

# Long-term efficacy of primary laser trabeculoplasty

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## Abstract

Sixty glaucomatous eyes of 60 patients treated with laser trabeculoplasty as primary therapy were reviewed retrospectively. There were 42 eyes with capsular glaucoma and 18 with simple glaucoma. The mean prelaser intraocular pressure (IOP) was 35.2 (SD=6.5) mmHg. Success was defined as IOP  $\leq$  22 mmHg without medication. The probability of success was 0.73 at 1 year, 0.66 at 2 years, 0.57 at 3 years, and 0.50 at 4 years. Three eyes experienced progressive visual field loss or disc damage in spite of an intraocular pressure below 22 mmHg without medication. High prelaser pressure and the severity of the visual field defects were significant predictors of treatment failure.

Laser trabeculoplasty (LTP) was introduced as an alternative to filtering surgery in the pre-surgical glaucoma patient on full medication.<sup>1</sup> Several reports have noted the efficacy and low complication rate associated with this procedure.<sup>1-3</sup> There are now a number of studies of it as a primary treatment in glaucoma.<sup>4-9</sup> The first results of a multicentre controlled study have recently been published.<sup>10</sup> To the best of our knowledge there are only two reports on long term results with primary LTP.<sup>8,9</sup>

We have retrospectively studied the long term results with laser as primary treatment in 60 eyes of 60 patients.

## Material and methods

The patients were collected from two earlier prospective studies on primary LTP investigating 180° versus 360° treatment<sup>11</sup> and the immediate pressure response to one- and two-stage LTP.<sup>12</sup> In these two studies 66 eyes were treated in 60 patients. For six patients one eye was randomised for one-stage and the other for two-stage treatment. One eye from each of these patients was randomised to the present study. There were 25 women and 35 men in the study sample. The mean age was 71.5 (SD=9.2) years. The material consisted of 18 eyes with simple glaucoma and 42 with capsular glaucoma.

The patients had to meet all of the following criteria to be included in the original two studies: (a) IOP  $\geq$  25 mmHg on each reading of the prelaser diurnal curve; the mean of these measurements was taken as prelaser IOP; (b) glaucomatous disc damage and/or visual field defects; (c) no earlier glaucoma treatment.

The cupping and pallor of the disc were evaluated with a Goldmann contact lens according to Schwartz.<sup>13</sup> Fundus photography was not performed. Glaucomatous damage of the optic nerve head was defined as a vertical cup-disc ratio  $\geq$  0.5 and at least one of the following

criteria: (a) cupping of the optic nerve head extending to the margin of the disc; (b) a difference of 0.2 or more of the C/D ratio between the two eyes; (c) different degrees of disc pallor in the two eyes with no other explanation subjectively assessed by one of the authors (TE) by contact lens examination.

Progressive disc damage was judged to have occurred with an increase in the C/D ratio of 0.2 or more and/or cupping progressing to the disc margin. Disc changes were subjectively estimated by one of the authors (TE) by contact lens examination comparing the present findings with the written description and drawings from the entry of the patients into the two earlier prospective LTP studies,<sup>11,12</sup> using the recommendations of Schwartz.<sup>13</sup> The optic nerve head was in these two studies evaluated by the same person (TE).

The visual field was examined with the Humphrey Visual Field Analyzer using the suprathreshold Armaly full field screening test<sup>11</sup> or the suprathreshold 76-point central screening test.<sup>12</sup> Both programs apply a quantified defect strategy. The original study<sup>11</sup> started some months before our automated perimetry service was established, and during this period the visual fields were plotted by Goldmann perimetry. In addition Goldmann perimetry was performed in patients who did not co-operate during automated perimetry or who had extensive central field defects. Glaucomatous visual field defects were defined as having at least three contiguous spots within the central 30° field and a depth of  $\geq$  5dB. We used the criteria of Ticho and Nesher<sup>3</sup> for detecting visual field decay in eyes monitored by automated perimetry and the criteria of Kidd and O'Connor<sup>14</sup> in patients followed up by Goldmann perimetry. Visual field deterioration was confirmed by retesting. Visual field defects were given scores according to the following classification.

0: Normal.

1: Scattered defects with a depth of  $\geq$  5 dB not creating a complete Bjerrum scotoma.

2: Spots with a depth  $\geq$  5 dB creating a complete Bjerrum scotoma extending from the blind spot to the horizontal nasal meridian.

3: Larger defects than 2.

Goldmann defects were classified according to Aulhorn.<sup>15</sup> The pigmentation of the chamber angle was not evaluated.

All patients were scheduled for re-examination by one of the authors and had the same ophthalmic examination as in the two reports<sup>11,12</sup> which recruited the patients to our study. Four patients died during the observation period and one patient did not attend for examination. The files of these patients were checked for the information needed, and it was included in the material up to their last visit.

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Success was defined as IOP  $\leq 22$  mmHg without medication. When the patient did not meet those criteria the result was classified as failure. If the IOP exceeded 22 mmHg, topical medication was added. If this was not sufficient, the patient was referred for trabeculectomy. During the first two weeks after laser treatment higher pressure levels were allowed before starting medication. If the intraocular pressure was  $\geq 40$  mmHg the day after LTP,  $\geq 30$  mmHg after one week, or  $\geq 25$  mm after two weeks, medication was prescribed.

LTP was performed with a Coherent argon laser photocoagulator. The spots were placed just in front of the scleral spur, with blanching, bubble formation, and pigment dispersion as the criteria for adequate laser exposure. Application parameters were 50  $\mu$ m spot size, 0.1 second duration, and a mean power of 1.2 W (range 0.8–2.0). The treatment was performed by one of the authors to keep the technique unchanged during our two studies. One hundred spots were distributed in 360° except for 14 eyes randomised to two sessions of 50 spots in 180° with an interval of four weeks.

Since the purpose of the present work is to relate the outcome of primary LTP to elapsed time and certain characteristics of the subjects under study (age, type of glaucoma, pretreatment IOP, etc), lifetime data analysis (survival analysis) expressing the characteristics as concomitant variables in a regression model is appropriate.<sup>16</sup>

The probability of success (survivor function) is estimated by the Kaplan-Meier method.<sup>17</sup> A hazard plot is shown to indicate the failure rate pattern, and the empirical failure rate is also estimated. The predictors of failure are evaluated by the Cox regression model<sup>18</sup> using a stepwise procedure as implemented in the Survival module in the SYSTAT statistical package.<sup>19</sup> Model control is carried out by residual analysis and graphical methods.

**Results**

Prelaser variables are listed in Table 1.

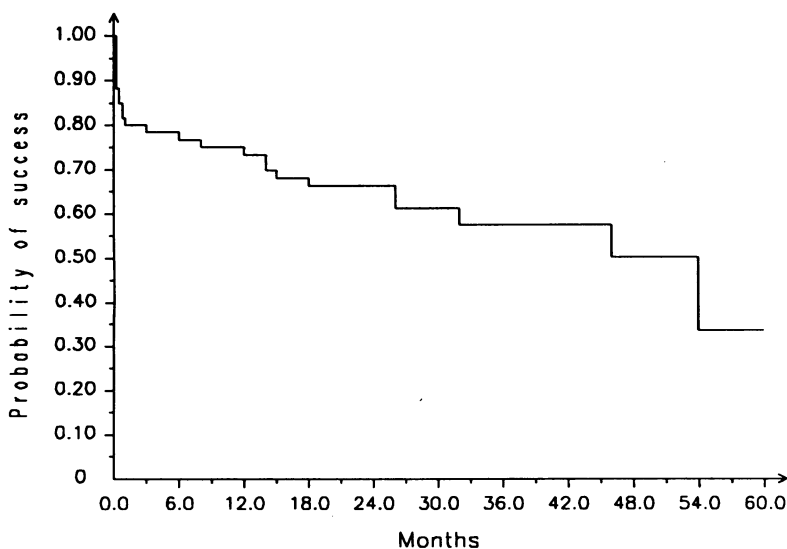


Figure 1 Kaplan-Meier plot showing probability of success for glaucomatous patients treated with primary LTP.

Table 1 Prelaser variables in eyes treated with primary LTP

Mean age	71.5 (SD=9.2) years
Mean prelaser IOP	35.2 (SD=6.5) mmHg
Mean cup-disc ratio	0.72 (SD=0.16)
Number of eyes (%) with cupping extending to the margin of the disc	26 (43%)
Mean visual field defects score in eyes examined with automated perimetry	1.5 (SD=1.4)

The total number of observations was 60, 23 of which were observed to fail. The Kaplan-Meier plot in Fig 1 shows the unconditional probability of success as a function of time since treatment. Accordingly, the probability of success was 0.73 at 1 year, 0.66 at 2 years, 0.57 at 3 years, and 0.50 at 4 years.

The hazard plot (Fig 2) indicates a rapidly decreasing failure rate during the first month after treatment, presumably because of failure in non-responders. The failure rate flattened out to a reasonably stable level, and increased towards the end of the observation period as seen in Fig 3. Twelve of a total of 23 failures occurred during the first month after LTP.

The high initial failure rate had a marked effect on the probability of success in the whole material. It is therefore worthwhile assessing the probability of success given success at 1 month. These probabilities were as follows: 0.92 at 1 year, 0.83 at 2 years, 0.72 at 3 years, and 0.63 at 4 years. Of the observed 23 eyes which failed, 18 needed medication on account of high pressure, and five were referred to trabeculectomy because of high IOP. Mean postlaser pressure in successfully treated eyes on the last visit was 15.6 (SD=2.6) mmHg.

We used only the pressure response as a criterion of success, while many other studies have also included stable visual field and optic disc in the definition of successful treatment. In our series two patients experienced deteriorating visual fields and one progressive cupping of the optic nerve head in spite of normal intraocular pressure without medication.

None of the other studies on primary LTP evaluated their results by lifetime data analysis as recommended by Gaasterland.<sup>20</sup> To make our results comparable with these reports we also included all patients, both successes and failures, up to the date of their last clinical visit. The mean follow-up of the material when evaluated in this manner was 34 (SD=13) months. Our results are compared with those of other studies in Table 2.

High prelaser IOP and visual field defect score were predictors of treatment failure ( $p < 0.05$ ). Table 3 presents the success rate at different levels of prelaser IOP. Age, sex, capsular or simple glaucoma, 180° x 2 versus 360° treatment, laser power, or the cup-disc ratio did not influence the outcome of treatment significantly.

The rate of complications and postlaser pressure elevations have been recorded elsewhere.<sup>11,12</sup>

**Discussion**

Our results are compared with those of other reports on primary LTP in Table 2. None of these studies have evaluated their results by lifetime data analysis. These investigations differ

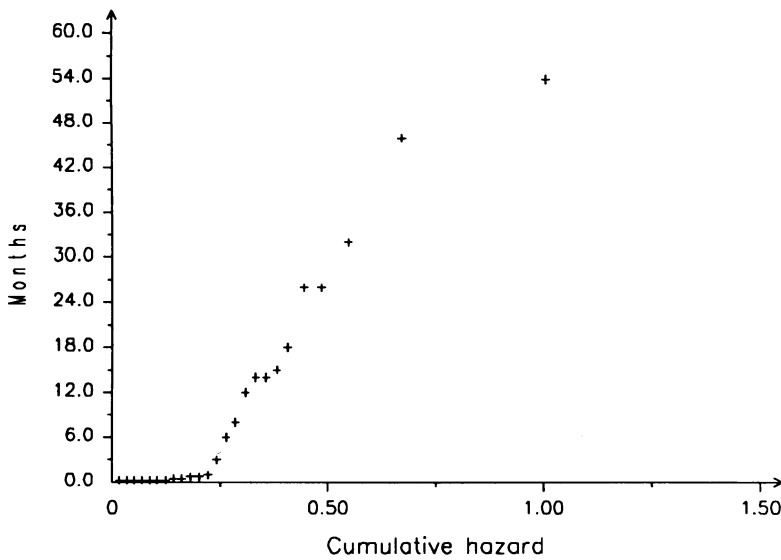


Figure 2 Plot of cumulative hazard with time since treatment with primary LTP. The curve indicates an initially decreasing failure rate and an increasing failure rate towards the end of the observation period.

regarding preleser IOP, the severity of the disease, and the percentage of capsular glaucoma, and are not directly comparable. Prelaser IOP varies between 24.0 and 35.2 mmHg.

Table 3 Prelaser IOP related to the success rate in primary LTP

Prelaser IOP mmHg	Success rate: number of successful eyes/total number of eyes (%)
≥40	4/12 (33%)
<40	26/37 (70%)
≥30	7/11 (64%)
<30	
≥25	

The longterm studies of Tuulonen *et al*<sup>6</sup> and Migdal and Hitchings<sup>8</sup> are not directly comparable to ours. The material of Tuulonen *et al* contains only cases of early glaucoma with a considerably lower preleser pressure than in our study. They reported that 50% were successfully treated after five years. Migdal and Hitchings's cases consisted exclusively of simple glaucoma, while our study has a majority of capsular glaucoma. Their preleser IOP of 34.9 mmHg was comparable with ours. In their material 44% were successfully treated after a follow-up period varying between seven months and three years. After four years 50% were successful in our study.

The failure rate pattern indicates that the first month after treatment is critical in the sense that the majority of eyes which are susceptible to

Table 2 Six studies on primary LTP compared with the present report

	Follow-up (months)	Number of eyes	Type of glaucoma	Prelaser IOP (mmHg)	Success rate (%)
Tuulonen <i>et al</i> <sup>6</sup>	12	21	Glaucoma simplex	25.6 (SD=0.9)	81
	18	18	Glaucoma simplex	25.1 (SD=0.7)	78
	12	42	Glaucoma capsulare	27.0 (SD=0.7)	100
Thomas <i>et al</i> <sup>5</sup>	18	34	Mostly glaucoma simplex	27.3 (SD=0.7)	94
	3-10	30	Mostly glaucoma simplex	30.3	83
Rosenthal <i>et al</i> <sup>4</sup>	6-18.5	43	Glaucoma simplex	Among successes First eye treated 30.7 (SD=1.3) Second eye treated 29.7 (SD=1.9) Among failures 34.1 (SD=2.0)	65
Tuulonen <i>et al</i> <sup>7</sup>	12	19	Glaucoma capsulare and simplex	29.4 (SD=7.6)	53
Migdal and Hitchings <sup>8</sup>	7-36	57	Glaucoma simplex	34.9	44
Tuulonen <i>et al</i> <sup>9</sup>	60	32	Glaucoma simplex	24.0 (SD=3.1)	50
Present study			Glaucoma capsulare	26.4 (SD=3.7)	
	12	60	Glaucoma	35.2 (SD=6.5)	76
	24	50	capsulare and simplex		64
	36	25	simplex		52
	48	12			50

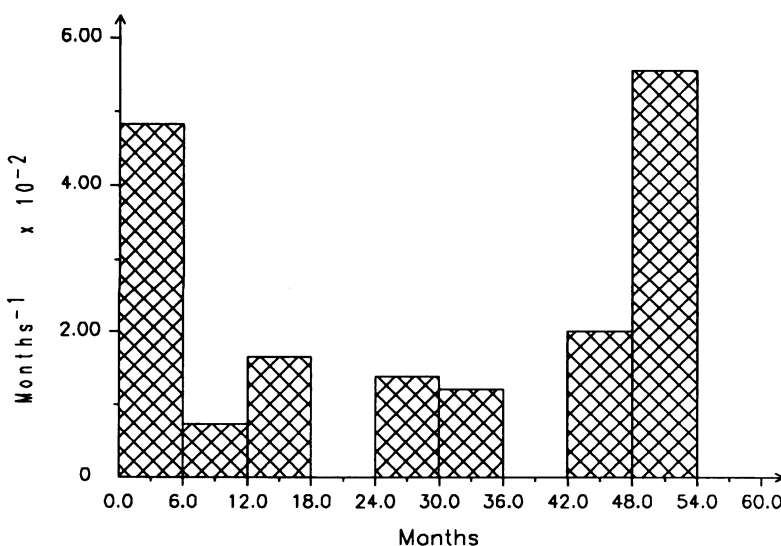


Figure 3 Estimated failure rate in time intervals after primary LTP.

failure in the first year will fail during the first month, and success beyond one month considerably increases the probability of long lasting success. Our observations show, however, that the failure rate increases after four years of success. So, although the data are sparse, they suggest an increasing failure probability after a rather stable level from one month to about four years after treatment. Shingleton *et al*,<sup>21</sup> studying patients with glaucoma on medication, noted a failure rate of 23% during the first year after LTP, which then levelled off to about 10% per year.

Only Rosenthal *et al*<sup>4</sup> have analysed prognostic factors in primary LTP. They observed, as in our study, that high pretreatment intraocular pressure was associated with treatment failure. The degree of glaucomatous damage, in contradiction to our results, did not influence the

results of LTP in their material. They also noted that well delineated angle landmarks were a predictor of success. The date of treatment was also correlated with successful treatment. Of the first 15 patients four were successes, while 14 of the final 18 patients were successes. This fact was interpreted as increased success when gaining experience with the procedure. All the eyes in our material were treated by the same experienced laser surgeon. We did not relate chamber angle parameters to treatment results.

There are several studies of the effect of different pre-laser variables on the outcome of LTP in glaucoma patients on medication.<sup>1-3 21-29</sup>

These studies differ regarding the factors influencing the result of treatment. Possible explanations of their contradictory results are that some of the series were too small, some authors did not apply lifetime data analysis, some series contained different types of glaucoma, and different criteria for success were adopted; moreover the values of some parameters were clustered round a median value and did not extend over a wider range. Age<sup>3 22 25 26</sup> and capsular glaucoma<sup>23 24 28</sup> are the factors most consistently related to the outcome of treatment by other authors. Schwartz *et al*<sup>22</sup> and Tuulonen *et al*<sup>23</sup> reported that high pre-laser pressure was a predictor of failure in glaucoma patients on medication. This was supported by our findings. Some reported observations indicate that, as in our material, the severity of the disease may be of importance. In a long-term study Wise<sup>2</sup> found that eyes with a cup-disc ratio  $\geq 0.9$  had a surgery rate of 51% compared with 16% in eyes with less advanced damage of the optic nerve head. Tuulonen *et al* noted that primary LTP gave better results than laser treatment in eyes already on medication.<sup>23</sup> In their patients eyes treated with primary LTP were in an earlier stage of the disease than eyes already on medication. This may indirectly suggest that the severity of the disease is also of importance.

In our opinion LTP should be considered as an alternative to medication for the initial treatment of glaucoma. The probability of success after four years is 0.50 even in a group of eyes with a mean pre-laser IOP of 35.2 mmHg. There is a high failure rate during the first month after LTP, presumably owing to a group of eyes not responding to laser treatment. Given success one month after treatment, the probability of success increases to 0.63 after four years. The treatment is easy to perform, the complication rate is low, there are no compliance problems as with medication, and the treatment is not expensive. All stages of the disease respond to treatment. On the other hand the severity of the visual field

defects and high pre-laser IOP are negative prognostic factors.

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