

# Ten Year Results of Laser Trabeculoplasty

## *Does the Laser Avoid Glaucoma Surgery or Merely Defer It?*

JAMES B. WISE

Oklahoma

### Summary

The first 150 consecutive phakic eyes from 113 patients aged 40 years or more treated with laser trabeculoplasty were evaluated. Twenty-four patients (37 eyes) have died, two eyes developed spontaneous rubeosis, and one patient (one eye) was not available, leaving 110 eyes with a 6 to 10 years follow-up. Of the 37 eyes of dead patients (average age 80 years), only one eye had filtering surgery, and 33 of the other 36 eyes had a last recorded intraocular pressure of  $<21$  mm Hg. Of the 110 eyes of living patients followed for 6 years, 33 had filtering surgery and 62 eyes (56 per cent) had an intraocular pressure of  $<21$  mm Hg. Of 10 eyes followed for 10 years, eight had intraocular pressures  $<23$  mm Hg, seven had pressures  $<21$  mm Hg, and two had had filtering surgery. Eyes with advanced disc damage at the time of trabeculoplasty had a 51 per cent rate of later glaucoma surgery, while eyes with a cup/disc ratio  $<0.9$  at trabeculoplasty had a glaucoma surgery rate of 16 per cent. Eyes of non-white patients did as well as eyes of white patients. Computer analysis of over 1,700 eyes with two-year follow-up indicated better long-term control when 100 or more laser burns were used for trabeculoplasty. Laser trabeculoplasty can defer surgery for the remaining lifespan in elderly patients, and has controlled primary open-angle glaucoma for over 10 years, but later glaucoma surgery is often required in eyes with far advanced glaucoma damage.

The initial reports of laser trabeculoplasty<sup>1,2</sup> found little deterioration of long-term control, but others<sup>3-5</sup> have found higher rates of late failure and filtering surgery. Laser trabeculoplasty is generally used for glaucoma not controlled by tolerated medical therapy and is therefore an alternative to filtering surgery. Early filtering surgery has given excellent results with few complications.<sup>6</sup> The question arises whether laser trabeculoplasty shows late failure often enough to merely defer surgery rather than actually avoiding surgery.<sup>7</sup> This study reviews the author's first 150 consecutive phakic eyes treated with argon laser trabeculoplasty and followed for 6 to 10 years to determine the long-term results, including surgery rates and timing, the types

of eyes most likely to respond or fail with trabeculoplasty, the results in elderly patients who died during the study, and the results in trabeculoplasty re-treatments.

### Materials and Methods

Between February 11, 1976 and January 9, 1980 the author treated 150 consecutive phakic eyes of 113 patients who were 40 years of age or more at the time of treatment. The average age was 69 years, with a range from 43 to 88 years. Of these, 24 patients (37 eyes) have died, 2 eyes of different patients have developed spontaneous rubeosis iridis, and one eye has been lost to follow-up, leaving 110 eyes of 86 living patients available for analysis. All eyes were treated in one session with a continuous wave argon laser (Coherent model 800) through a Goldmann 3-mirror contact lens. This

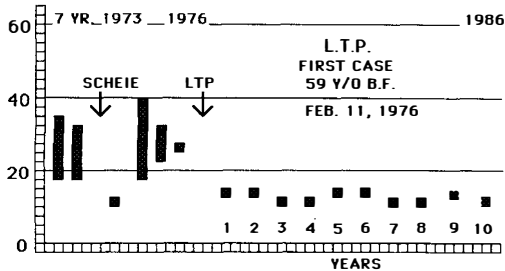


Fig. 1. Case 1.

laser produces a fundamental mode beam through a mirror arm delivery system and has been shown to produce a true 50  $\mu$ m diameter spot.<sup>8</sup> One hundred and seven eyes were treated 360°, one eye was treated 180°, one eye was treated 210°, and one eye was treated 240°. Average burn number was 110 burns, with a range of 62 to 188 burns. Exposure settings were 0.10 second, 50  $\mu$ m spot, and enough power to produce a small bubble or blanch.

The burns were aimed at the middle of the pigmented trabecular band, except for a few of the early cases where burns were also placed just posterior to the scleral spur. All burns were carefully aimed to give precise focus and a minimum spot size. A 'medication score'<sup>2</sup> was used in which medications of first use (pilocarpine <3 per cent, timolol, epinephrine) were scored '1', medications of second use (pilocarpine >3 per cent, carbachol, eserine) were scored '2', and the strongest medications (echothiophate, carbonic anhydrase inhibitors) were scored '3'. The medication score for an eye was the sum of the scores of the medications used. Data was stored on a 5 megabyte hard disc and analysed using an Apple III computer. The current status of all 150 eyes is known, except for the one eye lost to follow-up soon after trabeculoplasty.

### Case Reports

**Case 1.** The left eye of a 50 year old black woman had 98 per cent optic nerve cupping after seven years of glaucoma and an unsuccessful filtering procedure. Intraocular pressure was 28 mm Hg on therapy of 8 per cent pilocarpine plus oral acetazolamide. Laser trabeculoplasty was done on February 11, 1976 over the lower 210° of the angle using 100 burns. The pressure has ranged from 11 to 16 mm Hg ever since on therapy with 1 per cent pilocarpine until 1980 and then 0.5 per cent timolol once daily (Fig. 1). On February 11, 1986 the intraocular pressure was 13 mm Hg.

**Case 2.** The right eye of a 52 year old white woman had an intraocular pressure of 47 mm Hg in 1970. Intensive medical therapy, surgical peripheral iridectomy, and filtering surgery were done over

the next 5 years. Intraocular pressure was 30 mm Hg on therapy with 4 per cent pilocarpine, epinephrine, and acetazolamide. Trabeculoplasty was done on February 16, 1976 using 100 burns over the lower 240° of the angle. The intraocular pressure has ranged from 14 to 18 mm Hg since on minimal or no therapy. An extracapsular cataract extraction and posterior chamber implant lens was performed in 1984, resulting in 6/6 vision and no change in control (Fig. 2).

### Results

The 37 eyes of the 24 patients who died revealed an unexpected finding. These patients had an average age of 80 years at treatment, and of the 37 eyes only one eye, in a 66 year old man, had filtering surgery prior to death. That eye had previous retinal detachment surgery and a cup/disc ratio of 0.9. The last recorded intraocular pressure was <21 mm Hg in 33 of the other 36 eyes. In the 3 eyes with pressures over 20 mm Hg, two were in a patient who neglected angle closure and one was the only eye of an 85 year old black man, whose intraocular pressure was <21 mm Hg for four of the six remaining years of his life.

In calculating percentages of control of surgery, the denominator of the fraction is the original number of eyes treated and followed for the given interval, including those which have had surgery but not including patients who died before completing the interval. This denominator is 110 eyes for years 0 through 6, 76 eyes for 7 years, 48 eyes for 8 years, 21 eyes for 9 years, and 10 eyes for 10 years. Table I and Fig. 3 show that the post-laser average pressures and average medication scores varied little from year 1 through year 10, and show that the pressure control was not achieved by steady escalation of medical

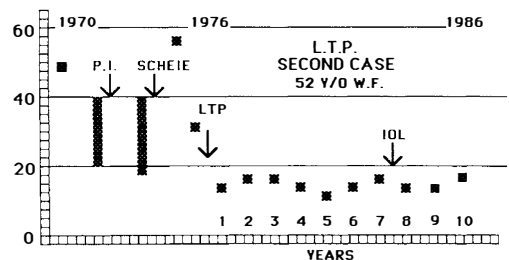


Fig. 2. Case 2.

**Table I** Average Intraocular Pressures and Medication Scores After LTP\*

Years post LTP	No. of eyes in interval	Average IOP in unoperated eyes	Average Rx score
Prelaser	110	29.6	3.1
1	110	17.7	1.7
2	110	18.4	1.9
3	110	16.6	1.8
4	110	18.0	1.8
5	110	17.3	2.1
6	110	17.2	2.2
7	76	17.1	1.9
8	48	17.0	1.8
9	21	16.2	1.9
10	10	17.1	2.0

\*Laser Trabeculoplasty

therapy. These numbers are influenced by removal of high-pressure, high-medication eyes which went on to surgery.

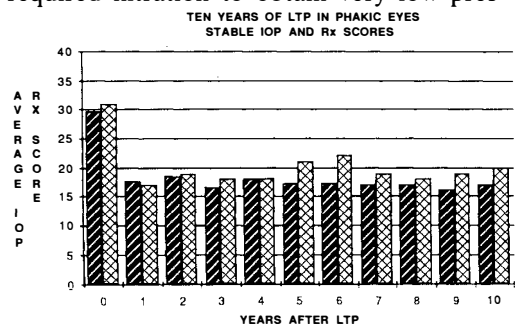
'Control' of glaucoma is commonly defined as an intraocular pressure of 20 mm Hg or less, although this may be too high for severely damaged discs.<sup>9</sup> Table II and Fig. 4 tabulate the 'control' rate for 10 years, dividing the actual number of eyes known to have a pressure of <21 mm Hg by the denominators described above. Eyes with 7 years follow-up, treated in the period April 1978 to June 1979, had an unusually low control rate though no changes in technique were noted. This has been considered to be due to patient variation.

The filtering surgery rate is tabulated for individual years after trabeculoplasty (Table III and Fig. 5) and cumulatively (Table IV and Fig. 6). The 110 eyes had a total of 59 subsequent operations, including 5 cataract extractions, 18 cataract extractions with implant lens, 3 cataract extractions with filtering surgery, 8 triple procedures (cataract, implant lens, filter), 22 filtering procedures, and 3 primary cryosurgical procedures. Many of the cataracts were in eyes referred for glaucoma control prior to planned cataract-implant lens surgery. If an eye had a filtering procedure alone or combined, this was an endpoint and any later surgeries were not considered. At six years the overall filtering surgery rate was 30/110 (27 per cent) and glaucoma surgery rate was 33/110 (30 per cent). The glaucoma surgery rate at 9 years was

4 of 21 eyes (19 per cent) and at 10 years was 2 of 10 eyes (20 per cent). The 'surgical avoidance rate' is obtained by subtracting the surgery percentage from 100 per cent. Therefore, from 63 per cent (seven years) to 92 per cent (one year) of these eyes with glaucoma previously uncontrolled by medical therapy avoided glaucoma surgery by having laser trabeculoplasty.

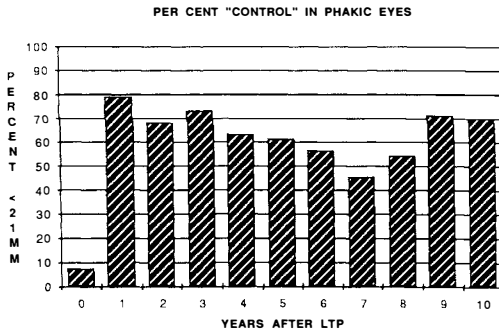
Of the 110 eyes in surviving patients, twelve eyes were in eight non-white patients (7 blacks, 1 American Indian). Their glaucoma was severe, as 7 of the 12 eyes had a cup/disc ratio of 0.9 or more. However, they did well with laser trabeculoplasty, with a 'control rate' (intraocular pressure less than 21 mm Hg) of 2/2 (100 per cent) at 10 years and at 9 years, 4/5 (80 per cent) at 8 years, 7/8 (87 per cent) at 7 years, and 9/12 (75 per cent) at 6 years. Two eyes had filtering surgery and one eye had cataract surgery followed by cryosurgery, for a glaucoma surgery rate of 3/12 or 25 per cent. These results were somewhat better than those of the total group of 110 eyes, and were much better than those of Schwartz *et al.*,<sup>4</sup> who estimated a mean time of 12 months for black patients to return to an intraocular pressure of >21 mm Hg.

The most important variable in predicting success proved to be the degree of glaucoma damage present at the time of laser treatment. Eyes with advanced cupping (cup/disc ratio of 0.9 or more) had a 51 per cent surgery rate, compared to 16 per cent glaucoma surgery in eyes with a cup/disc ratio of less than 0.9 (Table V). The prelaser average pressure and the pressure drop from trabeculoplasty were similar in the two groups. The eyes with advanced cupping continued to lose visual field at 'normal' pressures and therefore required filtration to obtain very low pres-

**Fig. 3.**

**Table II** Percentage of 'Control' After LTP

Years post LTP	No. of eyes in interval	No. with IOP less than 21 mm Hg	Per Cent <21 mm
Prelaser	110	8	7
1	110	87	79
2	110	75	68
3	110	80	73
4	110	69	63
5	110	67	61
6	110	62	56
7	76	34	45
8	48	26	54
9	21	15	71
10	10	7	70



**Fig. 4.**

asures.<sup>9,10</sup> Advanced cupping was also a poor prognostic factor for retreatments, as all 8 eyes retreated with the laser went on to filtering surgery. In contrast, retreatment in eyes with less glaucoma damage was successful in 6 of 8 eyes.

*Number of Burns:*

In evaluating the results of laser trabeculoplasty, an important variable is the number of burns applied. To correlate initial burn number with the ultimate result, a retrospective computer analysis was done on more than 1,700 eyes treated by the author with laser trabeculoplasty prior to 1984. The study concerned phakic eyes of patients 40 years or more in age, with a pre-laser intraocular pressure from 26 to 21 mm Hg and a minimum of 2 years of follow-up. Information on eyes meeting these criteria was retrieved by the computer in groups according to the number of single-session laser burns applied, such as 46-55 burns (average of 50 burns), 56-65

burns (average of 60 burns), and so forth up to 136-145 burns (average of 140 burns). Eyes having a second laser treatment within 3 months were considered to have had planned two-session trabeculoplasty and were excluded from this analysis. If an eye had repeat laser trabeculoplasty after 3 months or had filtration surgery, this was considered to indicate failure of the initial number of burns applied. An eye could fail only once, so that an eye re-treated with the laser and then filtered would count as only one failure. Table VI and Fig. 7 imply that burn numbers above 100 have a higher probability of successful glaucoma control. Since each burn produces an increment of trabecular shrinkage, truly long-term glaucoma control appears to require the cumulative shrinkage and trabecular tightening produced by 100 burns or more to pull widely open the meshwork. The eyes with 10-year control show nearly total depigmentation of the trabecular meshwork, implying that the meshwork has been widely stretched, allowing pigment, cells, and debris

**Table III** Annual Surgery Percentage

Years post LTP	No. of eyes in interval	No. of surgeries for glaucoma	Annual % surgery
0-1	110	9	8.2
1-2	110	3	2.7
2-3	110	5	4.5
3-4	110	8	7.3
4-5	110	6	5.5
5-6	110	2	1.8
6-7	76	3	3.9
7-8	48	1	2.1
8-9	21	0	0
9-10	10	0	0

**Table IV** Cumulative Surgery Percentage

Years post LTP	No. of eyes in interval	No. of surgeries for glaucoma	Per cent Surgery
1	110	9	8
2	110	12	11
3	110	17	16
4	110	25	23
5	110	31	28
6	110	33	30
7	76	28	37
8	48	15	31
9	21	4	19
10	10	2	20

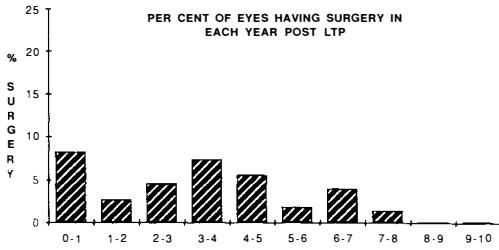


Fig. 5.

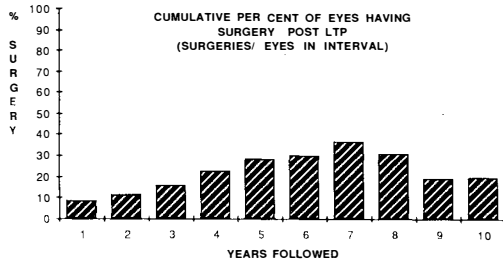


Fig. 6.

to pass through. If inadequate trabecular tightening is done with smaller numbers of burns,<sup>11</sup> initial intraocular pressure decrease can occur, but the meshwork is not pulled widely open and can plug up and collapse again, negating the effect of the inadequate trabeculoplasty. Repeat trabeculoplasty will again produce only the same temporary effect and duration of effect. I therefore believe that if laser trabeculoplasty is to be done at all, it should be done adequately by applying approximately 60 laser burns of true 50  $\mu\text{m}$  diameter into 180° of the pigmented trabecular band, waiting 4 weeks, and applying 60 burns into the other 180° of the pigmented band. The second 180° should always be done, even if a good response occurs to the first 180°, unless the intraocular pressure falls below 15 mm Hg on no therapy after the first 180° treatment.

### Discussion

The subtitle of this paper states the main point of discussion. In 36 of 37 eyes of patients who died, the laser avoided surgery for a period which proved to be the patient's remaining lifespan. The eyes with control for 8, 9 and 10 years also support the thesis that laser trabeculoplasty can do more than merely defer surgery. Laser trabeculoplasty does show some reduction in effect with time,<sup>3-5</sup> as

shown by the decreasing percentage of 'control' (Fig. 3) and increasing percentage of filtering surgery (Table IV) with the surgery spread over 7 years (Table III). Open-angle glaucoma is due to gradual deterioration of function of the trabecular meshwork, at least partly due to trabecular collapse from senile tissue stretching,<sup>1,2</sup> but with associated cellular loss<sup>12</sup> and other abnormalities including sclerosis, adhesion of layers, and various obstructing deposits. Laser trabeculoplasty shrinks the trabecular circumference and therefore the trabecular ring diameter, pulling apart the trabecular layers and increasing outflow. This can produce 10-year control even in eyes which were surgical failures. However, most eyes treated with trabeculoplasty must remain on medical therapy with all its problems of compliance, expense, side effects, and progression of glaucoma damage. In some eyes, the underlying trabecular deterioration sooner or later reappears, with recurrent elevation of intraocular pressure. Good arguments have therefore been made for prompt trabeculectomy,<sup>6</sup> which produced a greater reduction of intraocular pressure than did laser trabeculoplasty.<sup>13</sup>

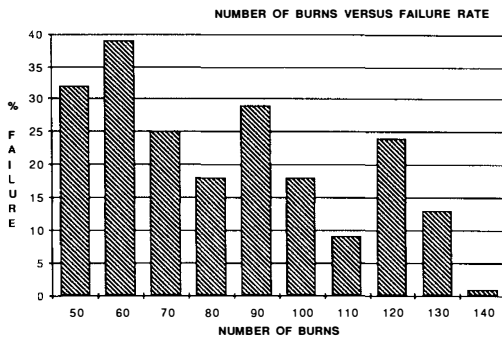
A pertinent question is 'Does trabeculectomy avoid further medical or surgical therapy, or just defer it?' There is evidence that it does not avoid further glaucoma therapy in all cases. In two recent studies,<sup>14,15</sup> trabeculectomy showed a decrease in effectiveness with time, at rates which appear comparable to laser trabeculoplasty. Honrubia found 15.5 per cent of trabeculectomies requiring medical therapy after 4 years, and quoted post-trabeculectomy medical therapy rates up to 30 per cent.<sup>14</sup> The principal difference between trabeculectomy and laser trabeculoplasty is the incidence of cataract after trabeculectomy, which was 15

Table V LTP Success versus Cupping of Disc

	C/D 0.9+	C/D <0.9
No. eyes	47	63
No. surgeries	24	10
% surgeries	51%	16%
No. retreated	8	8
Successful	0	6

**Table VI** 228 Phakic Eyes Treated With Various Burn Numbers. Pre-Laser IOP 26–30 mm. Re-RX 1–13 Weeks Excluded

No. Burns	No. Eyes	% Re-RX	% Surgery	Net % Failures
50	25	32	8	32
60	38	34	8	39
70	16	25	0	25
80	22	9	14	18
90	17	12	24	29
100	40	7.5	15	18
110	35	3	6	9
120	21	14	19	24
130	8	0	13	13
140	6	0	0	0



**Fig. 7.**

per cent,<sup>6</sup> 21 per cent,<sup>15</sup> and 25 per cent<sup>16</sup> in various series. Cataract formation would result in further surgery at the above rates, with the additional possibility of consecutive failure of the trabeculectomy which could lead to yet more surgery. With the availability of computerised perimeters to follow visual fields, laser trabeculoplasty rather than trabeculectomy would appear to be the safer course. Because badly excavated discs become so sensitive to pressure, either trabeculoplasty or trabeculectomy should be used in timely fashion when glaucoma is poorly controlled, before advanced disc damage occurs. The two methods are complementary. In eyes with moderate glaucoma damage, particularly if the patient is over 60 years of age, trabeculoplasty is the better choice. If compliance with medical therapy may be a problem, or if far advanced glaucoma damage is present, especially in

patients under 60 years of age, then trabeculectomy or a full thickness filtering procedure<sup>15</sup> should be done. The focal point must always be to obtain good control of the glaucoma, for blindness from glaucoma still remains the principal complication of all forms of glaucoma therapy.

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