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Therapeutic limitations of argon laser trabeculoplasty*

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SUMMARY Sixty-one patients (82 eyes) were studied after argon laser trabeculoplasty (ALT) to determine the lasting efficacy of such treatment. This investigation, now in its fourth year, was prospective, and the information derived was analysed with the aid of a computer. Success was defined as intraocular pressure (IOP) below baseline (22 mmHg). The mean follow-up time was 24·5 months, when the success rate was 74% compared with 75% at three months. Success declined to 45% at 42 months. No significant difference was noted when (*a*) first lasered eyes of all patients and those fellow eyes treated were analysed separately, (*b*) when right and left eyes were analysed separately, nor (*c*) when patients were divided into two treatment groups, (I) 100 burns at 1 W, and (II) 65 burns at 850 mW. Eight of 11 eyes showed progressive postlaser field loss despite below-baseline intraocular pressures. ALT is an alternative to carbonic anhydrase inhibitor therapy, with a success rate of 66·7% at two years. However, repeat ALT was successful in only 25% of patients seven months after treatment.

Although argon laser trabeculoplasty (ALT) has proved to be effective for the treatment of many patients with open angle glaucoma, a difference of opinion exists on its lasting benefits. Some reports[1,2] claim continued success, while others[3–5]† have indicated a loss of effect. We published an article in 1984[6] that indicated success with laser trabeculoplasty, though an intraocular pressure (IOP) rise was noted at the end of the follow-up period. This encouraged us to continue following patients up beyond two years and add new patients. The object of this ongoing investigation was to determine: (*a*) whether a longer follow-up might demonstrate further loss of effect, (*b*) whether analysis of the data would allow us to predict the likelihood of success based on type of patient or treatment method, and (*c*) whether ALT continues to be an effective alternative to carbonic anhydrase inhibitor (CAI) therapy.[7]

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Material and methods

All patients entered into the study had primary open angle glaucoma. Patients who did not have chronic open angle glaucoma—that is, secondary glaucoma, combined mechanism glaucoma, pseudoexfoliation, etc.—were excluded. Patients were sequentially entered into this study from a private practice setting. We began following up our first patients 42 months ago, with most patients entered at 26–30 months. All the patients were treated by one ophthalmologist (AIF). Preoperative intraocular pressure was defined as the average IOP immediately prior to laser treatment, and after the withdrawal of CAI with patients in that subgroup. The postlaser IOP was measured and slit-lamp examination performed the day after treatment and repeated weekly for one month, biweekly for a second month, and then monthly.

Continuous wave argon lasers (Coherent Radiation Model 800 and Synemed Ophthalas) were used. The method of treatment adopted for patients was similar to that described by Wise and Witter.[8] Patients were divided into two groups. Treatment group I (25 patients) received 100 50 μm burns, with a power that varied between 1·0 and 1·3 W, that were applied for 0·10 second and directed at the mid-

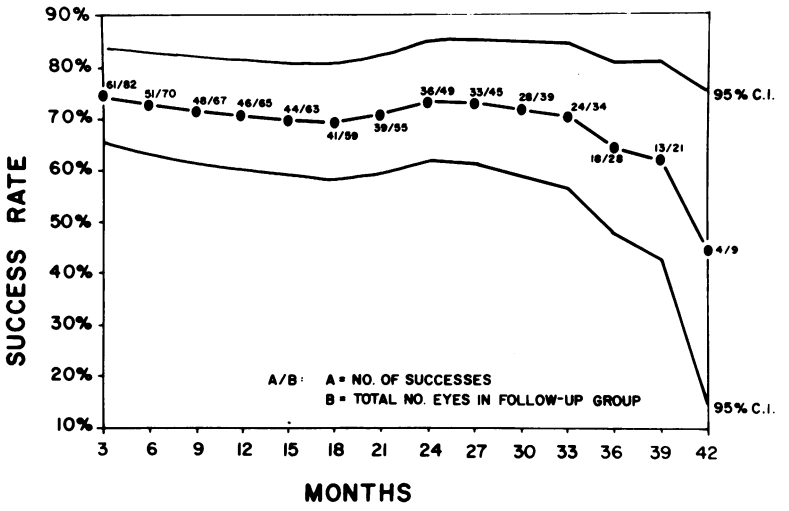

Fig. 1a *Success rate.*

trabecular meshwork. Treatment group II (36 patients) received 65 burns of 800–900 mW at the anterior-to-mid trabeculum.[9,10] All patients continued their prelaser regular medications with the exception of those patients on CAI drugs. We tried to determine whether ALT might be used as an alternative to CAI therapy on 18 patients (27 eyes) who were somewhat intolerant to CAI drugs.[7] All patients were given gentamicin and fluorometholone (FML) drops to be used four times a day in the treated eye. These two medications were discontinued after the first week. The cases were considered successfully treated if they met all of the following criteria: (1) IOP lower than baseline (22 mmHg), (2) no increase in disc cupping, (3) no increase in field loss. The data were analysed with a microcomputer. The mean, standard deviation, standard error of the mean, and analysis of significant (two-tailed *t* test for independent samples) were computed on a microcomputer statistical program. The data were expressed as the mean IOP plus or minus the standard error of the mean (95% CI). The data, including failures, were anlysed up to the point of failure and then with the failures excluded. We also analysed our data excluding failures completely. The data were then compared in three ways: (1) the response of first lasered eyes of all patients (series I) with those fellow eyes treated (series II), (2) the response of right and left eyes

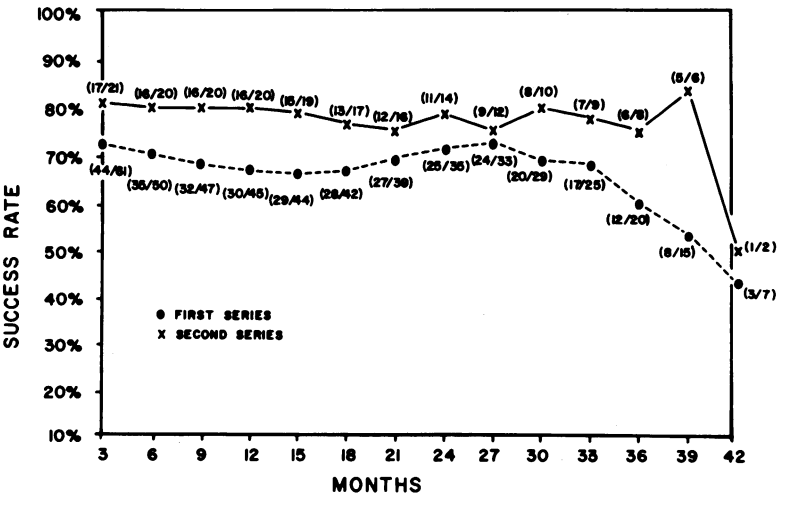

Fig. 1b *Success rate. Data for the first and second series.*

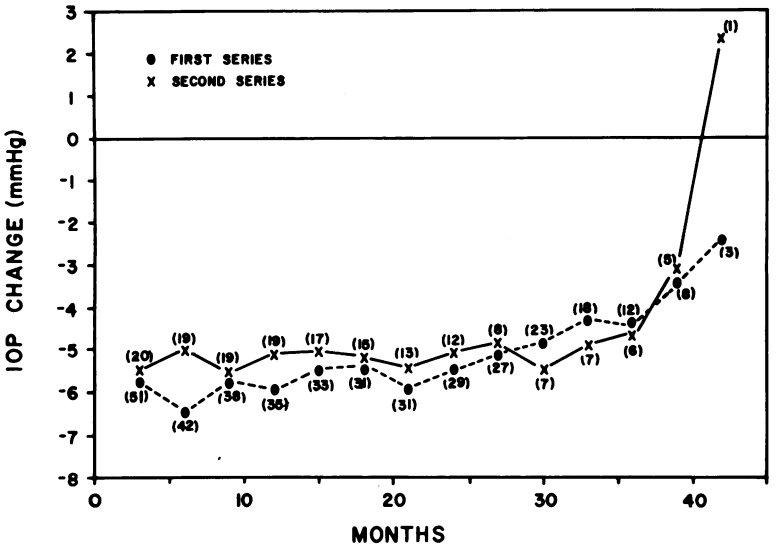

Fig. 2a *Mean drop in IOP with time. Data for first and second series analysed separately (failures included).*

analysed separately, and (3) the response of patients who had been divided into two treatment groups, group I (heavy) versus group II (light). Baseline IOP was defined as 22 mmHg on preoperative medical therapy. Postlaser IOP was the mean IOP on preoperative medications except in those patients in whom we eliminated CAI drugs. Visual fields were checked with a Goldmann perimeter and optic discs photographed every six months.

Results

Eighty-two eyes (41 right and 41 left, from 61 patients) were treated. Fifty-four patients (71 eyes) were white and seven patients (11 eyes) were black. Their mean age was 70·0 years, standard deviation 11·4 years. The mean preoperative IOP was 27·1 mmHg (SD 3·4) for all eyes, while preoperative IOPs for the first and second series were 27·4 mmHg (SD 3·7) and 26·1 mmHg (SD 2·1) respectively. The mean follow-up time was 24·7 months (22·6 for the first series of eyes, 25·7 for the second series), at which time the success rate was 74% for both eyes (71·4% for the first series, 78·6% for the second series). When we plotted success rate over time (Figs. 1a, b), success dropped from 75% for both eyes (71·4% first series, 78·6% second series) at three months to 45% for both eyes (42·9% first series, 50% second series)

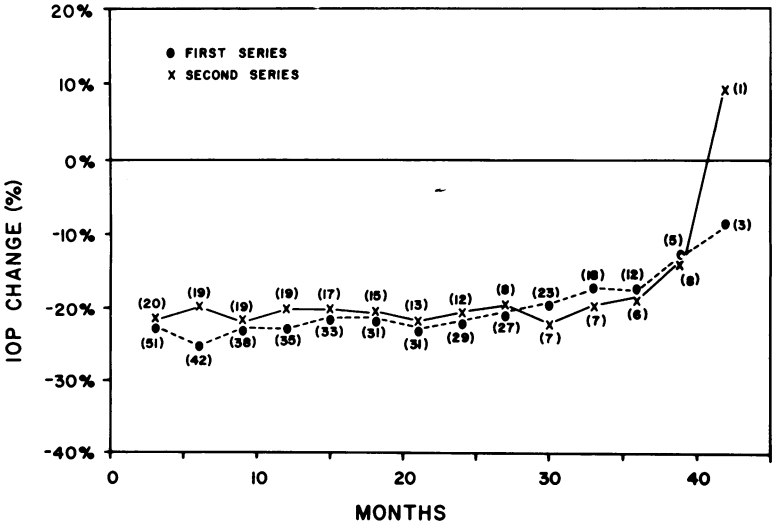

Fig. 2b *Percentage drop in IOP with time. Data for first and second series analysed separately (failures included).*

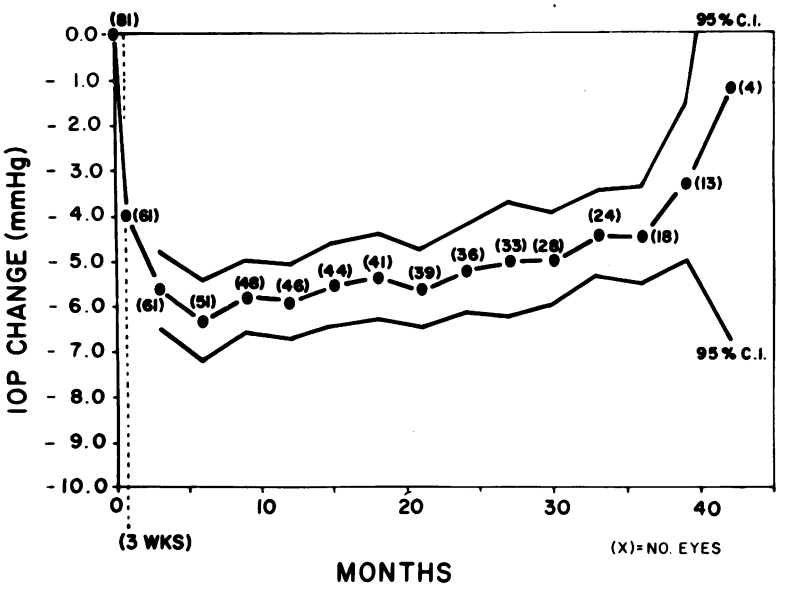

Fig. 3 *Mean drop in IOP with time (failures excluded).*

at 42 months (four successes/nine eyes, two lost to follow-up). The maximum IOP reduction for both series was obtained between six and nine months (Figs. 2a, b). The maximum reduction of each series (−6·4 mmHg first series, −5·5 mmHg second series) attained at this time slowly but steadily decayed until 36 months, when a sharp rise in IOP occurred (Figs. 2a, b). When the data were analysed with the failures omitted, nearly identical curves were obtained (Fig. 3). Eighteen patients (27 eyes) were on CAI drugs before laser therapy. At 24 months 12 of these patients (18 eyes) were able to continue without CAI medication, indicating a success rate of 66·7%±17·8% (95% CI) (Table 1). The patients were divided into two treatment groups. Group II (light treatment) did not show a significantly different response to ALT from group I initially (Fig. 4). However, at 36 months group I maintained significantly lower IOP. Nevertheless, by 39 months the group II patients' IOP reduction decayed to match that of group I.

We measured the IOP 24 hours after ALT, and 6·6% of patients had an IOP rise of 2–10 mmHg (mean 5·5 mmHg) which became normal within three

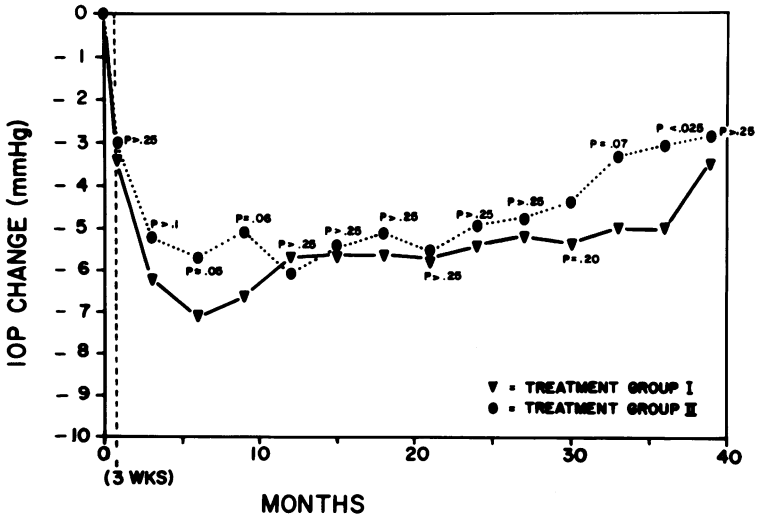

Fig. 4 *Comparison of two treatment groups.*

Table 1 *Response of patients to withdrawal of carbonic anhydrase inhibitor drugs and repeat ALT*

	Number of patients	*Number of eyes*	*Average IOP change (mm)*	*Success rate*	*Average follow-up (months)*
CAI	18	27	−7·2	66·7%	25·6
*Repeat ALT	12	13	−1·1	25·0%	7·0

*Average IOP rise between lasers: 6 mmHg.

Table 2 *Intraocular pressure change by category*

	Treatment group		*Age*		*Blacks*	*Diabetics*
	I	*II*	*≤65*	*>65*		
Max. IOP change (mmHg)	−6·4	−5·1	−5·0	−5·9	−8·8	−7·1
*IOP change (mmHg)	−5·4	−4·9	−4·43	−5·47	−4·8	−4·1
*n=	19	17	10	26	9	6
†p=	>0·25		>0·25		>0·25	>0·25

*Taken at average follow-up time of 24 months.
†Level of significance; T-test for independent samples.

weeks. Group II did not have a significantly lower IOP rise.

When we compared the ALT response of black patients with that of white patients with glaucoma, we found a greater decrease in IOP in black patients but a similar decay curve (Fig. 5). However, the difference was not significant, possibly owing to the small number of black patients in our study. The response of diabetics was compared with that of all patients following ALT (Fig. 6). Initially, diabetics responded as well, but in time averaged an IOP 1 mmHg higher than the entire group ($p>0·25$). Repeat ALT resulted in a 25% success rate (Table 1).

At 24·7 months 11 of 82 (13·6%) eyes showed progressive field loss. Eight of these 11 eyes had an IOP below baseline and 1/11 was black. The mean prelaser IOP in these eight eyes was 24 mmHg and mean IOP at 27 months was 19·1 mmHg.

There were minimal short-term complications, similar to those already reported by other investigators.[5]

Discussion

Argon laser trabeculoplasty is effective in lowering the IOP in glaucoma patients. There are minimal short-term complications. It may be a satisfactory but temporary alternative to CAI therapy. Our initial success rate of 75% and IOP drop of 23% is consistent with other reports.[11–13] The maximum IOP drop was observed six to nine months after treatment (Figs. 2a, b). The IOP reduction began to diminish steadily, beginning 24 months after treatment. Our 33 months success rate of 71% declined precipitously to 45% at 42 months. While it is true that at 42 months only nine eyes were being followed up (four successes), the change in slope of our success rate began at 33 months, when we were following up 48 eyes. Schwartz and coworkers[5] also demonstrated a similar decay up to four years after treatment.

Most clinical studies[14,15] agree with Wise and

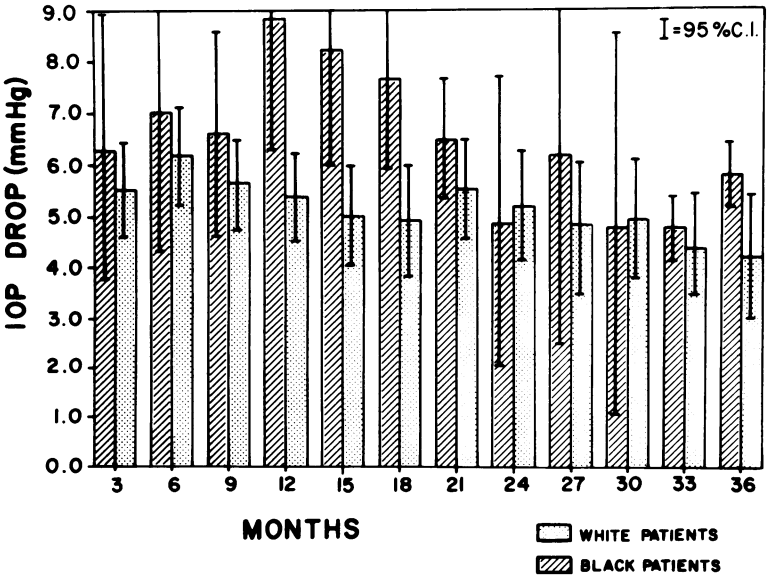

Fig. 5 *Mean pressure drop with time (black versus white patients).*

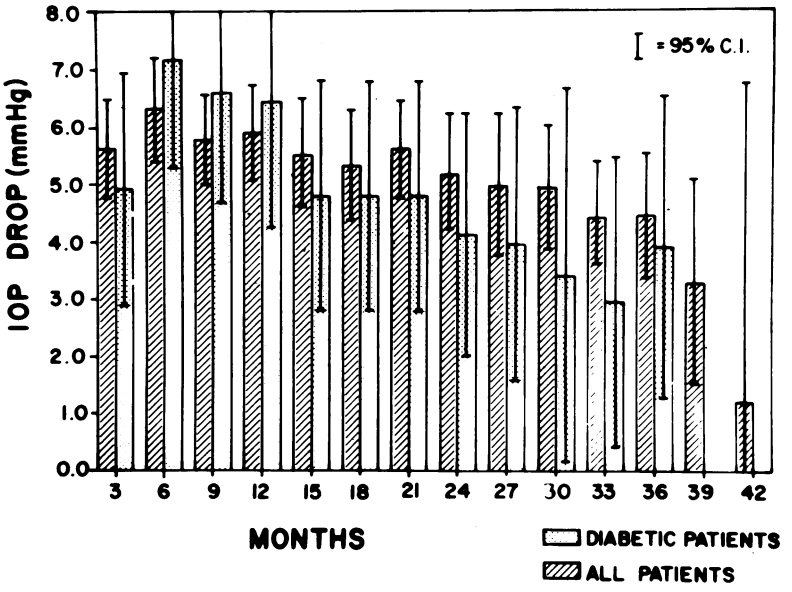

Fig. 6 *Mean pressure drop with time (diabetic versus all patients).*

Witter's[8] hypothesis that laser trabeculoplasty reduces IOP by increasing the coefficient of aqueous outflow. Histopathological and scanning electron microscopic studies of the trabecular meshwork suggested[16] that laser energy may induce, through fibrosis, an inner bowing of the trabecular meshwork to open Schlemm's canal. This finding seems to add credence to Wise's hypothesis that a tightening of the collagenous trabecular ring after laser surgery acts to open the intratrabecular spaces and Schlemm's canal, resulting in decreased resistance to aqueous egress. However, Van Buskirk *et al.*[17] could not demonstrate such a tightening of the collagenous ring in a histological analysis of laser-treated cadaver eyes.

While some of these effects may increase aqueous egress, others may be responsible for ultimate failure of the procedure. More specifically, the loss of trabecular cells at the burn site is of concern. Alvarado[18] suggested that a loss of trabecular cells following laser treatment may ultimately lead to trabecular fushion, increasing resistance to outflow and raising the IOP. This observation might explain why our repeat laser trabeculoplasties, accompanied by a further loss of trabecular cells, have had such little effect (Table 1). Starita *et al.*[19] and Brown *et al.*[20] also observed little effect of repeat ALT. The production of glaucoma by Gaasterland and Kupfer,[21] who lasered the entire trabecular meshwork of rhesus monkeys, has served as a warning that too much laser induced scarring of the trabeculum can increase the IOP. In view of Gaasterland and Kupfer's work and our low success rate, we would advise caution when considering repeat argon laser trabeculoplasty.

Argon laser trabeculoplasty may be an alternative to CAI therapy. Our investigation beginning in 1981 gave a success rate of 76% one year after treatment.[7] Our present mean follow-up time of 24 months demonstrated a 66·7% ±17·8% (95% CI) of patients as successful (Table 1).

Postlaser IOP rise has been of considerable concern to ophthalmologists engaged in this therapy,[22-24] and rises of IOP have been present up to six hours after treatment.[13] Krupin and coworkers,[25] who recorded an IOP rise in 53% of their patients, stated that most clinically significant increases of IOP were evident within one hour. Pretreatment with acetazolamide did not significantly alter this response. We tried to reduce the incidence of such IOP rise by reducing the number of burns and decreasing laser energy. However, in spite of these precautions the incidence of IOP rise was not reduced significantly.

Diabetic patients did not respond as well as the general population (Fig. 6). If, as Wise[8] suggests, tightening of the collagenous trabecular ring after laser surgery acts to open intratrabecular spaces, then abnormalities of collagen in diabetics[26,27] may offer some explanation as to why diabetics did not respond as well as other patients.

Older patients have been reported to have a greater and more predictable drop in IOP after trabeculoplasty than younger patients.[5,28] The collapse of an aging flaccid trabecular wall jammed against Schlemm's canal in older patients[29-32] might

explain this discrepancy. Tightening of the trabecular ring would thus be expected to have a greater effect on an older population. Our population with a mean age of 70 did not show any difference in IOP drop with age (Table 2), though few of our patients were really 'young'. It is of interest to note that in pigmentary glaucoma it is the younger group that has the greater postlaser IOP decrease.[33]

We cannot draw any valid conclusions with respect to the response to laser by race because we had very few black patients, reducing the statistical validity of our comparison. However, our impression, contrary to that of Schwartz and coworkers,[5] was that black patients did better than whites over the long term. It is interesting to note that Schwartz and colleagues' data may be biased by having very few white patients.

We found visual field loss in eight eyes despite an IOP below baseline. Pohjanpelto[34] found that 15 of 76 eyes with IOP reduction following ALT showed progressive field loss. Our 10% failure rate, and Pohjanpelto's 20% failure rate, despite 'normal' IOP reinforces the need for evaluation of ALT in conjunction with visual field testing, and argues against defining 'success' solely on the basis of IOP.

In spite of the confusion and fragmentary knowledge about the mechanism of action of ALT, it is effective in reducing the IOP in most patients with minimal side effects. The risk/benefit ratio continues to support its use as an alternative to CAI therapy and surgery. ALT may induce structural changes with unknown consequences. However, ALT has deferred the sight-threatening risks and cataractogenic effects of filtering surgery.[35]

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