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Long-term clinical results of selective laser trabeculoplasty in the treatment of primary open angle glaucoma

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PURPOSE. *To investigate the long-term efficacy of selective laser trabeculoplasty (SLT) in primary open-angle glaucoma, the authors performed a non-randomized, prospective, non-comparative clinical case series.*

METHODS. *Fifty-two eyes of 52 patients (19 male, 33 female) with primary open angle glaucoma were treated with SLT. Patients were treated with the Coherent Selecta 7000 (Coherent, Palo Alto, CA, USA) frequency-doubled q-switched Nd:YAG laser (532 nm). A total of approximately 50 non-overlapping spots were placed over 180° of the trabecular meshwork at energy levels ranging from 0.6 to 1.4 mJ per pulse. After surgery, patients were maintained with the drug regimen identical to that before treatment.*

RESULTS. *After 1 year the average reduction in intraocular pressure (IOP) from the baseline was 24.3% (6.0 mmHg), after 2 years 27.8% (6.12 mmHg), after 3 years 24.5% (5.53 mmHg), and after 4 years 29.3% (6.33 mmHg). A Kaplan-Meier survival analysis revealed a 1-year success rate of 60%, a 2-year success rate of 53%, a 3-year success rate of 44%, and a 4-year success rate of 44%.*

CONCLUSIONS. *Despite a declining success rate, SLT is an effective method to lower IOP over an extended period of time. (Eur J Ophthalmol 2006; 16: 100-4)*

KEY WORDS. *Long-term clinical results, Open angle, Glaucoma, Selective laser trabeculoplasty*

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INTRODUCTION

In 1979, Wise and Witter first described argon laser trabeculoplasty (ALT) as a therapy for medically uncontrolled open angle glaucoma (OAG) (1). The argon laser (λ = 488–514 nm) improves aqueous outflow by targeting the anterior border of the pigmented trabecular meshwork (TM) with spot size of 50 µm. The effects of facilitated outflow are best described by the mechanical and cellular theory. According to the mechanical theory a laser burn will cause scarring and thus enlarge the adjacent TM. This will enhance outflow (2, 3). In the cellular theory, macrophages will invade the TM in the neighborhood of the laser burn and thus clear the intertrabecular spaces of debris.

In 1995, Latina and Park first published a new laser treatment. Out of a variety of different laser systems, they chose a q-switched, frequency-doubled Nd:YAG laser (λ = 532 nm) for so-called selective laser trabeculoplasty (SLT) (4).

Histopathologic examinations in human autopsy eyes treated with either ALT or SLT revealed no evidence of coagulative damage or disruption of the corneoscleral or uveal trabecular beam structure. SLT caused less structural damage compared with ALT (5). According to Latina and coworkers, a yet unknown biologic mechanism of action is responsible for the intraocular pressure (IOP) lowering effect of SLT (6).

The efficacy of SLT up to 18 months after laser treatment has already been proved by some clinical stud-

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ies (7-11). The objective of our study was to investigate the long-term efficacy of SLT in a non-randomized prospective non-comparative clinical case series over a period of up to 56 months.

PATIENTS AND METHODS

Starting in January 1998, 52 consecutive eyes of 52 patients (19 male, 33 female) with primary OAG were enrolled in the study. Fourteen of the eyes had a capsular glaucoma (CG) (27%). Data were collected and then evaluated until September 2002. The patients included in this study were referred to the University Eye Clinic by clinical practices.

Patients were included if they had OAG with uncontrolled IOP (>20 mmHg) on maximal tolerable medical therapy or had failed previous ALT. Those patients had a long history of glaucoma treatment and were sent to us for further treatment. The IOP was taken during the opening hours of our outpatient department, usually between 8 and 12 am. Informed consent was taken. All patients were older than 18 years (mean 67.12 ± 10.76; range 30 to 87, median 67). Exclusion criteria were any corneal opacities precluding an adequate view of the trabecular meshwork (TM), any glaucoma other than OAG, a present or warranted condition with application of local or systemic corticosteroids, and if the patient had previous glaucoma surgery done other than ALT or peripheral iridectomy. The ocular history of familial glaucoma, previous and present ocular medication, and operations were recorded.

The grade of pigmentation of the trabecular meshwork was registered before treatment and graded according to a standard scale provided by the Coherent medical group (graded from 0 to 4+ where 0 = no pigment and 4+ dense homogeneous pigment). IOP was measured with a Goldmann applanation tonometer. Ocular assessment included best-corrected visual acuity, slit-lamp examination of the anterior segment, stereoscopic evaluation of the optic disk (78 D Volk lens), and gonioscopy with a 4-mirror Ritch gonioscopy lens.

Proxymetacaine hydrochloride 5.0 mg eyedrops were administered before trabeculoplasty and preoperative IOP was taken. Using a 4-mirror Ritch gonioscopy lens, 180° of the trabecular meshwork of each eye was treated with a 532 nm q-switched frequency-doubled Nd:YAG laser (Selecta 7000, Coherent Medical) using 50 non-overlapping applications, with a spot size of 400 µm (centered on the TM) and pulse duration of 3 ns. The initial energy used was 0.8 mJ. The energy was increased until bubble formation appeared and was then decreased by 0.1 mJ for the remainder of the treatment. Average power during treatment ranged from 0.8 to 1.4 mJ. Two hours after laser treatment IOP and the anterior chamber reaction were checked. During the study an attempt was made to keep the patients on the same hypotensive medication. If IOP worsened and the medication was increased or a second SLT or a filtering operation or cryotherapy was performed, the patient failed the study criteria and was excluded. Patients were evaluated in our outpatient department 2 hours after treatment, at 24 hours, and at the end of the first week, then approximately after 1, 3, and 6 months, then 1, 2, 3, and 4 years. At all follow-up examinations best-corrected visual acuity, slit-lamp examination, IOP, and stereoscopic examination of the optic disk were taken.

Statistical analysis

Statistical analysis was performed using the Wilcoxon matched-pairs signed-ranks test. A value of $p < 0.05$ was considered significant. Because of the variable length of the follow-up, the Kaplan-Meier survival analysis was used to estimate the success rate.

RESULTS

Fifty-two eyes of 52 patients were treated with SLT. The average number of applications of hypotensive medication before treatment was 2.5 (range 1–5). All patients were white. Follow-up ranged from 24 to 56 months (mean 41.2 ± 9.3).

The baseline IOP was 25.23 mmHg (±3.42, median 24, range 21–36). We examined the safety and efficacy of the laser treatment to reduce IOP from its baseline level. Figure 1 graphically shows the mean IOP over time for all treated eyes with standard deviation. Table I lists the mean IOP, mean change in pressure, and IOP reduction percentage from the baseline for all eyes remaining in the study.

The greatest drop in IOP occurred 1 day after the

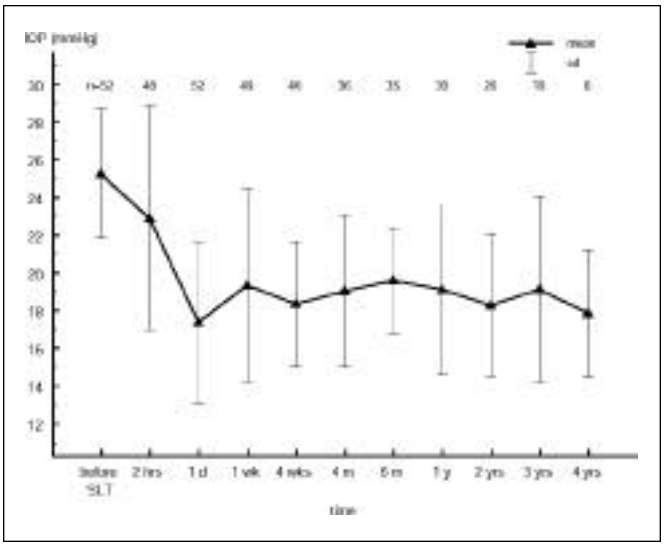

Fig. 1 - *Mean intraocular pressures over time with standard deviations.*

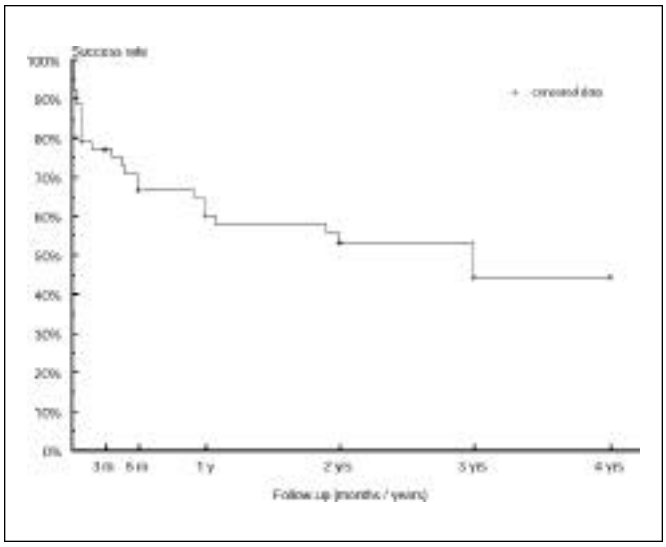

Fig. 2 - *Kaplan- Meier survival analysis.*

procedure. After 1 year the average percent IOP reduction from the baseline was 24.3% (6.0 mmHg), after 2 years 27.8% (6.12 mmHg), after 3 years 24.5% (5.53 mmHg), and after 4 years 29.3% (6.33 mmHg). The difference between the baseline and post-treatment IOP values was statistically significant throughout the study with $p < 0.05$.

Forty-eight of the 52 eyes responded to selective laser trabeculoplasty with an IOP reduction. However, in the course of the period of study 67.3% of the eyes failed the study criteria. The Kaplan-Meier survival analysis revealed a 1-year success rate of 60%, a 2-year success rate of 53%, a 3-year success rate of 44%, and a 4-year success rate of 44% (Fig. 2).

Eleven patients were excluded due to increased therapy, seven patients underwent filtering surgery, four patients had cryotherapy, and four patients received a second SLT.

A few patients experienced a mild anterior chamber reaction after SLT. This was visible within 1 hour after treatment and usually disappeared within 24 hours. In 10 eyes (19%) a transient IOP elevation of < 4 mmHg, in 2 eyes (4%) of < 7 mmHg, and in 3 eyes (5.8%) > 7 mmHg occurred within 1 hour after treatment. The IOP elevation was treated with topical antiglaucoma medication and resolved in all cases within 24 hours.

TABLE I - MEAN IOP AND CHANGE IN PRESSURE (MMHG) FROM BASELINE

	No. of eyes	Mean IOP mmHg	Mean IOP reduction, mmHg	IOP % reduction	p
Baseline IOP	52	25.23	N/A	N/A	N/A
2 h	48	22.88	2.19	9.3	<0.006
1 d	52	17.35	7.88	31.0	<0.0001
1 wk	49	19.33	5.71	23.4	<0.0001
1 mo	40	18.33	6.65	27.3	<0.0001
3 mo	36	19.03	6.22	24.6	<0.0001
6 mo	35	19.57	5.66	22.4	<0.0001
12 mo	30	19.10	6.00	24.3	<0.0001
24 mo	26	18.27	6.12	27.8	<0.0001
36 mo	19	19.11	5.53	24.5	<0.0033
48 m	06	17.83	6.33	29.3	<0.0458

IOP = Intraocular pressure; N/A = Not applicable

DISCUSSION

The aim of any laser surgery to lower IOP is to avoid or delay the need for filtering surgery with its attendant risks and potential complications. The present study aims to answer the questions of efficiency and duration of IOP reduction after selective laser trabeculoplasty over a longer period of time. Kramer and Noecker showed its potential advantage over argon laser trabeculoplasty in a histopathologic study in 2001 (5). They have shown a lack of thermal damage and scarring after SLT. In contrast to this, we know from ALT retreatment studies (12) that ALT has a potential risk of an even elevated IOP due to excessive scarring of the TM.

Up to now no study has been published with a follow-up time extending beyond 18 months after SLT. Gracner reported in a comparative study of OAG (10 eyes) and capsular glaucoma (CG) (10 eyes) a 12- and 18-month success rate of 64% in the CG and 78% in the OAG group (9). The difference was not significant. The mean IOP reduction from the baseline at 18 months was 8.5 mmHg (CG and OAG).

In the study by Kaulen and coworkers, 460 eyes with uncontrolled OAG were treated with SLT (10). The follow-up period was 10 months (range 1–20 months). The Kaplan-Meier survival analysis revealed a 76% success rate and a mean IOP reduction of 6 mmHg.

In our study the 12-month success rate was 60% and the mean IOP reduction from the baseline was 6.0 mmHg. This is comparable with the results by Gracner (9) and Kaulen et al (10) in respect to IOP reduction. But the success rate achieved by Kaulen and coworkers for a 12-month period is slightly higher. The fact that the patients in their private practice were unselected could explain this. Our patients, who were sent for further treatment to our hospital, may be considered to have a glaucoma that is more difficult to control.

The lack of all above cited studies including our study is that the baseline IOP was taken at a certain time and was not the mean of a series of measurements. In an ideal study not only the baseline IOP should be the mean of a 24 hours day and night pressure profile but althought the control measurements.

A transient IOP elevation within 2 hours after SLT is the major adverse event and occurred in 36% of eyes in the study conducted by Latina and coworkers (6). Gracner reported less IOP elevation (16%) but used 0.5% apraclonidine as routine pretreatment medication (9). Comparable with the study by Latina and coworkers (6), in our study 29% of the eyes had a transient IOP elevation.

Several long-term studies have shown the effect and efficiency of ALT (12, 13). In the study by Shingleton et al, 93 patients with OAG underwent 360° ALT (12). The average follow-up was 52 ± 43 months (mean ± standard deviation).

Successful treatment at the time of the final follow-up was defined as a decrease in IOP of 3 mmHg or greater compared to the pretreatment level, an IOP of 19 mmHg or less, a stable visual field, a stable optic nerve, and no further laser or surgical intervention.

The decrease in IOP was 8.9 ± 5.4 mmHg after 1 year, 10.0 ± 4.2 mmHg after 5 years, and 8.9 ± 5.2 mmHg after 10 years. The probability of success at 1 year was 77%, at 5 years 49%, and at 10 years 32%. Failure was most common in the first year after treatment (23%), and thereafter failure occurred at a rate of 5% to 9% per year.

In our study the probability of success was 60% after 1 year and 44% after 4 years and this therefore points to a lower success rate. But direct comparison of efficiency of SLT versus ALT in the study by Shingleton and coworkers is difficult, because they performed a 360° ALT whereas ours was a 180° SLT. In addition, patient demographics and criteria for success were different in the ALT study.

SLT is an efficient alternative to ALT with the advantage of less structural damage in the trabecular meshwork. The long-term results reveal a decreasing rate of success over the years, as already established after ALT.

All the patients' eyes in our study had advanced glaucomatous damage. To help the patients keep their vision and visual fields stable, a mean IOP of less than 18 mmHg is required, as the Advanced Glaucoma Intervention Study shows (14). Our study failed these criteria (see Fig. 1 and Tab. I).

The consequence is that SLT is not an advisable option for eyes with advanced glaucoma. As primary treatment for patients with newly detected glaucoma which has not yet been treated, it may be an effective alternative to antiglaucoma medication. This should be investigated in a randomized clinical trial.

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