A photometric study of the effect of pupil dilatation on Nd:YAG laser iridotomy area

B W Fleck, E Fairley, E Wright

Abstract

A photometric study of the effect of pupil dilatation on Nd:YAG laser iridotomy area was performed in 21 eyes of 21 patients. The iridotomy area was 0.075 (0.055) mm² (mean (SD)) before pupil dilatation and 0.073 (0.070) mm² after pupil dilatation (*t* test NS). Iridotomy area after pupil dilatation correlated with iridotomy area before pupil dilatation ($r=0.815$, $p<0.01$) but did not significantly correlate with measures of iridotomy shape or position, or with changed iris area following pupil dilatation. Two iridotomies became reduced to less than 20% of their initial area following pupil dilatation. Our findings suggest that the only effective method of avoiding development of unacceptably small iridotomy area after pupil dilatation is to create a sufficiently large iridotomy at the time of initial laser surgery.

(*Br J Ophthalmol* 1992; 76: 678-680)

Acute angle closure glaucoma may develop in the presence of a small but patent argon^{1,2} or Nd:YAG^{3,4} laser iridotomy. While acute angle closure glaucoma following operative peripheral iridectomy has generally been attributed to plateau iris syndrome,⁵⁻⁷ not all cases of acute angle closure glaucoma following a small laser iridotomy can be placed in this category.^{1,3,4,8}

The mechanism of failure of very small iridotomies may be related to obstruction of aqueous flow at very small iridotomy size.⁹ Below a critical surface area significant iris bombé may occur at normal aqueous flow rates. When iris bombé is sufficient to cause irido-corneal contact throughout a critical extent of the angle, acute angle closure glaucoma results.^{10,11} The minimum 'safe' size of iridotomy has not been defined, but an approximate value may be calculated using a simple mathematical model.⁹

One factor which might contribute to the area of an iridotomy falling below a critical level is the change in iridotomy configuration which occurs on pupil dilatation. We have performed a photometric study of the effect of pupil dilatation on iridotomy area in 21 eyes of 21 patients.

Materials and methods

Eyes studied had been treated by Nd:YAG laser iridotomy for chronic angle closure glaucoma or were fellow eyes. Eyes with a previous episode of acute angle closure glaucoma were excluded. A Zeiss 'Visulas' Nd:YAG laser and Zeiss anterior segment YAG contact lens were used to perform all iridotomies. The treatment site was in the superior iris, between 10 and 2 o'clock, approximately two thirds distance from the pupil margin

to the base of the iris. A single 5-10 mJ pulse was delivered to the treatment site. If this pulse did not penetrate the iris, further single pulses were delivered to the same site until penetration was achieved.

A photometric technique was devised to analyse changes in iridotomy area following pupil dilatation. Only one eye from each patient was studied. When both eyes were suitable for study only the right eye was used. Informed patient consent was obtained prior to enrolment. The horizontal corneal diameter was measured using a Haig Streit slit-lamp measuring eyepiece, which incorporates a graticule with 0.1 mm divisions. The cornea and iris were then photographed using a Zeiss anterior segment camera. Photographs were taken at both the 0.65 and 1.8 magnification settings.

The pupil was dilated using one drop of tropicamide 1% and the eye was again photographed, using identical camera settings.

Colour transparency photographs were prepared, and projected onto a white screen. The projected horizontal corneal diameter of 0.65 magnification photographs was measured in millimetres, and compared with the measurement obtained using the slit-lamp measuring eyepiece. A magnification factor for the projected image was derived from these measurements for each patient. The magnification factor was approximately $\times 80$ in every case.

The following measurements were made using a millimetre scale set on the projected image, and converted to unmagnified values using the magnification factor:

- horizontal pupil diameter, pupil undilated
- horizontal pupil diameter, pupil dilated
- distance from limbus to nearest point of iridotomy, pupil undilated
- distance from limbus to nearest point of iridotomy, pupil dilated.

Photographs at $\times 1.8$ magnification setting were used to study the iridotomy site. The magnification factor used for these measurements was greater by a factor of $\times 2.77$ ($1.8/0.65$). A millimetre scale was used to measure:

- iridotomy diameter in the longest and shortest axis, pupil undilated
- iridotomy diameter in the longest and shortest axis, pupil dilated.

The area of full thickness iridotomy before and after pupil dilatation was measured by placing millimetre graph paper on the white screen and counting the number of squares covered by the image of the iridotomy.

Linear regression analysis was used to detect significant correlations between changes in iridotomy area on dilating the pupil and a variety of parameters which might potentially influence this.

Princess Alexandra Eye
Pavilion, Chalmers
Street, Edinburgh EH3
9HA

B W Fleck
E Fairley
E Wright

Correspondence to:
Dr B W Fleck.

Accepted for publication
7 July 1992

Fig 1A

Fig 1B

Figure 1 (A) Reduction of iridotomy area following pupil dilatation. Pupil undilated. Area of full thickness iris patency indicated by arrow. Iridotomy area 0.027 mm^2 . (B) Reduction of iridotomy area following pupil dilatation. Pupil dilated. Area of full thickness iris patency indicated by arrow. Iridotomy area 0.003 mm^2 .

Figure 2 (A) Effect of pupil dilatation on iridotomy shape. Pupil undilated. Elliptical iridotomy, area 0.151 mm^2 . (B) Effect of pupil dilatation on iridotomy shape. Pupil dilated. Circular iridotomy, area 0.227 mm^2 .

Fig 2A

Fig 2B

Results

Photographs of 21 eyes of 21 patients were analysed. The mean patient age was $67.0 (11.5)$ years; 14 patients were female, seven were male.

The mean iridotomy area prior to pupil dilatation was $0.075 (0.055) \text{ mm}^2$. The mean iridotomy area following pupil dilatation was $0.073 (0.070) \text{ mm}^2$ (Student's t test not significant). The area of nine iridotomies became larger when the pupil was dilated, 11 became smaller

and one remained unchanged. The mean percentage change in iridotomy area was $96.7 (63.6\%)$ (range 11–233%). Iridotomy area following pupil dilatation correlated with iridotomy area prior to pupil dilatation ($r=0.815$, $p<0.01$), but did not significantly correlate with any other measured factor.

In two eyes the iridotomy area was reduced to less than 20% of its initial area (Fig 1). These eyes had a small initial iridotomy area (0.027 and

0.031 mm²), but no other factor was identified which might have predicted reduction of iridotomy area on pupil dilatation.

The cornea and iris approximated to a circle in every case, and diameter was used to calculate area. The area of the iris before and after pupil dilatation could be obtained from the difference between the area of the cornea and the area of the pupil. The mean iris area following pupil dilatation was 75.8 (11.1)% of that prior to pupil dilatation. Change in iris area did not correlate with change in iridotomy area on dilating the pupil.

With the pupil undilated every iridotomy was elliptical, with the long axis radial to the limbus. On dilating the pupil the iridotomy shape changed. Twelve iridotomies became elliptical with the long axis circumferential to the limbus, three iridotomies became circular, and six remained elliptical with the long axis radial to the limbus. The radial diameter/circumferential ratio was termed the 'ellipse ratio'. The mean iridotomy ellipse ratio prior to pupil dilatation was 3.0 (2.3), and the mean iridotomy ellipse ratio following pupil dilatation was 1.14 (0.82). An ellipse ratio of 1.0 would describe a circle.

Change from an elliptical shape to a more circular shape might be expected to increase area, as in Figure 2. However there was no significant correlation between the change in iridotomy area on pupil dilatation and the ellipse ratio of the iridotomy prior to pupil dilatation, the ellipse ratio of the iridotomy after pupil dilatation, or the change in ellipse ratio on pupil dilatation.

The mean distance of the nearest point of the iridotomy to the limbus prior to dilating the pupil was 1.08 (0.43) mm. The mean distance of the nearest point of the iridotomy to the limbus after dilating the pupil was 0.60 (0.43) mm. There was no significant correlation between the change in iridotomy area on pupil dilatation and the distance of the nearest point of the iridotomy to the limbus before or after dilating the pupil.

Discussion

Several factors may contribute to the reduction in area of an iridotomy of theoretically 'safe' area below that needed to prevent acute angle closure glaucoma. Most cases of acute angle closure glaucoma following Nd:YAG laser iridotomy have occurred within 1 month of treatment. Naveh has observed rapid diminution of Nd:YAG laser iridotomy area within 1 hour of treatment in six eyes.¹² In each case a return to the original area occurred within 2 weeks. Localised iris oedema around the treatment site may have been responsible.

Re-closure of Nd-YAG laser iridotomies owing to iris pigment epithelium proliferation is unusual, and tends to occur 1–4 months following treatment.^{3,4,12–14} Re-closure resulted in acute angle closure glaucoma in two eyes reported by Wishart,¹³ and one eye reported by Gray.³

Provocation tests have not been helpful in identifying eyes at risk, as eyes which developed acute angle closure glaucoma following Nd:YAG laser iridotomy did so before a provocation test had been performed.^{3,13}

Our findings indicate that iridotomies may become reduced to less than 20% of their initial area following pupil dilatation. Changes in iridotomy area following pupil dilatation are unpredictable, and the only factor we could identify which correlated with iridotomy area following dilatation was iridotomy area prior to dilatation. It would appear that the only effective method to preventing unacceptably small iridotomy area following pupil dilatation is to create a sufficiently large iridotomy at the time of initial laser surgery. We have previously postulated that an iridotomy should be at least 200 µm in diameter (0.031 mm² area if circular) in order reliably to prevent the development of angle closure glaucoma,⁹ and we continue to suggest that this figure is used as a guideline for treatment.

This study was supported by a grant from the WH Ross Foundation.

- Mandelkorn RM, Mendelsohn AD, Olander KW, Zimmerman TJ. Short exposure times in argon laser iridotomy. *Ophthalmic Surg* 1981; 12: 805–9.
- Brainard JO, Landers JH, Shock JP. Recurrent angle closure glaucoma following a patent 75-micron laser iridotomy: a case report. *Ophthalmic Surg* 1982; 13: 1030–2.
- 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.
- Brazier DJ. Neodymium-YAG laser iridotomy. *J Roy Soc Med* 1989; 79: 658–60.
- Douglas WHG, Strachan IM. Surgical safety of prophylactic peripheral iridectomy. *Br J Ophthalmol* 1967; 51: 459–62.
- Lowe RF. Primary angle-closure glaucoma: postoperative acute glaucoma after phenylephrine eyedrops. *Am J Ophthalmol* 1968; 65: 552–4.
- Wand M, Grant WM, Simmons RJ, Hutchinson BT. Plateau iris syndrome. *Trans Am Acad Ophthalmol Otolaryngol* 1977; 83: 122–30.
- Yamanoto T, Shirato S, Kitazawa Y. Argon laser iridotomy in angle-closure glaucoma: a comparison of two methods. *Jpn J Ophthalmol* 1982; 26: 387–96.
- Fleck BW. How large must an iridotomy be? *Br J Ophthalmol* 1990; 74: 583–8.
- Phillips CI. Closed angle glaucoma: significance of sectoral variations in angle depth. *Br J Ophthalmol* 1956; 40: 136–43.
- Phillips CI. Sectoral distribution of goniosynechiae. *Br J Ophthalmol* 1956; 40: 129–35.
- Naveh N, Zborowsky-Gutman L, Blumenthal M. Neodymium-YAG laser iridotomy in angle closure glaucoma: preliminary study. *Br J Ophthalmol* 1987; 71: 257–61.
- Wishart PK, Hitchings RA. Neodymium YAG and dye laser iridotomy – a comparative study. *Trans Ophthalmol Soc UK* 1986; 105: 521–40.
- McAllister JA, Schwartz LW, Moster M, Spaeth GL. Laser peripheral iridectomy comparing Q-switched neodymium YAG with argon. *Trans Ophthalmol Soc UK* 1985; 104: 67–9.