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# Original Article

## Five-year follow up of selective laser trabeculoplasty in Chinese eyes

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### ABSTRACT

**Purpose:** To study the effectiveness and safety of selective laser trabeculoplasty (SLT) on primary open-angle glaucoma and ocular hypertension in Chinese eyes.

**Methods:** This was a prospective randomized controlled clinical study in which 58 eyes of 29 patients with primary open-angle glaucoma or ocular hypertension were included. One eye of each patient was randomized to receive SLT (Group 1) and the fellow eyes received medical treatment (Group 2). Patients were evaluated after laser treatment at 2 h, 1 day, 1 week, 2 weeks, 1 month, 3 months, 6 months, and then yearly.

**Results:** All patients (13 male, 16 female) were Chinese. The mean age was 51.9 ± 14.7 years. The mean baseline intraocular pressure was 26.8 ± 5.6 mmHg in group 1 and 26.2 ± 4.2 mmHg in group 2 ($P = 0.62$). The failure rate, defined as intraocular pressure >21 mmHg with maximal medications, was 17.2% in group 1 and 27.6% in group 2 at 5-year follow-up ($P = 0.53$). Eight eyes (27.6%) in group 1 required medications to control the intraocular pressure to below 21 mmHg. There was no statistically significant difference in the intraocular pressure reductions between the two groups at all time intervals ($P > 0.05$). The mean number of antiglaucoma medications was significantly lower in the SLT than the medical treatment group up to 5 years of follow up ($P < 0.001$). Transient post-SLT intraocular pressure spike >5 mmHg was observed in three eyes (10.3%).

**Conclusion:** With fewer medications, SLT gives similar intraocular pressure reduction to medical therapy alone in Chinese patients with primary open-angle glaucoma or ocular hypertension.

**Key words:** ocular hypertension, primary open-angle glaucoma, selective laser trabeculoplasty.

### INTRODUCTION

Laser treatment of the trabecular meshwork has become a widely accepted modality for the management of glaucoma since Wise and Witter described a technique using argon laser (wavelength 488 nm) in 1979.[1] They placed laser burns on the trabecular meshwork (TM) and effectively increased the aqueous drainage and lowered the intraocular pressure (IOP). Diode laser (wavelength 790–850 nm) and continuous wave Neodymium:Yttrium-aluminium-garnet (cw Nd:YAG) laser (wavelength 1064 nm) were also used by others with comparable IOP lowering effect and less postlaser inflammation.[2,3] The exact mechanism of action of laser trabeculoplasty is unknown but there is evidence showing the destructive nature of this treatment modality. Histological studies showed coagulative damage in the form of cellular necrosis and disruption of trabecular beams in the TM.[4,5] The use of laser trabeculoplasty was limited by the lack of long-term IOP lowering effect[6,7] and the associated complications including pain, uveitis, peripheral anterior synechiae, sector sphincter pupillae palsy and increased risk of Tenon cyst after trabeculectomy.[8–11]

Selective laser trabeculoplasty using a Q-switched, frequency-doubled Nd:YAG laser (wavelength 532 nm) selectively targets pigmented TM cells, thereby lowering the IOP without causing damage to the tissues adjacent to the TM. Studies have shown that SLT was effective in lowering the IOP in patients with primary open-angle glaucoma (POAG), ocular hypertension (OHT) and in patients previously treated with argon laser trabeculoplasty (ALT).[12–14] However, long-term studies on the effectiveness and safety of SLT, especially in Asian eyes, are limited. Asian eyes have more pigmented TM and thus the laser energy required and the clinical response might be different from eyes with lightly pigmented TM.

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This randomized, prospective study evaluated the effectiveness and safety of SLT compared with medical treatment in patients with POAG or OHT in Chinese eyes.

## METHODS

The study was approved by the Ethics Committee of the Chinese University of Hong Kong. Patients newly diagnosed with POAG or OHT were included in the study. All patients had IOP >21 mmHg in both eyes without antiglaucomatous medications and those with POAG demonstrated optic disc changes and/or visual field changes typical of glaucomatous damage. Exclusion criteria included previous laser trabeculoplasty, previous intraocular surgery disturbing the aqueous outflow, active ocular inflammation, poor visualization of the trabecular meshwork, single eye and pregnancy. Written informed consent was obtained from every patient prior to the study.

Patients included in this study were screened twice with an interval of 2 weeks before receiving the laser treatment. During the first screening examination, the following were recorded: IOP measured with Goldmann applanation tonometer, best-corrected visual acuity by the standard Snellen chart, slit-lamp biomicroscopy of the anterior segment, gonioscopy, fundal examination including the assessment of cup/disc ratio and visual field assessment by static automated perimetry (Humphrey full-threshold central 30–2 program).

Intraocular pressure measurement with Goldmann applanation tonometry was performed at the second screening examination. Patients were excluded if the baseline IOP of one eye differed from the fellow eye by more than 15% at either of the two screening visits. For recruited subjects, IOP was measured in two separate visits. The average of the two measurements was taken as the baseline IOP. One eye of each patient was randomized by computer-generated allocation schedule to receive SLT (Group 1) and the fellow eyes received medical treatment (Group 2). To minimize the extent of cross-over effect with medical treatment, patients were instructed to apply digital lacrimal punctual pressure for 5 min after instilling the eye drops.

The laser procedure was performed by one surgeon (JSML) under topical anaesthesia with proparacaine. One drop of 1% apraclonidine was instilled into the eye to receive SLT 1 h prior to treatment. The Selecta 7000 frequency-doubled Q-switched Nd:YAG laser (Coherent, Palo Alto, CA, USA) was used. A 3-mirror Goldmann goniolens was placed on the cornea and the trabecular meshwork was brought into focus using the modified Coherent LDS-10 slit lamp with LAS-10 spot mirror illumination.

The initial laser energy was set at 0.8 mJ. A single laser pulse was delivered starting at the 12 o'clock position. The energy was then increased or decreased by 0.1 mJ until bubble formation became just invisible. Treatment was then continued in single-burst mode at this energy level until about 100 non-overlapping laser spots were placed throughout 360° of the TM. Immediately following laser treatment, one drop of 1% apraclonidine and 1% prednisolone acetate were administered to the laser-treated eye. The prednisolone acetate eye drop was continued at a frequency of 4 times per day for 7 days.

Intraocular pressures of the laser-treated and the fellow eyes were measured with Goldmann applanation tonometer hourly for 2 h following SLT and continued to be monitored hourly if the rise was more than 5 mmHg. Anterior chamber reaction was assessed by slit-lamp biomicroscopy. For the fellow eyes, topical antiglaucoma medications including β-blocker, pilocarpine, dorzolamide and latanoprost were started either as monotherapy or in combination 2 h after SLT.

Patients were followed up after 1 day, 1 week, 2 weeks, 1 month, 3 months and 6 months and then yearly after the laser treatment. During these visits, the following parameters were assessed: IOP measured with Goldmann applanation tonometer, best-corrected visual acuity by the standard Snellen chart, slit-lamp biomicroscopy of the anterior segment, gonioscopy, fundal examination including assessment of the cup/disc ratio. The degree of TM pigmentation and the presence of peripheral anterior synechiae were recorded.

The primary aim of this study was to evaluate the IOP lowering effect and safety of SLT. The outcome was analysed based on the magnitude of the IOP reduction and the mean number of medications at yearly follow-up intervals. Failure was defined as IOP > 21 mmHg on maximal tolerated medications.

## RESULTS

A total of 64 eyes of 32 patients were included in the study from March to June 1998 at the Prince of Wales Hospital, the Chinese University of Hong Kong. Three patients defaulted follow up within 6 months of commencement of treatment and were excluded. Data from the remaining 29 patients (58 eyes) were analysed. Twenty-four patients (82.8%) were successfully followed up yearly for a period of 5 years. All patients were Chinese with dark brown iris. The mean age was 51.9 ± 14.7 years with 13 men and 16 women. Seventeen patients were diagnosed to have POAG and 12 had OHT. The best-corrected visual acuity ranged from 0.1 to 1.0 in group 1 and from 0.2 to 1.0 in group 2. The mean cup/disc ratio was 0.4 ± 0.2 in group 1 and 0.5 ± 0.2 in group 2 ($P = 0.95$, Student's $t$-test). The mean baseline IOP was 26.8 ± 5.6 mmHg in Group 1 and 26.2 ± 4.2 mmHg in Group 2 ($P = 0.62$, Student's $t$-test).

The mean IOP reduction was 8.6 ± 6.7 mmHg (32.1%) in group 1 and 8.7 ± 6.6 mmHg (33.2%) in group 2 at the 5-year follow-up visit ($P = 0.95$, Student's $t$-test). Figure 1 shows the short and long-term mean IOP reductions after treatment in both groups. There was no significant difference in the mean IOP reductions between the two groups from day 1 to the last follow up at 5 years. In the SLT group, eight eyes (27.6%) required additional medical therapy to

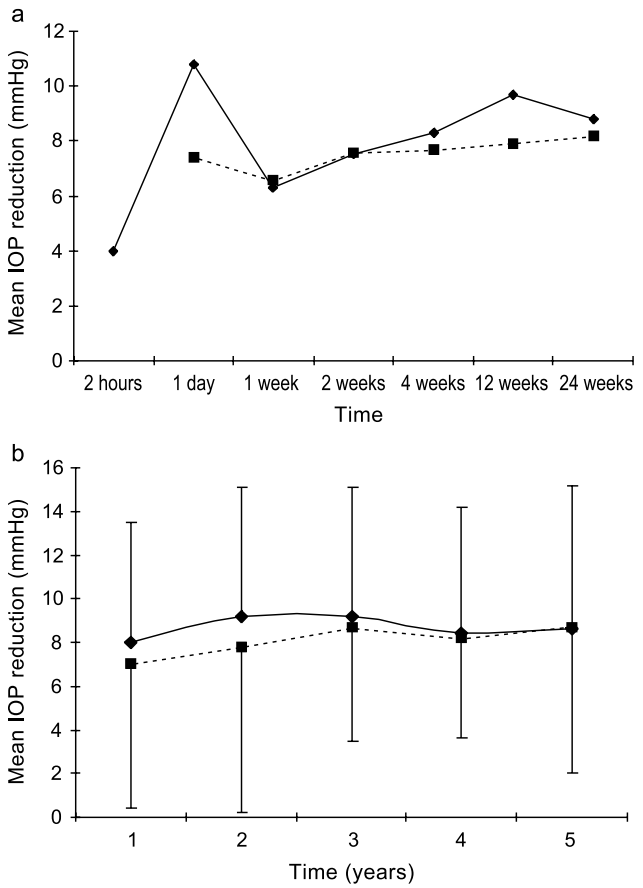


**Figure 1.** (a) Short-term and (b) long-term intraocular pressure (IOP) reductions in (◆) the selective laser trabeculectomy group and (■) the medical treatment group. $P > 0.05$ at all time intervals (Student's *t*-test).

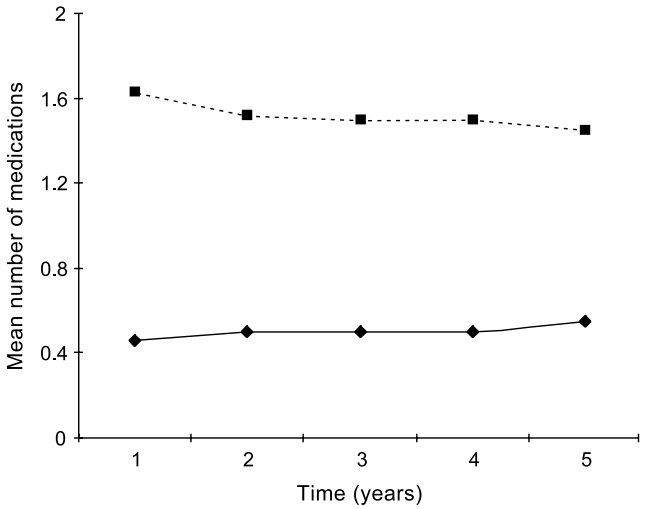


**Figure 2.** Mean number of medications in (◆) the selective laser trabeculectomy group and (■) the medical treatment group. $P < 0.001$ at all time intervals (Student's *t*-test).

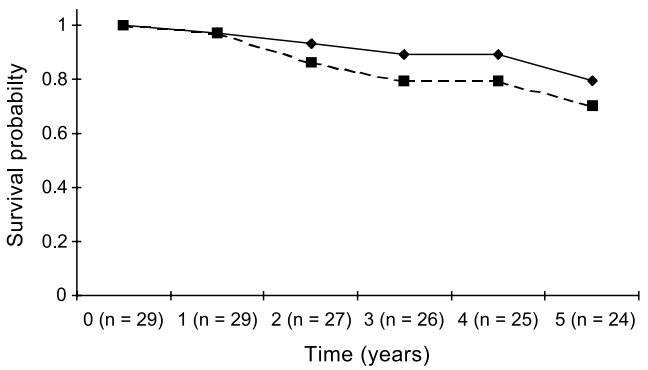


**Figure 3.** Kaplan–Meier curve showing survival probability of (◆) the selective laser trabeculectomy group and (■) the medical treatment group.

control the IOP to below 21 mmHg. One of these eight eyes required supplementary medication as early as 4 weeks after the SLT and the remaining seven eyes only required supplementary medications 1 year after SLT. The mean number of medications required for IOP control remained significantly lower in the SLT than the medical treatment group up to the last follow up at 5 years ($P < 0.001$, Student's *t*-test). Figure 2 shows the mean number of medications at various time points. The mean number of medications required to control the IOP ranged from 0.46 to 0.55 in the SLT group and from 1.45 to 1.63 in the medical treatment group. The number was significantly lower in the SLT group during the 5-year follow up ($P < 0.001$).

Five eyes (17.2%) in the SLT group and eight eyes (27.6%) in the medical treatment group had IOP >21 mmHg despite maximal medications and required filtration surgery. However, the difference in the failure rates defined as IOP >21 mmHg on maximal medications was not statistically significant ($P = 0.53$, $\chi^2$ test). The Kaplan-Meier curve in Fig. 3 shows the survival probability of both treatment groups. In the remaining patients, those in the medical treatment group were put on either topical β-blocker, pilocarpine, dorzolamide, latanoprost or various combinations of them. In the SLT group, the eight patients who required supplementary medications during 5-year follow up were put on topical β-blocker. Two of them required dorzolamide and one required latanoprost in addition to the β-blocker.

The mean laser energy per spot to achieve the endpoint was $1.0 \pm 0.1$ mJ. The mean total laser energy used was $73.6 \pm 16.4$ mJ. Transient postlaser IOP spike of greater than 5 mmHg was observed in three eyes (10.3%). No persistent anterior chamber reaction beyond 1 week post-laser was recorded. No patients in group 1 had increase in TM pigmentation or formation of peripheral anterior synechiae as a result of the laser treatment. The mean cup/disc ratio at 5 years was $0.5 \pm 0.2$ in group 1 and $0.5 \pm 0.2$ in group 2. There was no statistically significant change compared to the pretreatment ratio. ($P = 0.80$ group 1, $P = 0.78$ group 2, Student's *t*-test.)

## DISCUSSION

Argon laser trabeculoplasty, introduced by Wise and Witter, effectively decreases IOP in patients with POAG[1] but the laser energy induces thermal injury in the pigmented TM cells with concurrent damage to the adjacent non-pigmented cells and collagen trabecular beams.[4,5] SLT is a frequency-doubled Q-switched Nd:YAG (wavelength 532 nm) laser system that delivers energy with short pulse duration and low fluence to the target tissues. It selectively targets pigmented TM cells without coagulative damage to the adjacent tissues, and histological studies showed minimal damage in the trabecular beams and endothelial cells in eyes treated with SLT.[15]

We adopted the regimen of using 1% apraclonidine 1 h before and immediately after SLT. Only three eyes (10.3%) had increased IOP >5 mmHg within 2 h after laser treatment. These three patients were monitored hourly and the IOP came down to <5 mmHg of baseline within 4 h after laser treatment. The incidence is lower than the ALT series reported in the Glaucoma Laser Trial Research Group (34%)[16] and the SLT series reported by Latina *et al.* (24%).[12] The mean laser energy per spot required to reach the end-point in our pigmented eyes was similar to that required in non-Asian eyes. No persistent anterior chamber reaction beyond 1 week postlaser was recorded with the use of topical 1% prednisolone acetate.

From our study, the mean IOP in Group 1 of the SLT-treated eyes started to decrease by 4.0 mmHg (14.9%) 2 h after treatment before antiglaucoma medication was given to the fellow eye. It continued to drop by 10.8 mmHg (40.3%) on day 1 but the decrease in IOP became less dramatic after the first week and became stabilized after the first month with a reduction of 8.3 mmHg (31.0%) (Fig. 1a). The immediate IOP response to SLT in our group of patients was similar to that reported by Lanzetta *et al.*[13] Damji *et al.* also reported immediate IOP reduction 1 h after SLT and ALT.[14] They also showed that SLT was equivalent to ALT in lowering the IOP in the first 6 months after treatment. In Group 2, the mean IOP decreased by 7.4 mmHg (28.2%) on day 1 but the magnitude became less after the first week and stabilized after the first month with a reduction of 7.7 mmHg (29.4%) (Fig. 1a).

The IOP lowering effect of SLT was maintained for 5 years in the majority of cases. Only 13 eyes required the addition of antiglaucoma medications for control of IOP, of which more than 90% occurred at least 1 year after SLT. Out of these 13 eyes, eight had IOP controlled below 21 mmHg and five required filtration surgery. In the medical group, eight eyes with failed maximal medical treatment required filtration surgery. Our results in terms of IOP reductions, number of medications reduction and the failure rate compare favourably with other SLT studies.[12–15,17,18]

The major flaw of this study is the evaluation of the effects of SLT and medications on the same patient. The contralateral effect of topical beta-adrenergic antagonists was reported to be significant in the Ocular Hypertensive Treatment Study.[19] We tried to minimize this cross-over effect by applying lacrimal punctual pressure for 5 min after administration of eye drops. Ariturk *et al.* have shown that occlusion of the nasolacrimal canal by plugging the punctum significantly increased the IOP reduction effect of antiglaucoma eye drops but there was no significant change in the IOP in the unplugged eyes.[20] Nevertheless our results should be interpreted with the potential overestimation of the IOP lowering effect of SLT.

In conclusion, the IOP lowering effect of SLT in this group of Chinese patients with POAG or OHT is effective. SLT significantly reduces the number of antiglaucoma medications required for IOP control. Its IOP lowering effect is fast in onset and is maintained in the majority of cases up to 5 years. Immediate postlaser IOP spike and persistent anterior chamber reaction were minimized by the use of apraclonidine and short-term topical steroid, respectively. Long-term excessive angle scarring in the form of peripheral anterior synechiae was not noted. The overall clinical response was similar to reported series in non-pigmented eyes.

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