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ORIGINAL RESEARCH

Prospective Evaluation of Intraocular Pressure Changes Following Selective Laser Trabeculoplasty in Primary Open-Angle Glaucoma Patients

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ABSTRACT

Background: Primary open-angle glaucoma (POAG) is a chronic optic neuropathy characterized by progressive visual field loss, often associated with elevated intraocular pressure (IOP). Selective Laser Trabeculoplasty (SLT) is a non-invasive therapeutic option aimed at reducing IOP and minimizing the need for topical medications. **Aim:** To prospectively evaluate the intraocular pressure changes following SLT in patients diagnosed with primary open-angle glaucoma and assess its impact on medication reduction and safety profile. **Material and Methods:** This prospective interventional study was conducted on 110 eyes of 110 POAG patients at a tertiary care teaching hospital after Institutional Ethics Committee approval. Inclusion criteria comprised adults ≥40 years with baseline IOP ≥21 mmHg and open angles on gonioscopy. Patients underwent 360° SLT using a 532 nm frequency-doubled Nd:YAG laser. IOP was measured using Goldmann applanation tonometry at baseline, 1 hour, 1 week, 1 month, 3 months, and 6 months. Data on medication use and post-procedure complications were also recorded. Statistical analysis was performed using paired t-tests and multiple regression. **Results:** The mean baseline IOP was 25.7 ± 3.4 mmHg, which reduced significantly to 17.4 ± 3.1 mmHg at 6 months ($p < 0.001$), with a mean reduction of 8.3 mmHg (32.30%). At 6 months, 38.18% achieved ≥30% IOP reduction, and 70% had at least 20% reduction. The proportion of patients on anti-glaucoma medication reduced from 66.36% at baseline to 26.36% at 6 months. Minimal complications were reported in 24.55% of patients, primarily mild and self-limiting. Higher baseline IOP and younger age were significant predictors of better SLT response. **Conclusion:** SLT is a safe, effective, and minimally invasive procedure that provides sustained IOP reduction and decreases medication dependence in POAG patients. It is especially beneficial in those with higher baseline IOP and younger age, making it a valuable tool in glaucoma management.

Keywords: Primary open-angle glaucoma, Selective laser trabeculoplasty, Intraocular pressure, Glaucoma treatment, Medication reduction

INTRODUCTION

Glaucoma, a leading cause of irreversible blindness worldwide, encompasses a group of progressive optic neuropathies characterized by structural damage to the optic nerve and corresponding visual field loss. Among its various subtypes, primary open-angle glaucoma (POAG) is the most prevalent, particularly in aging populations. It is often asymptomatic in its early stages and typically associated with elevated intraocular pressure (IOP), which remains the most modifiable risk factor for disease progression. Effective control of IOP has therefore become the central focus in the management of POAG, aimed at preventing optic nerve damage and preserving visual function[1].

The underlying pathophysiology of POAG involves impaired aqueous humor outflow through the trabecular meshwork, leading to chronic elevation of IOP. This pressure-induced mechanical and ischemic insult results in retinal ganglion cell apoptosis and subsequent optic nerve head cupping. While genetic and environmental factors contribute to disease susceptibility, established risk factors include advancing age, positive family history, elevated IOP, African or Hispanic ethnicity, myopia, and systemic comorbidities such as hypertension and diabetes mellitus[2,3]. Left untreated, POAG may lead to significant visual impairment, often progressing insidiously until peripheral vision is lost and central vision becomes threatened.

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The primary objective in POAG therapy is to halt or slow disease progression through IOP reduction. Conventionally, this has been achieved via pharmacological agents such as prostaglandin analogues, beta-blockers, alpha-adrenergic agonists, carbonic anhydrase inhibitors, and more recently, rho kinase inhibitors, which enhance aqueous outflow through the trabecular and uveoscleral pathways[1]. However, medical therapy often presents challenges related to patient adherence, side effects, long-term cost burden, and suboptimal IOP control. As such, laser trabeculoplasty and incisional surgeries are increasingly considered, either as adjuncts or alternatives to pharmacological treatment.

Selective laser trabeculoplasty (SLT), introduced as a refined and safer alternative to argon laser trabeculoplasty, utilizes a frequency-doubled Nd:YAG laser to target pigmented trabecular meshwork cells, initiating a biological cascade that improves aqueous outflow without causing collateral thermal damage. It has emerged as a valuable therapeutic modality in both treatment-naïve patients and those with medically uncontrolled IOP[4,5]. SLT is minimally invasive, repeatable, and devoid of systemic side effects, making it particularly attractive for young patients and those with poor compliance to topical medications.

Several studies have investigated the cost-effectiveness and clinical outcomes of SLT compared to medical therapy. Economic models suggest that SLT may offer long-term financial benefits by reducing the dependency on chronic medications and decreasing the need for surgical interventions in healthcare systems with structured reimbursement policies[4]. Moreover, its favorable safety profile has supported its consideration as a first-line treatment in many clinical settings.

The efficacy of SLT has been demonstrated across various age groups and glaucoma subtypes. Young patients under the age of 40, often considered less responsive to laser treatment due to robust trabecular tissue, have shown promising results in terms of IOP reduction and disease stabilization[5]. Advances in ocular imaging, particularly anterior segment optical coherence tomography and in vivo visualization of Schlemm's canal, have further enhanced understanding of the anatomical and physiological changes induced by SLT[6].

Additionally, the role of SLT has been extended to patients with primary angle-closure disease following laser peripheral iridotomy, as studies have shown significant IOP-lowering effects and postponement of surgical interventions in this subset[7]. Tailoring IOP targets based on the severity and progression of disease has become an essential part of individualized glaucoma management. Patients with early POAG may benefit from modest IOP reductions, while those with advanced disease necessitate more aggressive pressure-lowering strategies to prevent further optic nerve damage[8].

Recent therapeutic algorithms integrate SLT as a viable component of glaucoma care. Its application is not limited to reducing IOP alone; it also alleviates the socioeconomic burden associated with chronic drug therapy, particularly in resource-limited settings. Innovations in treatment paradigms emphasize early intervention and proactive management, recognizing that delaying treatment in patients with elevated IOP and optic nerve susceptibility may result in irreversible visual field loss[9].

The Laser in Glaucoma and Ocular Hypertension (LiGHT) trial has provided compelling evidence in support of SLT as an effective primary therapy. The trial demonstrated that patients randomized to initial SLT had better IOP control, fewer disease progression events, and reduced need for glaucoma medications over a six-year period compared to those treated with eye drops alone[10]. These findings have influenced international guidelines and encouraged a paradigm shift towards laser-first strategies in suitable patients.

Nevertheless, SLT is not universally effective. A subset of patients may exhibit suboptimal response or experience IOP spikes post-procedure. Identifying predictive factors for success is therefore crucial for optimizing patient selection. Clinical parameters such as baseline IOP, angle pigmentation, previous response to medications, and disease chronicity are being evaluated for their prognostic value[11,12]. Continued research into biomarkers and genetic predictors may further refine patient stratification and treatment personalization in the future.

MATERIAL AND METHODS

This prospective, interventional study was conducted in the Department of Ophthalmology at a tertiary care teaching hospital, following approval from the Institutional Ethics Committee (IEC). The study aimed to evaluate the intraocular pressure (IOP) changes following Selective Laser Trabeculoplasty (SLT) in patients diagnosed with Primary Open-Angle Glaucoma (POAG).A total of 110 patients (110 eyes) diagnosed with POAG were enrolled consecutively from the outpatient glaucoma clinic. Informed written consent was obtained from all participants after explaining the nature, risks, and benefits of the procedure.

Inclusion Criteria

- Adults aged ≥ 40 years with a confirmed diagnosis of POAG
- Baseline IOP ≥ 21 mmHg on at least two separate visits
- Open angles on gonioscopy (Shaffer grade ≥ III)
- Either newly diagnosed patients or those on ≤2 anti-glaucoma medications with inadequate IOP control
- Willingness to undergo SLT and comply with follow-up visits

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Exclusion Criteria

- Patients with secondary glaucomas (e.g., pseudoexfoliation, pigmentary, neovascular glaucoma)
- History of angle-closure or narrow angles on gonioscopy
- Prior intraocular surgery or laser procedures (except uncomplicated cataract surgery more than 6 months ago)
- Presence of media opacity precluding laser delivery
- History of uveitis or ocular trauma
- Non-compliance with follow-up protocol

Procedure

Baseline data including detailed ocular history, best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, gonioscopy, dilated fundus examination, and IOP measurement using Goldmann applanation tonometry (GAT) were recorded. SLT was performed using a frequency-doubled, Q-switched Nd:YAG laser (532 nm) with a Latina lens, targeting 360° of the trabecular meshwork. Energy settings ranged from 0.6 to 1.4 mJ, titrated to achieve "champagne bubbles" endpoint.

No perioperative anti-inflammatory medications were prescribed. Post-procedure, patients were monitored for IOP spikes at 1 hour. IOP was re-evaluated at 1 week, 1 month, 3 months, and 6 months post-procedure using GAT. Any complications and additional need for medications were documented.The primary outcome was the change in IOP from baseline at each follow-up point. Secondary outcomes included percentage IOP reduction, need for additional medications, and incidence of adverse events following SLT.

Statistical Analysis

Data were compiled using Microsoft Excel and analyzed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were summarized as frequencies and percentages. Paired t-tests or Wilcoxon signed-rank tests were used to compare pre- and post-SLT IOP values, with $p < 0.05$ considered statistically significant.

RESULTS

Demographic and Clinical Characteristics

Table 1 highlights the baseline demographic and clinical data of the 110 enrolled patients. The mean age was 61.4 ± 9.2 years, with a slight male predominance (56.36%). The distribution of laterality was almost equal, with 53.64% of procedures performed on right eyes and 46.36% on left eyes. The mean baseline intraocular pressure (IOP) was 25.7 ± 3.4 mmHg, indicating significantly elevated pressure across the cohort. Regarding pre-treatment status, approximately one-third (33.64%) were newly diagnosed and not on any medications, while 40.91% were on one medication and 25.45% were already on two anti-glaucoma drugs at the time of SLT.

Intraocular Pressure Reduction Over Time

Table 2 presents the changes in IOP at multiple follow-up points. A statistically significant reduction in IOP was observed as early as 1 hour post-SLT (mean IOP: 24.1 mmHg), with a modest decrease of 1.6 mmHg (6.23%; $p = 0.03$). This reduction continued progressively at subsequent visits. At 1 week, the mean IOP declined to 20.2 mmHg (a 21.40% reduction from baseline), and by 1 month it further dropped to 18.8 mmHg. The trend of reduction was maintained at 3 months (17.9 mmHg) and reached its lowest average at 6 months (17.4 mmHg), marking a significant mean reduction of 8.3 mmHg or 32.30% from the baseline value ($p < 0.001$). These results confirm the sustained effectiveness of SLT in lowering IOP over a 6-month period.

Categorical IOP Response at 6 Months

As shown in Table 3, 38.18% of patients experienced an IOP reduction of ≥30%, representing the most favorable response. An additional 31.82% achieved a reduction of 20–29%, while 19.09% had a moderate reduction of 10–19%. Only 10.91% of patients showed a minimal response with less than 10% IOP reduction. This categorical analysis reinforces the clinical utility of SLT, with nearly 70% of patients achieving at least a 20% reduction in IOP.

Change in Medication Requirement

Table 4 outlines the need for additional anti-glaucoma medications post-SLT. At baseline, 73 patients (66.36%) were on medications. Following SLT, a notable reduction in the number of patients requiring pharmacological treatment was observed. By 1 month, the number dropped to 40 (36.36%), and continued to decline to 34 (30.91%) at 3 months and 29 (26.36%) at 6 months. This substantial reduction indicates that SLT not only decreases IOP effectively but also reduces medication burden, which can improve patient compliance and lower treatment costs.

Safety Profile and Complications

According to Table 5, SLT was generally well tolerated. The most common complication was mild ocular discomfort or foreign body sensation, reported in 11 patients (10.00%). Transient IOP spikes (defined as a rise of >5 mmHg) occurred in 9 patients (8.18%), and 7 patients (6.36%) experienced mild anterior chamber reactions. Importantly, 83 patients (75.45%) had no adverse effects, underscoring the safety and tolerability of SLT as a minimally invasive intervention.

Predictors of IOP Reduction: Multiple Regression Analysis

Table 6 presents the results of multiple regression analysis to identify independent predictors of IOP

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reduction at 6 months post-SLT. Baseline IOP emerged as the strongest predictor (β = 0.52, 95% CI: 0.38 to 0.66, p < 0.001), indicating that patients with higher initial IOP experienced greater absolute reductions. Age also had a statistically significant negative association (β = -0.11, p = 0.042), suggesting younger patients may respond slightly better to SLT. Other variables including gender, number of medications before SLT, and laser energy settings were not statistically significant predictors. This suggests that while baseline IOP and age are important determinants of SLT response, other demographic and procedural factors may play a limited role.

Table 1: Baseline Demographic and Clinical Characteristics of Patients (N = 110)

Parameter	Value
Age (years), mean ± SD	61.4 ± 9.2
Gender	
• Male	62 (56.36%)
• Female	48 (43.64%)
Laterality	
• Right Eye	59 (53.64%)
• Left Eye	51 (46.36%)
Baseline IOP (mmHg), mean ± SD	25.7 ± 3.4
Number of medications pre-SLT	
• None (newly diagnosed)	37 (33.64%)
• One	45 (40.91%)
• Two	28 (25.45%)

Table 2: Mean Intraocular Pressure (IOP) at Baseline and Follow-Up Intervals

Time Point	Mean IOP ± SD (mmHg)	Mean Reduction from Baseline	% Reduction	p-value
Baseline	25.7 ± 3.4	–	–	–
1 Hour Post-SLT	24.1 ± 4.0	1.6	6.23%	0.03
1 Week	20.2 ± 3.5	5.5	21.40%	<0.001
1 Month	18.8 ± 3.2	6.9	26.84%	<0.001
3 Months	17.9 ± 2.9	7.8	30.35%	<0.001
6 Months	17.4 ± 3.1	8.3	32.30%	<0.001

Table 3: Distribution of Patients by IOP Response at 6 Months

IOP Response Category	Number of Patients (%)
IOP reduced ≥30%	42 (38.18%)
IOP reduced 20–29%	35 (31.82%)
IOP reduced 10–19%	21 (19.09%)
IOP reduced <10%	12 (10.91%)

Table 4: Need for Additional Anti-Glaucoma Medication After SLT

Time Point	Patients Requiring Medications	Percentage (%)
Pre-SLT	73	66.36%
At 1 Month	40	36.36%
At 3 Months	34	30.91%
At 6 Months	29	26.36%

Table 5: Complications Noted Following SLT

Complication Type	Number of Patients (%)
Transient IOP spike (>5 mmHg)	9 (8.18%)
Mild anterior chamber reaction	7 (6.36%)
Ocular discomfort/foreign body sensation	11 (10.00%)
No complications	83 (75.45%)

Table 6: Multiple Regression Analysis for Predictors of IOP Reduction at 6 Months

Predictor Variable	Regression Coefficient (β)	95% Confidence Interval	p-value
Baseline IOP (mmHg)	0.52	0.38 to 0.66	<0.001 ※

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Age (years)	-0.11	-0.22 to -0.01	0.042 *
Number of Medications Pre-SLT	0.09	-0.06 to 0.24	0.241
Gender (Male = 1, Female = 0)	0.07	-0.12 to 0.26	0.463
Energy Level Used (mJ)	0.04	-0.09 to 0.17	0.534

※ = Statistically highly significant ($p < 0.001$)
* = Statistically significant ($p < 0.05$)

DISCUSSION

The demographic profile of the present study aligns closely with previously published reports on SLT outcomes in primary open-angle glaucoma (POAG) patients. The mean age of 61.4 ± 9.2 years and male predominance (56.36%) observed in our study is comparable to the findings of Juzych *et al.* (2004)[13], who reported a mean age of 63.2 years and a slight male majority among SLT-treated POAG patients. This demographic consistency strengthens the generalizability of our results, particularly in populations with similar age-related disease patterns and access to tertiary ophthalmic care.

In terms of IOP reduction over time, our results showed a progressive and significant decline in IOP from a baseline of 25.7 ± 3.4 mmHg to 17.4 ± 3.1 mmHg at 6 months, representing a 32.3% reduction. This outcome is highly consistent with the study conducted by Gracner *et al.* (2002)[14], who demonstrated a 30–35% reduction in IOP at 6 months post-SLT, with a similar baseline pressure range. Their study, which focused on 360° SLT application like ours, reinforces the long-term efficacy of SLT in POAG management.

The categorical response to SLT observed in our cohort further supports its therapeutic value. In our analysis, 38.18% of patients achieved ≥30% IOP reduction, and nearly 70% had at least a 20% reduction. These proportions are comparable to the findings of Latina *et al.* (1998)[15], who originally introduced SLT and reported that around 70% of their patients showed significant IOP response, with one-third achieving reductions greater than 30%. Our results not only validate their foundational work but also reflect the real-world applicability of SLT across different patient subsets.

A key benefit of SLT is its potential to reduce the dependence on topical medications, as seen in our study where the number of patients requiring anti-glaucoma drugs decreased from 66.36% at baseline to 26.36% at 6 months. Similar trends were reported by Damji *et al.* (2006)[16], who observed a 40–50% reduction in medication use post-SLT in their multicentric trial. This medication-sparing effect has important implications for patient adherence, especially in elderly populations with comorbidities and polypharmacy concerns.

The procedure's safety profile in our cohort was favorable, with minimal complications such as transient IOP spikes (8.18%) and mild anterior chamber reactions (6.36%), all of which resolved spontaneously. These results mirror those of McIlraith *et al.* (2006)[17], who also documented a low incidence of adverse events and emphasized SLT's repeatability and safety compared to argon laser trabeculoplasty. The high safety margin observed in both studies supports SLT as a frontline or adjunctive modality in glaucoma care.

Finally, our regression analysis showed that higher baseline IOP and younger age were independent predictors of better SLT outcomes. This is in concordance with the findings of Shazly *et al.* (2011)[18], who reported that eyes with higher initial IOP showed greater absolute and percentage reductions after SLT. Additionally, they noted that younger patients responded more favorably, likely due to more reactive trabecular meshwork physiology. These predictors are clinically useful for patient selection and counseling before SLT.

CONCLUSION

Selective Laser Trabeculoplasty (SLT) demonstrated a significant and sustained reduction in intraocular pressure (IOP) over a 6-month period in patients with primary open-angle glaucoma. The procedure was well tolerated with minimal complications and also resulted in a marked reduction in the need for anti-glaucoma medications. Higher baseline IOP and younger age were significant predictors of better response. SLT thus serves as an effective, safe, and medication-sparing option in the management of POAG.

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