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Original Article

# Effectiveness of Selective Laser Trabeculoplasty as Initial or Adjunctive Treatment for Primary Open-Angle Glaucoma

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**Abstract**

**Objectives:** The aim of this study was to evaluate the effectiveness of selective laser trabeculoplasty (SLT) at lowering intraocular pressure (IOP) as initial or adjunctive treatment in patients with primary open-angle glaucoma (POAG).

**Methods:** This was a prospective, comparative study. A total of 162 eyes of 81 patients with bilateral POAG were evaluated. The patients were categorized into 2 groups. SLT was performed as an adjunctive treatment in 42 POAG patients (Group 1, 84 eyes) and as initial treatment in 39 POAG patients (Group 2, 78 eyes).

**Results:** The mean baseline IOP and post-SLT IOP for the entire study group was 23.3±4.8 mm Hg and 14.6±2.7 mm Hg, respectively. The mean percentage reduction of IOP post-SLT at the final visit was 34.5% in Group 1 and 40.5% in Group 2. The number of medications used in the Group 1 before SLT was 2.11±0.88 (range: 1-4), while after SLT, medication use decreased to 0.9 ±0.15 (range: 0-3). The mean length of follow-up was 49.85±8.2 weeks (range: 24-78 weeks).

**Conclusion:** SLT can be used effectively as a primary or an adjunctive therapy for the treatment of POAG. It was also effective at reducing the quantity of medications used. The reduction in IOP was similar in the primary and adjunctive group for up to 1 year of follow-up.

**Keywords:** Antiglaucomatous treatment, primary open angle glaucoma, selective laser trabeculoplasty.

## Introduction

Glaucoma is a progressive and degenerative disease of the optic nerve that is one of the leading causes of blindness. One of the primary goals in order to preserve sight is intraocular pressure control (IOP). There are several methods to reduce IOP, including pharmaceutical treatment, laser treatment, and glaucoma surgery (1, 2).

Laser therapy is now used to treat glaucoma. One laser method is argon laser trabeculoplasty (ALT); however, it has limitations. It can lead to disruption and coagulative damage of the trabecular meshwork (3). Therefore, the procedure cannot be performed again (4). A second laser method is selective laser trabeculoplasty (SLT), which is based on selective photothermolysis of pigmented trabecular cells without any collateral structural damage to the trabecular meshwork (5-7). This method has the benefits of using 80-100 times less energy than ALT, preservation of the trabecular meshwork architecture in animal models, and being a potentially repeatable procedure (8). SLT can be performed as an adjunctive or a primary therapy for patients with glaucoma (9). A number of reports have demonstrated the efficacy of SLT as an IOP-lowering initial treatment for newly diagnosed primary open-angle glaucoma (POAG) (9-14).

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Antiglaucomatous medications (AGM) are commonly used as a first-line treatment for glaucoma, but include disadvantages, such as adverse drug effects, required repeated use of the drugs, and medical costs. The effectiveness of the treatment may be lessened if patients are non-compliant. AGM also have wide fluctuations in IOP results due to trough effects or not using the medications at the appropriate times, as well as worsening the prognosis of glaucoma surgery as a result of changes to the ocular surface. SLT may be a preferred initial treatment option for POAG to drug therapy.

SLT is also used as adjunctive therapy to medication. It may reduce the number of needed medications in medically controlled eyes, and can prevent or delay the need for glaucoma surgery.

The objective of this prospective study was to evaluate the safety and efficacy of SLT as a means to lower IOP as an initial or adjunctive treatment in patients with POAG.

## Methods

### Patient Selection

POAG was defined as IOP of >22 mm Hg (recalculated) regarding to central corneal thickness (CCT) measured on 2 separate occasions combined with either a glaucomatous visual field defect or optic disc changes. In all cases, the results of a glaucoma hemifield test were outside out of the normal limits.

The results of SLT performed in 162 eyes of 81 patients diagnosed with bilateral POAG were analyzed. The patients were categorized into 2 groups: Group 1 consisted of patients treated with AGM. SLT was offered to patients who were noncompliant with AGM therapy, poorly controlled on medications, or requested fewer medications. Laser therapy was performed as adjunctive therapy in Group 1 (84 eyes of 42 patients). Group 2 comprised patients with a recent POAG diagnosis and no previous use of AGM. Laser therapy was performed as primary therapy in Group 2 (78 eyes of 39 patients).

The inclusion criteria applied were age >18 years, POAG diagnosis, adequate visualization of the angle, and no previous SLT treatment. Patients were excluded if there were advanced visual field defects observed with automated perimetry, ocular surgery within 1 year, any previous surgery for glaucoma, identifiable secondary glaucoma, use of systemic or topical steroids, or monocular status.

### Study Design

This was a prospective, comparative clinical study. Data prospectively recorded for each patient included age, sex, IOP, glaucoma medications, CCT measurement, visual field analysis, and the SLT protocol. A detailed ophthalmological examination was performed before recruitment for the laser treatment. A Goldmann applanation tonometry IOP assessment, slit-lamp examination, gonioscopy examination, and fundoscopy evaluation of cup/disc ratio and pallor were performed. At least 2 preoperative IOP measurements were performed within 3 weeks before the laser therapy. The average of the preoperative IOP values was used as the baseline IOP.

Approval for the data collection and study analysis was granted by the local ethics committee. Informed consent was obtained from all of the patients before each procedure and the study was conducted according to the tenets of the Declaration of Helsinki.

### SLT Procedure

The procedures were performed in the hospital glaucoma clinic by a single ophthalmologist. The patients were treated using a Coherent Selecta 7000 laser (Coherent, Inc., Palo Alto, CA, USA), a frequency-doubled, Q-switched neodymium-doped yttrium aluminum garnet (Nd: YAG) laser with a beam emission of 532 mm, a pulse duration of 3 ns, and a spot size of 400 mm, coupled with a slit-lamp delivery. The Latina SLT Gonio laser lens (Ocular Instruments, Inc., Bellevue, WA, USA) was used to visualize the angle. The procedure was performed with topical proparacaine for anesthesia. The pigmented trabecular meshwork was targeted and non-overlapping laser spots were placed in the entire 360° of trabecular meshwork. The laser energy was initially set at 0.8 mJ and increased by 0.1 mJ increments until bubble formation occurred. When bubble formation was seen, treatment was continued at this minimal energy level. The total number of pulses and total amount of energy were recorded. The patients did not receive any topical steroids or non-steroidal anti-inflammatory medications after the procedure. No permanent adverse effects of SLT were noted in any of the patients. Follow-up was performed at 1 week and 1, 3, 6, and 12 months. At each follow-up visit, IOP was measured using a Goldmann applanation tonometer. The mean IOP change and mean percentage decrease in IOP from baseline to the last postoperative visit was calculated.

### Target Intraocular Pressure

A target IOP was determined for each patient based on the American Academy of Ophthalmology Guideline (15). The aim of glaucoma treatment is to maintain the IOP in a range at which a glaucomatous eye is likely to remain stable or at which worsening of glaucoma will be slow enough that the risk of additional treatment is not justified. The estimated upper limit of this range is called the target pressure. The

initial target pressure is an estimate and a means to protect the patient's vision. Therefore, we individualized the target pressure goal and sometimes made adjustments to this target during the course of the disease. An automated visual field test and ocular coherence tomography were used if an adjustment was required. If the SLT did not provide a target IOP, AGM was initiated. If the AGM treatment was not sufficient to achieve the target IOP, the quantity of medication was increased.

### Statistical Analysis

The data were analyzed using IBM SPSS Statistics for Windows, Version 22.0 statistical software (IBM Corp., Armonk, NY, USA). A paired samples t-test was used to compare IOP values before and after SLT treatment. An independent samples t-test was used to compare the mean IOP of Group 1 and Group 2. A p value of <0.05 was considered statistically significant. Descriptive statistics were used for age, gender, CCT, and follow-up time per group. The Mann-Whitney U test was used to assess gender difference.

## Results

The mean age of the patients was 64.4±12.1 years (range: 26-88 years). The mean age was 64.8 years (range: 38-88 years) in Group 1 and 64.02 years (range: 26-84 years) in Group 2. The patient age, mean CCT, follow-up time, and IOP pre and post SLT are presented in Table 1. The mean baseline IOP for the total number of subjects was 23.3±4.8 mm Hg (range: 10-35 mm Hg). The mean post-SLT IOP for the total study group was 14.6±2.7 mm Hg (range: 8-22 mm Hg). The decrease in mean IOP after SLT was statistically significant at the last visit (p<0.001). The mean percentage reduction of IOP post SLT at the final visit was 34.5%.

The mean IOP of the groups were also compared. The mean baseline IOP was 22.9 mm Hg (range: 10-34 mm Hg) in Group 1 (adjunctive treatment in patients using AGM) and 23.8 mm Hg (range: 14-35 mm Hg) in Group 2 (primary treatment with no preoperative medication use). The baseline IOP was not significantly different between the 2 study groups (Table 2). The mean post-SLT IOP for Group 1 was 15 mm Hg (range: 10-22 mm Hg), whereas the post-SLT IOP for Group 2 was 14.2 mm Hg (range: 8-21 mm Hg). The post-SLT IOP values were not significantly different between the 2 study groups (Table 2). The decrease in the mean IOP after SLT in each group was statistically significant at the final visit (p<0.001). The mean percentage reduction of IOP post SLT at the last visit was 34.5% in Group 1 and 40.5% in Group 2.

If the target IOP was not reached in patients with SLT treatment, AGM use was initiated or increased in both groups. Table 3 provides the study data of successful achievement of the target IOP with SLT alone, with additional treatment, and failure to reach the target IOP. In Group 1, 52.3% were successful with just SLT, and in Group 2, 65.3% successfully achieved the target IOP with only SLT treatment. In Group 1, at the last visit, 60 of 84 patients (71.5%) had decreased or eliminated the use of glaucoma medications after SLT treatment. At the final visit, 51 of 78 Group 2 patients (65.3%) had not found initiation of glaucoma medication necessary after the SLT procedure.

The mean number of AGM used in Group 1 before SLT was 2.11±0.88 (range: 1-4) for a mean of 16.1 months (range: 9-48 months), while after the SLT procedure, medication use decreased to a mean of 0.9±0.15 (range: 0-3). The difference was statistically significant (p<0.001). AGM use was discontinued in 44 eyes after SLT, reduced in 16 eyes, remained the same in 18 eyes, and increased in 6 eyes. The AGM use before and after SLT is illustrated in Table 4. The use of AGM was considered necessary in 26 out of 78 eyes in order to reach the target IOP despite SLT in Group 2, with a mean of 0.3±0.12 (range: 0-3) medications.

**Table 1.** Characteristics of the patients

| Characteristics of the patients (n=81) | |
|---|---|
| Age | 64.4±12.1 years |
| Pre-SLT IOP | 23.3±4.8 mmHg |
| Post-SLT IOP | 14.6±2.7 mmHg |
| CCT | 511.9±39.1 µm |
| Follow-up | 49.85±8.2 weeks |

CCT: Central corneal thickness; IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty.

**Table 2.** Characteristics and IOP values of both groups

| | Characteristics of the groups | | |
|---|---|---|---|
| | Group 1 (n=42) | Group 2 (n=39) | p |
| Number of eyes | 84 | 78 | |
| Age (years) | 64.8±11.6 | 64.02±12.8 | 0.68 |
| Gender (female/male) | 19/20 | 20/23 | 0.27 |
| CCT pre-SLT (µm) | 522.8±36.1 | 511.3±39.8 | 0.08 |
| Pre-SLT IOP (mm Hg) | 22.9±5.2 | 23.8±4.4 | 0.32 |
| Post-SLT IOP (mm Hg) | 15.0±2.6 | 14.2±2.8 | 0.38 |
| Follow-up time (weeks) | 50.09±9.1 | 49.5±7.2 | 0.62 |

CCT: Central corneal thickness; IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty.

**Table 3.** Target IOP success with SLT and adjunctive glaucoma therapy

| | Laser and additional treatments | | |
|---|---|---|---|
| | **Group 1, n (%)** | **Group 2, n (%)** | **Total, n (%)** |
| Target IOP with SLT alone | 44 (52.3) | 51 (65.3) | 95 (58.6) |
| Target IOP with SLT and additional treatment | 81 (96.4) | 74 (94.9) | 155 (95.7) |
| Failure to achieve target IOP | 3 (3.6) | 4 (5.1) | 7 (4.3) |

IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty.

**Table 4.** The number of antiglaucomatous medications used before and after SLT in Group 1

| | Antiglaucomatous medication use | |
|---|---|---|
| **Number of medications** | **Baseline visit (eyes) (%)** | **Final visit (eyes) (%)** |
| 4 | 8 (9.5) | 0 (0) |
| 3 | 14 (16.6) | 10 (11.9) |
| 2 | 42 (50) | 22 (26.1) |
| 1 | 20 (23.8) | 8 (9.5) |
| 0 | 0 (0) | 44 (52.3) |

SLT: Selective laser trabeculoplasty.

## Discussion

The results of this study indicated that SLT effectively decreased IOP as a primary or adjunctive treatment to AGM in patients with POAG. The mean±SD baseline IOP for all eyes was 23.3±4.8 mm Hg and the final IOP measurement was 14.6±2.7 mm Hg, a reduction of 37%. No significant differences were observed between the groups in the average percentage of decrease in IOP.

Latina et al. (9) studied 101 patients (45 patients on maximum AGM and 56 patients with previous failed ALT) treated with SLT. They found a 70% success rate based on a 3-mm Hg (20%) or greater reduction in IOP and no additional medication needed 6 months after treatment. Gracner (10) prospectively applied 180° SLT to 50 eyes of 28 patients with medically uncontrolled POAG. After 6 months, a mean pre-treatment IOP of 22.48 mm Hg was reduced by 5.06±2.37 mm Hg (22.5%). In another study of patients with medically uncontrolled POAG, the mean IOP reduction from the baseline was 4.0 mm Hg (15.8%) 9 months after SLT, and 4.2 mm Hg (16.6%) 12 months after SLT (11). In our study, SLT as an adjunctive therapy (Group 1) yielded a 7.9 mm Hg (34.5%) decline in IOP at the end of 50.09±9.1 weeks of follow-up. This is consistent with previously published studies. In our study, SLT alone was sufficient to reach the target IOP in 52.3% of the eyes. The addition of AGM treatment led to success in 94.9% of the eyes studied. The success rate in Group 1, where patients previously using glaucoma medications were able to discontinue or decrease the use of medication following SLT, was 71.5% (60 of 84 eyes). These results support the finding that SLT can reduce the medication burden in medically controlled eyes or can be an adjunctive treatment to medication. It also potentially allows for the use of fewer medications in a majority of patients with medically controlled or uncontrolled POAG.

Several studies have suggested that SLT might be a primary therapy for POAG or ocular hypertension (OHT). Melamed et al. (12) found that 40 of 45 eyes (89%) that underwent SLT as primary treatment had an IOP decrease of 5 mm Hg or more. The mean IOP reduction was 7.7 mm Hg (30%) 18 months after SLT treatment. McIlraith et al. (13) also performed a clinical trial to investigate the efficacy of SLT as an initial treatment for newly diagnosed POAG. Of 100 eyes in 61 subjects, 74 eyes received SLT and 26 were treated with latanoprost. After 12 months, the mean IOP reduction was similar in the SLT (8.3 mm Hg, 31%) and latanoprost (7.7 mm Hg, 30.6%) groups. These nonrandomized, prospective studies by Melamed et al. (12) and McIlraith et al. (13) investigating the use of SLT as initial therapy reported an approximately 30% reduction in IOP compared with the baseline level, which is comparable with our study findings. The mean percentage reduction of IOP post SLT at the final visit was 40.5% in the present study. This may, in part, be a result of the use of non-complicated POAG cases in the

present study, since our clinic is a primary eye center. Nagar et al. (14) treated 167 eyes in 167 patients in a prospective, randomized trial. The success rates (defined as 20% or 30% IOP lower than the baseline without additional AGM therapy at 1 year) of latanoprost and 360° SLT treatment were similar. Lai et al. (16) prospectively enrolled 29 patients newly diagnosed with POAG or OHT with no previous history of AGM use, ALT, or glaucoma surgery. One eye of each patient was randomly assigned to undergo 360° SLT, and topical medical treatment was used in the other eye. They found no significant difference in the IOP reduction between the 2 groups. Katz et al. (17) prospectively compared the outcome of SLT with medical therapy in glaucoma patients. They found that the IOP reduction was similar in SLT and medication groups after 9 to 12 months follow-up. Shazly at al. (18) found a mean IOP reduction of 5.7±2.1 mm Hg with SLT in a POAG group at 30 months of follow-up. The literature results support the option of SLT as a safe and effective initial therapy to reduce IOP in POAG. In studies published to date, the success rate of SLT varies from 40% to 84% (1, 12-14, 16-18). In the present study, SLT used as primary therapy (Group 2) achieved a 65.3% success rate at a mean of 49.5±7.2 weeks of follow-up. The target IOP was reached with only SLT in 65.3% of eyes. The target IOP was reached with SLT and additional anti-glaucomatous treatment in (94.9%) of the eyes. These findings further support the consideration of SLT as a first-line treatment option in POAG.

Among our patients using preoperative glaucoma medications (Group 1), the mean number of medications used significantly statistically decreased throughout the study period, from 2.11±0.88 (range: 1-4) before SLT to 0.9±0.15 (range: 0-3) at the end of approximately 1 year ($p<0.001$). These results are comparable to those of Abdelrahman et al. (19), who reported a decrease in the number of medications required after SLT from 2.25±0.97 to 1.00±1.3 at postoperative 18 months. Francis et al. (20) prospectively examined the ability of SLT to decrease the number of medications used by 66 patients with medically controlled POAG or exfoliative glaucoma while maintaining a predetermined target IOP. During the 12 months of follow-up, 87% of the patients successfully decreased their medication use. After 6 months, the mean number of medications used decreased by 2.8±1.1 and after 12 months by 1.5±0.9. Medical therapy is most often used as an initial treatment strategy to lower the IOP in patients with POAG. However, the effectiveness of the treatment may be reduced if patients are non-compliant. Hence, SLT may offer a safe and effective alternative or an additional IOP-lowering option to medical therapy (19-24).

The present study found no significant statistical differences between Group 1 and Group 2 in the baseline IOP ($p=0.32$), post-SLT IOP ($p=0.38$), or IOP reduction at the end of approximately 12 months of follow-up. The mean percentage reduction in IOP treated with SLT as an adjunctive treatment was 34.5% and a mean reduction of 40.5% was observed in eyes treated with SLT as a primary treatment. There were no significant differences between the groups with regard to the mean percentage reduction of IOP after SLT.

One of the limitations of our study was the rather short length of follow-up. Selection bias could also be a limitation to our findings. All of the patients were treated at a primary glaucoma center where the patient population tends to have early and newly diagnosed glaucoma. In addition, the method of using 2 eyes of the same patient may be considered a limitation. We recognize that such simple randomization can be problematic in relatively small-sized clinical trials.

Nonetheless, this study provides evidence that SLT can be performed safely and effectively as a primary or an adjuvant treatment for patients with POAG to achieve IOP reduction. The reduction of IOP was similar in the primary and adjunctive groups of this comparative study after up to 1 year of follow-up.

SLT should be considered a good choice for patients who cannot tolerate medication or with poor compliance as a primary treatment, and it can be selected as an adjunct treatment to medication. Adherence to medication use, drug side effects, and the costs of medical therapy are important considerations. The results of present study indicate that SLT is effective as a primary therapy to reduce IOP, has few side effects, reduces the medication burden in medically controlled eyes, and can prevent the need for glaucoma surgery in eyes poorly controlled with maximal medical therapy. SLT is easy to perform, has an excellent safety profile, and is well tolerated by patients.

**Disclosures**

**Ethics Committee Approval:** Selcuk University, Ethics Committee of Clinical Research, 2014/6.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

**Authorship Contributions:** Involved in design and conduct of the study (HIY, MO); preparation and review of the study (HIY, MO); data collection (HIY, MO); and statistical analysis (HIY, MO).

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