

## Argon laser iridotomy

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**SUMMARY** Argon laser iridotomy was successfully performed on 47 out of 52 eyes of 35 patients by the continuous wave argon laser. The technique of argon laser iridotomy is described in detail. A number of complications were observed. The reasons for these are discussed, and measures for the avoidance of complications are suggested.

Argon laser iridotomy was first reported in 1973 by Khuri<sup>1</sup> working with rabbits, and later Abraham and Miller reported success with this technique in humans.<sup>2</sup> Since then several series<sup>3-10</sup> in which various techniques were used have been published. The reports have differed on such factors as burn duration, spot size, number of burns, use of contact lens, use of steroids, and site of treatment.

Iridotomy using the dye<sup>11</sup> and neodymium YAG (yttrium, aluminium, garnet) laser<sup>12</sup> are widely reported as being effective techniques. However, the argon laser is much more generally available, and the additional expense of the Abraham lens is small. The argon laser iridotomy shares with the other two methods the advantage that it may be performed as an outpatient procedure with consequent sparing of hospital beds and attendant social disruption.

We report a critical examination of argon laser iridotomy as performed on a group of patients who would otherwise have required a surgical peripheral iridectomy, presenting at Greenwich District Hospital and St Thomas's Hospital. A technique was devised which combined the most advantageous features of previous series, drawing most particularly on the work of Pollack.<sup>3</sup>

The indications for surgical iridotomy were: acute angle closure, fellow eye of acute angle closure,

chronic angle closure, chronic simple glaucoma with narrow angle, and pupil block glaucoma (Table 1). Patients excluded from the study were those whose intraocular pressure could not be brought under control by medical means, who therefore underwent emergency surgery.

### Material and methods

Fifty-two eyes of 35 patients were recruited for the study. Seven were male and 28 were female. Their ages ranged from 35 to 91 with a mean age of 71 years.

A coherent radiation 900 continuous wave argon laser was used. All iridotomies were performed by one operator (R.A.H.). If the patient was not already receiving miotics, one drop of pilocarpine 1% was administered to the eye to be treated one hour prior to operation to produce miosis. A single drop of oxybuprocaine was used to anaesthetise the cornea prior to the fitting of an Abraham lens,<sup>2</sup> methylcellulose being used as a lubricant. This lens is a modification of the Goldmann fundus lens. A flat glass plate is attached to its anterior surface into which an 8 mm hole has been trephined and a 66 dioptre plano convex lens inserted. The principal advantage of this lens is that it produces a convergent beam which, when focused on the iris, increases the power intensity fourfold and correspondingly diminishes the relative power intensity at the cornea and the retina. The use of a contact lens also assists in fixing the eye, keeps the lids open, and acts as a heat sink for the cornea.

The site for the iridotomy was chosen at either 10 o'clock or 2 o'clock, at the base of a crypt at the junction of the inner two-thirds with the outer third of the iris. All patients were treated in either the superonasal or superotemporal iris, with the gaze directed so as to displace the macula from the firing line. In order further to minimise the risk to the

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Table 1 *Indications for iridotomy*

Diagnosis	Number
Acute angle closure glaucoma	16
Fellow eye of acute angle closure glaucoma	19
Chronic angle closure glaucoma	6
Chronic simple glaucoma with narrow angle	9
Pupil block glaucoma	2

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macula 18 out of the last 20 iridotomies were performed in the superonasal quadrant, with the treated eye in adduction, and no difficulty was encountered. The authors consider that this is the safest site for laser iridotomy. Stretch burns were applied at a distance of one or two clock hours from the proposed iridotomy site.

These burns were of 0.2 second duration with a 500  $\mu$ m spot size and power of 500 milliwatts. Pilocarpine induced miosis brings about radial tension and the stretch burns produce stromal contraction and circumferential tension, so the stroma at the iridotomy site becomes thin and tense.

Laser burns were then applied to the stretched area of 0.2 second duration, 50  $\mu$ m spot size and power of 1000 milliwatts in the first instance. The power was adjusted according to the response of the iris stroma. In general, blue irides required a higher power than brown irides. Accurate focusing of the laser beam was essential for maximum effect. The spot size was not varied. In some patients with dark brown irides the burn duration was reduced to 0.02 second, as this brought about less stromal charring and more effective penetration. The beam was directed at the centre of the crypt until the stroma was penetrated. This was heralded by the appearance of a plume of pigment-laden aqueous, which ascended to the top of the anterior chamber, and confirmed by a clear view of the anterior lens capsule. Further burns were applied to the stroma until a hole of 0.2 mm in diameter was formed through which the anterior capsule could be clearly seen. Transillumination of the iris is an unreliable guide to the patency of the iridotomy, since stromal fibres sufficient to stop the passage of aqueous may persist after all the pigment has been dispersed.

Care was taken not to direct the beam at the lens capsule for fear of burning the lens or the underlying retina. A few patients, particularly those with blue irides, experienced some pain with the first few iris burns, but this was not severe and did not prevent the completion of the procedure. Postoperatively all patients continued their previous medications and in addition prednisolone eyedrops 0.3% were prescribed 2-hourly for 24 hours and four times a day for the next two weeks.

Patients were reviewed in outpatients one day, one week, one month, and three months postoperatively. The acuity was measured, tonometry performed, the iridotomy was examined for size and patency and the cornea, the lens and anterior drainage angle were examined, and the anterior chamber depth measured with the Haag-Striet anterior chamber depth gauge. In addition, at three months the fundus was examined ophthalmoscopically and a provocative test was performed to assess the efficacy of the iridotomy in

pharmacologically induced block. This test was a modification of the method used by Mapstone<sup>13</sup>: one drop of pilocarpine 2% was instilled followed by one drop of phenylephrine 10% in an attempt to induce angle closure secondary to pupil block; one hour later the intraocular pressure was measured.

### Results (Table 2)

A patent iridotomy was achieved in 47 eyes. Four eyes did not receive a sufficient number of laser burns to create a patent iridotomy; this was due to the inability of these patients to remain still at the slit-lamp. Two eyes were those of a 72-year old man who was aphasic and hemiplegic, the second patient was a deaf-mute, and the third a very anxious 81-year-old woman. Of the remaining 47 eyes in which a successful iridotomy was achieved three did not become patent until one month after treatment, and three more took one week before they were patent. Two of these eyes were dark brown and four were blue. A second attempt to create a laser iridotomy at the same site was not made, because absence of pigment at the treatment site in the blue irides and charred pigment at the treatment site in the dark irides would have made further laser ineffective. Furthermore, because laser iridotomies observed over several weeks showed progressive enlargement there were grounds to expect that the closed iridotomies would open up. In a further three eyes the amount of pigment at the treatment site after one session of treatment was sufficient to justify a second session two days later, and in these cases a patent iridotomy was easily achieved.

Closure occurred in two patients. In the first case the iridotomy was only 0.05 mm in diameter and became blocked by pigment from the posterior chamber. The iridotomy was easily opened and enlarged by a second session of laser treatment. The second patient had marked anterior chamber flare

Table 2 Results

Number of eyes	52
Total successful	47
Technical failures	4
Iridotomy patent immediately	38
Iridotomy patent after 1 week	3
Iridotomy patent after 1 month	3
Iridotomy requiring 2 treatment sessions	3
Closure: early; re-opened	1
late due to chronic iritis	1
<i>Iris colour</i>	<i>Mean energy used (joules)</i>
Blue	37.0
Hazel	31.8
Light brown	28.4
Dark brown	24.0

and cells at the time of treatment. The anterior chamber activity did not subside until three weeks later, by which time the patent iridotomy had become closed. No attempt was made to reopen it with the laser.

Comparisons were made between the anterior chamber depth and gonioscopic appearance pre-operatively and at three months. Deepening of the anterior chamber based on the comparison of the means of three readings made with the Haag-Streit pachymeter was observed in 24 eyes. In 10 eyes the anterior chamber became shallower and in four eyes it remained unchanged. On gonioscopy the angle became more open in 16 eyes, more closed in eight eyes, and remained the same in 20 eyes. Many patients stopped pilocarpine treatment over this time and others had their dosage changed, and so in some instances the deepening of the anterior chamber may be attributable to the reduction or cessation of pilocarpine treatment. Forty-five patients were examined ophthalmoscopically after three months and no retinal burns were seen.

Forty-one patients underwent a provocative test to induce pupil block and angle closure but none developed raised intraocular pressure.

Thirteen patients complained of pain or headache within 24 hours of operation (Table 3). In each case the pain resolved and required no stronger analgesia than aspirin.

Eight eyes lost one line of visual acuity and four eyes lost two lines. The remainder either improved or stayed the same. Where two lines of acuity were lost, this was due to enlargement of a malignant melanoma in one case, further progression of already severe nuclear sclerosis in a second case, and in two cases the acuity obtained was at all times unreliable because of the patient's inability to cooperate.

Ten eyes had small endothelial opacities at the end of the procedure. In four eyes opacities were still visible after one week but all had disappeared by one month.

Lens burns were present in 21 eyes. They were small anterior subcapsular lens opacities lying immediately posterior to the iridotomy. They were usually 0.05 mm in diameter, the largest being 0.15 mm in diameter. They did not impair vision and were not seen to enlarge during the three months of follow-up.

All eyes had some flare and pigment debris immediately after treatment. Twenty-two eyes had some anterior chamber activity after one week, but after one month occasional cells in the anterior chamber were seen in only six eyes. However, persistent anterior chamber activity and posterior synechiae were seen in one case where there was a prolonged anterior uveitis which had been present

Table 3 *Complications*

Pain or headache within 24 hours	13
Pigment in the angle	42
Lens opacity	21
Intraocular pressure rise within 24 hours	5
Loss of visual acuity of 2 lines or more	4
Corneal burn lasting more than one week	4
Monocular diplopia	2
Posterior synechiae	1
<i>Eye iris colour</i>	<i>Percentage developing lens opacities</i>
Blue	29%
Hazel	29%
Light brown	53%
Dark brown	75%

prior to treatment. Not all patients' pupils were dilated at the end of the study, and so the true incidence of posterior synechiae is not known.

In five cases a preoperative intraocular pressure of less than 22 mmHg rose to greater than 25 mmHg 24 hours later. In only one case did the pressure rise above 30 mmHg.

Pigment in the trabecular meshwork was seen inferiorly between 5 and 7 o'clock in 42 eyes.

Two patients developed intermittent monocular diplopia. In both instances the iridotomy was large (smallest diameter 0.5 mm and 1.0 mm), and the diplopia was not troublesome.

## Discussion

Laser iridotomies were successfully produced in 47 out of 48 eyes that underwent the complete procedure. In 38 out of 52 eyes a patent iridotomy was immediately produced. The overall success rate of 90% is lower than most other series,<sup>3-6</sup> but careful patient selection could have improved this. The number of patients successfully treated in one session is the same as one series<sup>8</sup> but greater than most.<sup>3,5,6</sup>

No difficulty was found in penetrating the iris, nor was there the high incidence of closure described in other papers,<sup>3,5,8</sup> and relatively few patients had more than one treatment session. Clearly those patients who did not develop a patent iridotomy until some days or weeks after operation were at risk of angle closure. However, only one of these patients had had a previous attack of angle closure and she was observed as an inpatient until the iridotomy became patent.

In the majority of cases the iridotomy enlarged over the period of follow-up. This is contrary to the experience of some authors, who report a high incidence of closure which occurred during the first six weeks after operation.<sup>3,5,8</sup> We consider that our low incidence of closure may be attributable to the

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maintenance of steroid treatment for two weeks or more, thereby diminishing anterior chamber activity and pigment epithelial proliferation. The authors reporting a high incidence of closure used steroids for three days only,<sup>3</sup> probably for only 36 hours,<sup>8</sup> and not at all.<sup>5</sup>

Contrary to the findings of several authors<sup>2,3,9</sup> we found, like Yassur *et al.*,<sup>6</sup> that the laser energy required to produce an iridotomy was greatest in patients with blue eyes (see Table 2). Had we not treated the dark brown irides of Negro or Asian patients with short duration burns of 0.02 second we would probably have found, like Quigley,<sup>7</sup> that the blue and dark brown irides required the greatest amount of treatment. The difficulty encountered in penetrating blue irides arose because the pigment epithelium and the stromal pigment were dispersed by the first few laser burns, and unless penetration was achieved before depigmentation of the stroma considerable energy was required to penetrate the translucent stroma, which absorbed laser energy very poorly.

The incidence of lens opacities in our series was high. Lens opacities are probably caused by heat conducted to the anterior capsule from adjacent pigment epithelium rather than from direct laser burns to the lens capsule.<sup>14,15</sup> This suggestion is supported by our finding that the incidence of lens opacities was higher in the dark coloured eyes (Table 3), where the pigment epithelium is densest, and lower in the light coloured eyes, where there is less pigment epithelium, and the risk of direct laser burns of the anterior capsule is actually greater. Lens opacities have been found not to enlarge<sup>6,10,16</sup> even after follow-up for as long as eight years.<sup>17</sup> Others have found an incidence of between 0%<sup>4,5</sup> and 54%.<sup>4</sup> It was striking that those series with the fewest lens opacities used short duration burns of 0.02 second and power of 1000 to 1500 mW. Yamanoto *et al.* compared short duration burns with long duration burns and found an incidence of lens opacities of 54% where long duration burns were used and of 3% where a burn duration of 0.02 second was used.<sup>4</sup>

In five of our cases a preoperative intraocular pressure of less than 22 mmHg rose to greater than 25 mmHg in the first 24 hours. Yamanoto *et al.*<sup>4</sup> found the same rise in intraocular pressure in 42% of their patients. This rise was maximal after the first hour, with a mean increase of 12 mmHg, and then steadily declined. It is probable that some of our patients had unrecorded elevations of intraocular pressure. In the series of Yamanoto *et al.* the administration of either timolol drops 0.5% or indomethacin drops 0.5% or retrobulbar lignocaine had no influence on the rise in intraocular pressure. We suggest that acetazolamide 250 mg four times daily should be administered for

the first 24 hours after operation, the first dose being given with the preoperative miotics.

Pigment on the trabecular meshwork was seen inferiorly between 5 and 7 o'clock in 42 eyes. In one study tonography was performed after laser iridotomy<sup>9</sup> and showed decreased outflow facility in 89% of eyes. However, there was no measurement preoperatively and the findings might very well be attributed to pre-existing trabecular damage. At present it is not possible to say whether pigment deposition damages the trabecular meshwork or affects the outflow facility after argon laser iridotomy.

Others have reported cystoid macular oedema,<sup>18</sup> snuffing of the central field,<sup>19</sup> hyphaema, and retinal burn.<sup>16</sup> We did not observe any of these complications.

We have found that iris penetration can be achieved without excessive difficulty, and consider that this is a practical and safe alternative to other methods of making an iridectomy or iridotomy.

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