	12.77 (3.34)

Table 8 Visual acuity 2 months after treatment, logMAR units (mean (SD))

	Acute eye	Fellow eye
PI	0.26 (0.28)	0.20 (0.26)
YAG PI	0.49 (0.58)	0.15 (0.22)

Table 9 Visual acuity 3 years after treatment, logMAR units (mean (SD))

	Acute eye	Fellow eye
PI	0.30 (0.28)	0.15 (0.24)
YAG PI	0.57 (0.67)	0.30 (0.38)

had an intraocular pressure less than 21 mm Hg with topical medication, three had an intraocular pressure greater than 21 mm Hg with no medication, and three had an intraocular pressure less than 21 mm Hg following trabeculectomy. There was no significant difference between these outcomes using the χ^2 test with Yates's correction.

Glaucomatous optic disc cupping with a cup:disc ratio greater than 0.6 was present in two AACG eyes treated with PI, four AACG eyes treated with YAG PI, and two fellow eyes treated with PI. Areas of absolute glaucomatous visual field loss using a Friedmann visual field analyser were present in one AACG eye treated by PI, four AACG eyes treated with YAG PI, and no fellow eyes. There were no statistically significant differences between the PI group and the YAG PI group using the χ^2 test with Yates's correction.

Visual acuity 3 years after treatment is shown in Table 9. One YAG PI fellow eye had had cataract surgery. There were no significant differences between the PI group and the YAG PI group for either AACG eyes ($p=0.08$) or fellow eyes ($p=0.1$).

Discussion

The safety and effectiveness of a therapy for acute angle closure glaucoma may be assessed by measuring the incidence of immediate treatment complications, the incidence of recurrent AACG, the long term visual acuity outcome, and the long term glaucoma outcome. Operative peripheral iridectomy is a well established procedure with few complications and very satisfactory long term outcome.⁵ Any new therapy, even if more convenient than operative peripheral iridectomy, must produce at least as satisfactory results if it is to be generally recommended.

We have previously reported that Nd:YAG laser iridotomy is a satisfactory alternative to operative peripheral iridectomy in the treatment of fellow eyes.⁶ However, measurement of outcome is more complex in AACG eyes.⁷⁻⁹ Patients present with AACG episodes of varying duration, and responses to initial medical treatment vary.⁵⁻⁹ Visual acuity outcome is particularly difficult to assess as visual acuity before the development of AACG is usually not known. Mild pre-existing cataract may be present in some patients, and worsened by ischaemia during the acute episode. Some eyes may be amblyopic. Visual acuity assessment following initial medical control may also be unreliable owing to persisting corneal oedema, ocular ischaemia, and miosis. Conclusions drawn from retrospective studies and uncontrolled studies must therefore be cautious.⁷⁻⁹ We have performed a randomised prospective comparison of bilateral Nd:YAG laser iridotomy and bilateral peripheral iridectomy in a

consecutive group of patients presenting with uniocular AACG. While the number of patients included in this study was small, the study design allows some useful comparisons of long term outcomes.

Complications arising at the time of or within 24 hours of laser or operative treatment were infrequent and of no long term significance. Post treatment intraocular pressure elevation spikes were infrequent, probably because all patients were already being treated with topical timolol and oral acetazolamide.

Acute angle closure glaucoma recurred in one eye treated with laser iridotomy despite the presence of a small, patent iridotomy. An operative iridectomy was then performed and the intraocular pressure remained normal subsequently. This complication has been described previously,¹⁰⁻¹² and is probably avoidable by creating an iridotomy of at least 200 μ m in diameter.¹³ A further four laser treated patients needed additional laser (three patients) or operative (one patient) treatment to obtain an iridotomy of adequate size. Three patients treated by operative iridectomy required further laser treatment in order to obtain iris patency. In each case the iris stroma was excised but the pigment layer was not excised. Iris oedema secondary to ischaemia may have led to separation of the iris layers. When a 'knob' of iris tissue is pulled out of the eye with forceps the iris layers may further separate, leading to excision of only the stromal layer. Playfair and Watson reported one case of non-patent operative iridectomy which required further surgery.⁵

We found that 70.4% of operative iridectomy patients and 71.8% of laser iridotomy patients had an intraocular pressure less than 21 mm Hg without medication 3 years after treatment. Playfair and Watson reported 72% of patients had an intraocular pressure less than 21 mm Hg without medication after 6-12 months of follow up.⁵ Buckley *et al* reported that 75% of operative iridectomy patients and 65% of laser iridotomy patients had an intraocular pressure less than 21 mm Hg without medication after a minimum follow up period of 1 year. A Chinese study found 82.4% of patients had a 'successful' outcome 3 years following Nd:YAG laser iridotomy for acute angle closure glaucoma.¹⁴

In our study four eyes treated with laser iridotomy had developed glaucomatous optic disc cupping and visual field loss 3 year after treatment, compared with one eye treated with operative iridectomy. This difference was not statistically significant. Playfair and Watson reported 16/81 (19.7%) of eyes undergoing operative iridectomy for AACG developed cupping within the first year of surgery.⁵

We found no significant difference in the mean visual acuity score of AACG eyes 3 years after operative iridectomy or laser iridotomy. The statistically non-significant reduction of mean visual acuity of the YAG PI group may have been related to the greater mean age of this group. While there was a trend towards worsening acuity with time in both groups, presumably because of age related lens

changes, there was no significant change in visual acuity after 3 years compared with either visual acuity following initial medical control or visual acuity 2 months following treatment. Buckley *et al*, in a retrospective study, found no significant difference in visual acuity outcome following operative iridectomy or laser iridotomy.⁸ In their study visual acuity in the fellow eye at presentation was used as an assumption of the visual acuity in the affected eye before the episode of AACG. This assumption may be flawed by factors such as amblyopia and asymmetry of cataract development. Floman *et al* reported two or more lines of visual acuity loss in 51% of eyes 1–3 years after operative iridectomy for AACG.¹⁵ However only final visual acuity was reported, and visual loss may have been pre-existing or due to AACG rather than caused by operative iridectomy.

The results of this study, and previous retrospective studies,^{8,9} suggest that Nd:YAG laser iridotomy is a satisfactory alternative to operative iridectomy in the treatment of AACG eyes. However, in view of the relatively small number of patients in our study, and the inherently unsatisfactory nature of retrospective studies of this disease,^{7–9} doubt must persist as to which treatment is optimal.¹⁶ A larger prospective study should help to resolve this issue.

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1 Frankhauser F, Roussel P, Steffen J, Van Der Zyphen E, Chrenkova A. Clinical studies on the efficiency of high

- power laser radiation upon some structures of the anterior segment of the eye. First experience of the treatment of some pathological conditions of the anterior segment of the human eye by means of a Q-switched laser system. *Int Ophthalmol* 1981;**3**:129–39.
- 2 Rivera AH, Brown RH, Anderson DR. Laser iridotomy vs surgical iridectomy—have the indications changed? *Arch Ophthalmol* 1985;**103**:1350–4.
- 3 Rich W. The economics of Nd:YAG laser treatment. *Dev Ophthalmol* 1987;**14**:93–6.
- 4 Spaeth GL. Laser treatment is invasive surgery (editorial). *Ophthalmic Surg* 1988;**19**:463–4.
- 5 Playfair TJ, Watson PG. Management of acute primary angle-closure glaucoma: a long term follow up of the results of peripheral iridectomy used as an initial procedure. *Br J Ophthalmol* 1979;**63**:17–22.
- 6 Fleck BW, Dhillon B, Khanna V, Fairley E, McGlynn C. A randomised, prospective comparison of Nd:YAG laser iridotomy and operative peripheral iridectomy in fellow eyes. *Eye* 1991;**5**:315–21.
- 7 Saunders DC. Acute closed-angle glaucoma and Nd:YAG laser iridotomy. *Br J Ophthalmol* 1990;**74**:523–5.
- 8 Buckley SA, Reeves B, Burdon M, Moorman C, Wheatcroft S, Edelsten C, Benjamin L. Acute angle closure glaucoma: relative failure of YAG iridotomy in affected eyes and factors influencing outcome. *Br J Ophthalmol* 1994;**78**:529–33.
- 9 Fleck BW, Fairley EA, McGlynn C. A prospective comparison of Nd:YAG laser iridotomy and surgical peripheral iridectomy in the treatment of acute closed-angle glaucoma. In: Khoo CY, Ang BC, Cheah WM, Chew PTK, Lim ASM, eds. *New frontiers in ophthalmology*. Amsterdam: Excerpta Medica, 1991:852–8.
- 10 Wishart PK, Hitchings RA. Nd:YAG and dye laser iridotomy—a comparative study. *Trans Ophthalmol Soc UK* 1986;**105**:521–40.
- 11 Gray RH, Hoare Nairn J, Ayliffe WHR. Efficacy of Nd:YAG laser iridotomies in acute angle closure glaucoma. *Br J Ophthalmol* 1989;**73**:182–5.
- 12 Brazier DJ. Neodymium:YAG laser iridotomy. *J Roy Soc Med* 1989;**79**:658–60.
- 13 Fleck BW. How large must an iridotomy be? *Br J Ophthalmol* 1990;**74**:583–8.
- 14 Jiang YQ. The long term effect of Nd:YAG laser iridotomy. *Chinese J Ophthalmol* 1991;**27**:221–4 (English abstract).
- 15 Floman N, Berson D, Landau L. Peripheral iridectomy in closed angle glaucoma—late complications. *Br J Ophthalmol* 1977;**61**:101–4.
- 16 Salmon JF. Acute angle closure glaucoma: relative failure of YAG iridotomy (letter). *Br J Ophthalmol* 1995;**79**:100.