BMC Ophthalmology

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Selective laser trabeculoplasty for the treatment of intraocular pressure elevation after viscocanalostomy with Ologen implant in the management of primary open-angle glaucoma: a retrospective cohort study

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Abstract

Background Selective laser trabeculoplasty (SLT) is a non-invasive treatment option for glaucoma. It uses a Q-switched Nd: YAG laser. The aim of this study was to evaluate the efficacy of SLT as a treatment option for eyes with primary open-angle glaucoma (POAG) that have previously undergone viscocanalostomy with an Ologen implant, displaying uncontrolled intraocular pressure (IOP).

Methods This retrospective cohort study included 26 eyes of 26 patients with POAG who had had SLT after viscocanalostomy or phacoviscocanalostomy with Ologen implant. These eyes showed a progression of glaucomatous damage, the IOP was above 21 mmHg, or with intolerable glaucoma medications. SLT was done using Tango Reflex multimodality YAG/SLT laser which is a Q-switched Nd: YAG laser producing a single 532 nm wavelength pulse with a 400 mm spot size and 3 ns pulse duration. The follow-up period was one year.

Results One year post-SLT, complete success was achieved in 19 cases (73.1%), qualified success in 4 cases (15.4%), and failure in 3 cases (11.5%). The mean decrease in IOP was 5.64 ± 4.05 mmHg, the mean reduction of antiglaucoma medications was 1.00 ± 0.85, and the mean percentage of reduction in IOP was 23.5 ± 16.4. There was a statistically significant decrease in IOP and antiglaucoma medications (p = < 0.01).

Conclusion SLT is a simple and effective procedure that can be used as a treatment option for eyes with POAG after viscocanalostomy with Ologen implant to reach the target IOP and decrease the number of antiglaucoma medications.

Keywords SLT, Open-angle glaucoma, Viscocanalostomy

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Background

Primary open-angle glaucoma (POAG) is a slowly progressive optic neuropathy in which intraocular pressure (IOP) is the main, principal, and only treatable risk factor. It is characterized by visual field loss and optic disc changes. It is one of the most important causes of irreversible blindness [1].

Surgical intervention may be warranted to manage IOP and achieve the designated target IOP in instances where medical treatments prove ineffective or when patients experience intolerance to medications. Trabeculectomy stands as the established surgical approach for addressing glaucoma. Non-penetrating glaucoma surgeries, such as viscocanalostomy and deep sclerectomy, are emerging as viable alternatives. Viscocanalostomy presents as a preferable option with fewer complications compared to trabeculectomy, including reduced occurrences of complications such as bleb leakage, hypotony, and bleb-associated complications [2–4].

Selective laser trabeculoplasty (SLT) is a non-invasive treatment option for glaucoma. It was approved by the Food and Drug Administration in 2001 [5, 6]. The mechanism by which SLT reduces the IOP remains unclear [7]. SLT uses a Q-switched, frequency-doubled Nd: YAG laser that selectively targets the pigmented cells of the trabecular meshwork with no damage to the adjacent structures [5, 6]. It causes IOP reduction similar to Argon laser trabeculoplasty (ALT) but with less damage and no coagulative effects on the trabecular meshwork. [5, 6, 8–9] SLT produces a 20–30% reduction in IOP in eyes with POAG [10, 11].

This work aimed to assess SLT as a treatment option to decrease the IOP to reach the designated target IOP in eyes with POAG after viscocanalostomy or phacoviscocanalostomy with Ologen implant whose IOP remained or became uncontrolled.

Table 1 Demographic and preoperative data for patients who underwent selective laser trabeculoplasty after viscocanalostomy

Parameters	
Sex, *n* (%)	14 (53.85)
Male	12 (46.15)
Female	
Age, yrs	23–78
Range	51.38 ± 15.72
Mean ± SD	
Baseline IOP, mmHg	12–28
Range	21.81 ± 3.86
Mean ± SD	
Baseline medications, *n*	0–3
Range	1.58 ± 1.17
Mean ± SD	
Type of initial surgery	15 (57.69)
Viscocanalostomy	11 (42.31)
Phacoviscocanalostomy	

Methods

This was a retrospective cohort study done for eyes with POAG who had had SLT after viscocanalostomy or phacoviscocanalostomy with Ologen implant to control the IOP. Between May 2019 and May 2022, sixty-three patients underwent viscocanalostomy or phacoviscocanalostomy with an Ologen implant for uncontrolled IOP. The patients were followed up by IOP, visual field examination using Humphrey field analyzer (HFA; Carl Zeiss Meditec Inc., Oberkochen, Germany), and optical coherence tomography (RTvue XR Avanti system OCT, Optovue, Inc., CA, USA) to confirm the stabilization of glaucoma. Patients were included in the study if they had mild or moderate glaucoma according to Hodapp, Parrish, and Anderson System (HPA) system [12] and the postoperative follow-up IOP was above 21 mmHg, there is a proven glaucoma deterioration and the IOP was above the target level, or the patient did not tolerate the medical treatment. The target IOP was defined according to the European Glaucoma Society guidelines “Target IOP is an estimate of the mean IOP obtained with treatment that is expected to prevent further glaucomatous damage” [13]. The upper limit of the target IOP was set according to Sihota et al. as 18 mmHg in mild glaucoma and 15 mmHg in moderate glaucoma [14]. Patients were excluded if they had other types of glaucoma, advanced glaucoma (according to the HPA grading system), patients under 18 years old, or if the postoperative follow-up period was less than one year after SLT.

Selective laser trabeculoplasty

Selective laser trabeculoplasty was performed using the Tango Reflex multimodality YAG/SLT laser system (Ellex Medical Pty. Ltd., Manson Lakes, Australia), a Q-switched Nd: YAG laser that emits a single 532 nm wavelength pulse with a 400 mm spot size and 3 ns pulse duration. The initial power setting ranged from 0.8 to 1.2 mJ and was adjusted until the appearance of champagne bubbles was observed. Before the procedure, patients received a single drop of topical benoxinate hydrochloride 0.4%. A three-mirror goniolens (Ocular, Bellevue, WA, USA) was utilized with 2.5% hydroxypropyl methylcellulose to enhance the visualization of angle structures. The treatment session comprised laser application to 180° of the trabecular meshwork, with 50 to 60 adjacent non-overlapping laser spots performed inferiorly. Post-procedure IOP was assessed around 30 min post-treatment to detect early pressure spikes. IOP measurements were conducted using a Goldmann applanation tonometer, except for immediate post-procedure checks, for which the iCare TA01i tonometer (Icare Finland Oy, Vantaa, Finland) was employed. In cases where re-treatment was indicated, at least one month after the initial session, the laser was applied to the superior 180°

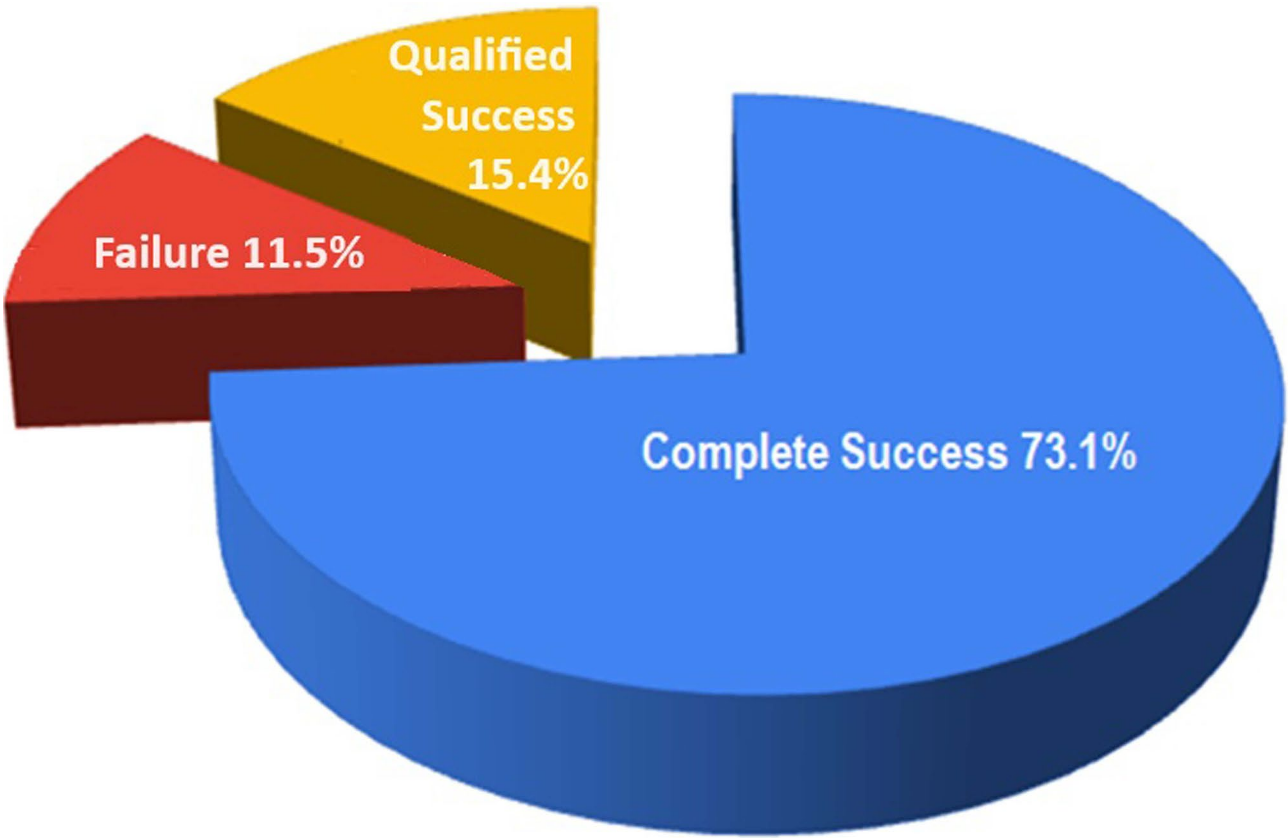

Fig. 1 Success results after one year of selective laser trabeculoplasty after viscocanalostomy for eyes with POAG and previous glaucoma filtering surgery ($n=26$)

of the trabecular meshwork in a similar manner. The follow-up period spanned 12 months postoperatively, with IOP measurements taken at one week, one month, three months, six months, and one year after SLT. The primary outcome measure was IOP levels at the one-year follow-up, with complete success defined as achieving the target IOP without or with only one antiglaucoma medication. Qualified success was defined when the target IOP was reached with two antiglaucoma medications, while failure was defined when the postoperative target IOP could not be attained despite the use of two antiglaucoma medications.

Statistical analysis

The data were subjected to analysis using the Statistical Package for Social Science (SPSS) version 16.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were presented as mean ± SD and compared utilizing the student t-test. The two-tailed test was employed to ascertain significance between the two groups, while the one-tailed t-test was utilized to determine significance before and after the intervention within the same group. Nonparametric data are displayed by median and range. For comparing data on paired analysis, the Wilcoxon signed-rank test was used in comparing indecently. Regarding the type of surgery, Mann Whitney U is used independently. Categorical variables were expressed as numbers and percentages and underwent analysis using the chi-square ($\chi 2$) test. A p-value < 0.05 was deemed statistically significant.

In cases where patients were classified as failures during the follow-up period, baseline IOP measurements were utilized for follow-up statistical analysis.

Results

The study encompassed a cohort of twenty-six eligible patients, with 53.8% (14 patients) exhibiting mild glaucoma and 46.2% (12 patients) presenting with moderate glaucoma. Detailed demographic information for the cohort is outlined in Table 1. The initial SLT was conducted within 15 days to four months following goniopuncture. Successful IOP control was achieved with a single SLT session in four eyes (15.4%). A second SLT session was administered to 21 eyes (80.8%) due to reasons such as uncontrolled IOP (8 eyes), IOP re-elevation (7 eyes), intolerance to medications (4 eyes), and a combination of IOP re-elevation with medication intolerance (2 eyes). The second session SLT was done from

Table 2 Results of selective laser trabeculoplasty after viscocanalostomy ($n=26$)

Parameters		*P* value
Intraocular pressure, mmHg (mean ± SD) Baseline One-year post-SLT	21.81 ± 3.86 16.35 ± 3.39	< 0.01*
Antiglaucoma medications, *n* median (range). Baseline One-year post-SLT	2 (0–3) 0 (0–3)	< 0.01†

* Student t-test

†Wilcoxon signed-rank test

one month to 4 months following the initial SLT. Failure to respond to the first SLT session was observed in one eye (3.9%), and consequently, a second session was not performed. This particular patient was referred for an alternative treatment approach, with baseline IOP considered in subsequent follow-up analyses. During the first week following treatment, transient adverse events were reported, including discomfort in 6 eyes (23.1%), transient uveitis in 8 eyes (30.8%), and an IOP spike in 5 eyes (19.2%).

One year post-SLT, complete success was observed in 19 eyes (73.1%), qualified success in 4 eyes (15.4%), and failure in 3 eyes (11.5%), Fig. 1. There were significant reductions in IOP and antiglaucoma medications ($p<0.01$), Table 2. Figure 2 illustrates the IOP levels from baseline to the one-year follow-up after SLT. The mean IOP reduction after SLT was 6.50 ± 3.02 mmHg at 3 months, 6.42 ± 3.36 mmHg at 6 months, and 5.64 ± 4.05 mmHg at one year. At the one-year post-SLT, the mean reduction in antiglaucoma medications was 1.00 ± 0.85. The mean percentage of reduction in IOP after SLT was 28.8 ± 10.7 at 3 months, 28.3 ± 12.7 at 6 months, and 23.5 ± 16.4 at 12 months, as illustrated in Fig. 3.

The patients were further categorized into two groups: viscocanalostomy group ($n=15$) and phacoviscocanalostomy ($n=11$). Demographic information and one-year outcomes for both groups are presented in Table 3. Except for age, there were no statistically significant differences between the two groups in terms of preoperative data. While the mean IOP and medication use in the phacoviscocanalostomy group (both preoperatively and postoperatively) were lower than those in the viscocanalostomy group, these differences did not reach statistical significance. The rate of complete success was 66.7% (10 cases) in the viscocanalostomy group and 81.8% (9 cases) in the phacoviscocanalostomy group, whereas qualified success was observed in 20.0% (3 cases) of the viscocanalostomy group and 9.1% (1 case) of the phacoviscocanalostomy group. Failure rates were 13.3% (2 cases) in the viscocanalostomy group and 9.1% (1 case) in the phacoviscocanalostomy group. However, there were no statistically significant differences in success rates between the two groups. Figure 4 illustrates the IOP levels at baseline and the one-year follow-up in both groups after SLT.

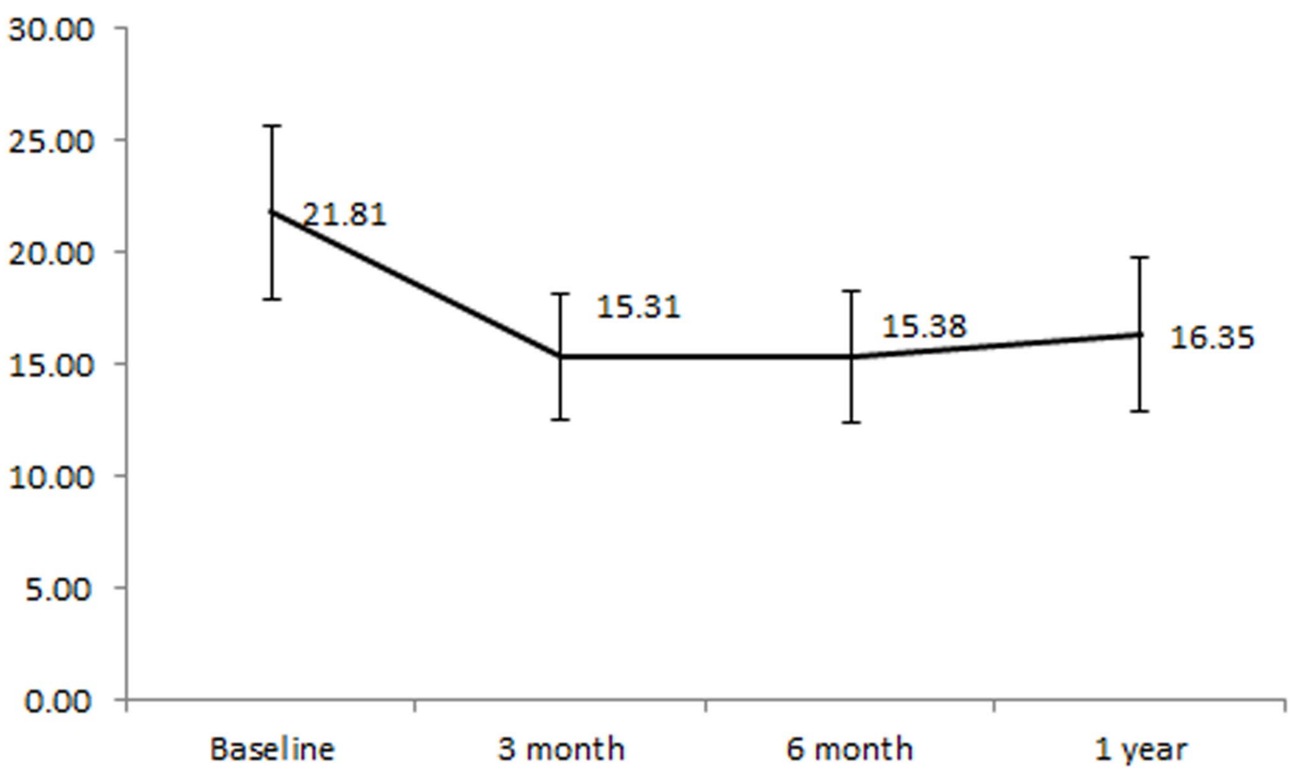

Fig. 2 Baseline and one-year follow-up after selective laser trabeculoplasty ($n=26$); mean ± SD intraocular pressure (mmHg)

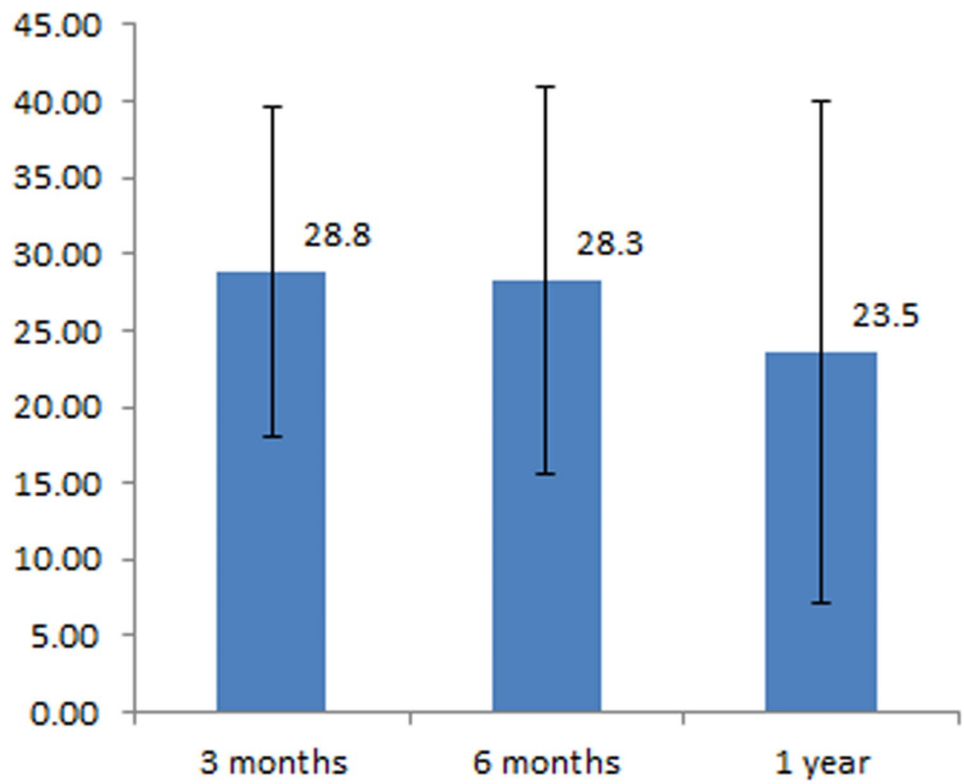

Fig. 3 Mean ± SD percentage of reduction of the intraocular pressure (mmHg) after selective laser trabeculoplasty (*n* = 26)

Discussion

Table 3 Comparison between selective laser trabeculoplasty after viscocanalostomy or phacoviscocanalostomy

Parameters	Viscocanalostomy (*n* = 15)	Phacoviscocanalostomy (*n* = 11)	*P* value
Sex, *n* (%) Male Female	8 (53.33) 7 (46.67)	6 (54.55) 5 (45.45)	0.95**
Age, yrs Range Mean ± SD	23–60 40.27 ± 10.31	60–78 66.55 ± 5.56	< 0.001*
Baseline IOP, mmHg Range Mean ± SD	12–28 22.20 ± 3.91	13–26 21.27 ± 3.90	0.56*
IOP after 1 year, mmHg Range Mean ± SD	12–25 16.93 ± 3.13	12–26 15.55 ± 3.72	0.33*
Baseline medications, *n* Median (range)	2 (0–3)	2 (0–3)	0.64†
Medications after 1 year, *n* Median (range)	0 (0–3)	0 (0–3)	0.61†
Results after 1 year, *n* (%) Success Qualified success Failure	10 (66.67) 3 (20.00) 2 (13.33)	9 (81.81) 1 (9.09) 1 (9.09)	0.39‡ 0.45‡ 0.74‡

* Student t-test

† Mann-Whitney U test

‡ X^2 test

This retrospective cohort study was conducted on eyes diagnosed with POAG that had undergone prior viscocanalostomy or phacoviscocanalostomy with Ologen implant, yet experienced uncontrolled IOP. The aim was to evaluate the efficacy of SLT as an intervention to reduce IOP and achieve the targeted IOP levels. Our findings indicate favourable outcomes in 23 out of 26 patients (88%). Over the one-year follow-up period, patients experienced a significant reduction in IOP and/or a decrease in the need for antiglaucoma medications, successfully reaching the targeted IOP. Notably, three cases were identified as not attaining the target IOP despite using a maximum of two antiglaucoma medications.

The success rate observed in this study aligns with findings from previous research, which has reported rates ranging from 64 to 89%. The variability in success rates across studies is attributed to differences in the definition of the target IOP [15–19].

We observed that the reduction in IOP achieved through SLT in glaucoma patients who underwent cataract surgery is comparable to that in phakic patients. Specifically, individuals who underwent phacoemulsification exhibited a slightly, but statistically insignificant, lower mean IOP both before SLT and one year after SLT compared to phakic patients. This observed decrease in mean IOP in eyes who had undergone cataract surgery may be attributed to the impact of cataract extraction.

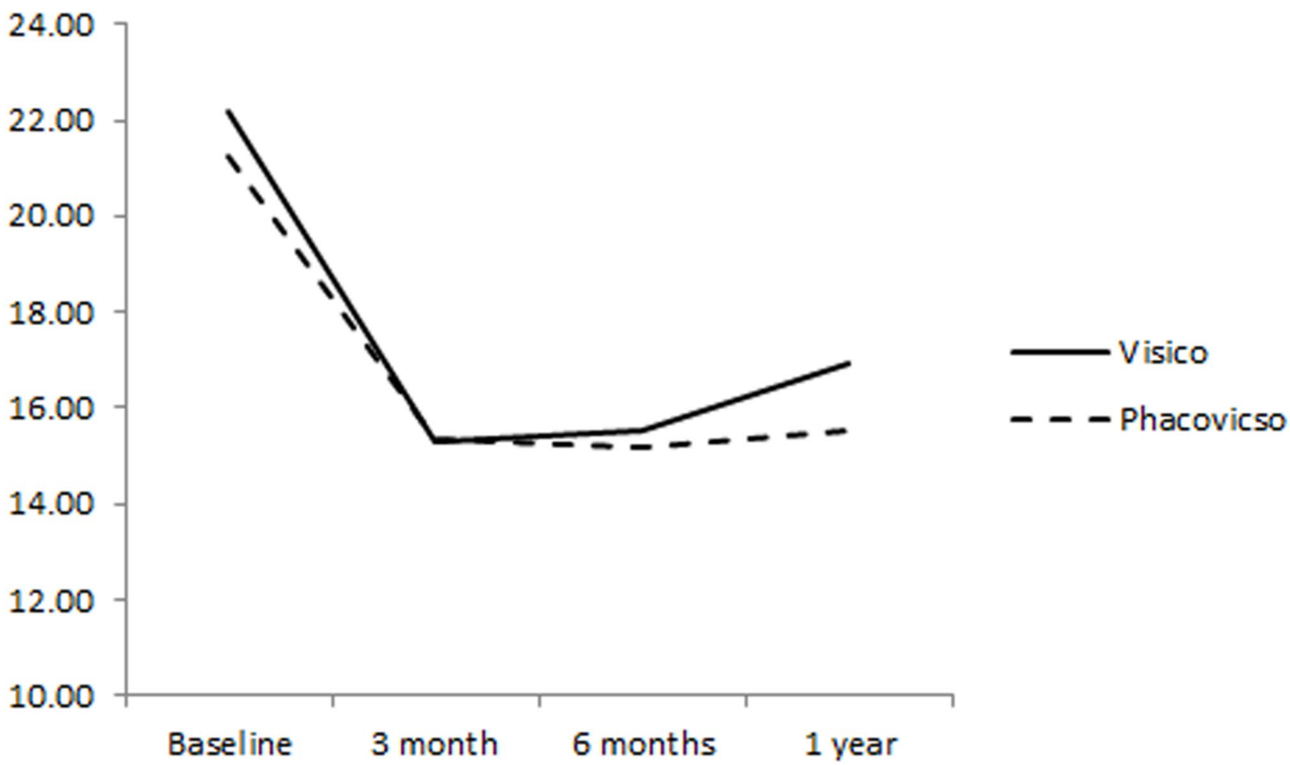

Fig. 4 Mean baseline IOP (mmHg) and one-year follow-up after selective laser trabeculoplasty in viscocanalostomy ($n = 15$) and phacoviscocanalostomy group ($n = 11$)

A previous study demonstrated that the efficacy of SLT in reducing IOP is notably greater when applying treatment to 180° or 360° of the angle, as opposed to a 90° laser treatment. However, no significant distinction in pressure-lowering effectiveness was observed between the application of 180° and 360° laser treatment [20]. We applied laser treatment for 180° of the angle in the first session. A subsequent SLT session was deemed necessary for 81% of patients (21 individuals) who did not attain the targeted IOP following the initial session. The additional impact of the second session effectively lowered the IOP, successfully reaching the target in 19 patients. Consequently, a strategic approach involves treating 180° of the angle initially and reserving the remaining half for a potential second session, if required.

The effectiveness of SLT in managing POAG is akin to that of ALT, albeit with a reduced impact on the trabecular meshwork [21]. The limited trabecular damage associated with SLT theoretically suggests a potential for long-term success compared to ALT. The formation of trabecular membranes may be a contributing factor to the observed prolonged loss of effect after ALT [18, 21–23]. In this study, a one-year follow-up revealed a loss of SLT effect in only 2 cases (8%). However, an extended follow-up period is essential to comprehensively evaluate the long-term impact of SLT. The mechanisms underlying the pressure-lowering effects of SLT remain not fully elucidated. Sherwood et al. proposed a biological theory to explain SLT's impact on reducing IOP. They posited that trabecular photocoagulation induces a biological response that may contribute to a subsequent reduction in IOP [24].

In this study, the one-year follow-up demonstrated a mean IOP reduction of 6.30 mmHg, with a maximum reduction of 12 mmHg. The mean percentage reduction in IOP was 27%, with a maximum reduction of 43%. Consequently, the selection of a patient with glaucoma for SLT hinges on factors such as the target IOP, baseline IOP, and baseline medications. The baseline IOP levels and medications should align with the typical IOP-lowering effects of SLT, as indicated in the literature, where the range is generally reported to be between 20% and 30%.

Prior research has established the sustained efficacy of SLT. In a study involving Chinese patients, SLT significantly reduced IOP and decreased the need for antiglaucoma medications to maintain IOP control. LiGHT study has found that SLT is a safe treatment for open-angle glaucoma, it gives better long-term IOP control than antiglaucoma medications and it should be offered as a first-line treatment for open-angle glaucoma [25, 26]. Also, Sharpe et al. have found that SLT is an efficacious procedure in eyes with prior incisional glaucoma surgery and resulted in IOP reductions comparable to eyes without prior incisional glaucoma surgery [27]. Siedlecki et al. have found SLT is an effective therapy after iStent implantation in glaucoma medication reduction in iStent patients [28]. In addition, SLT has been proven to have no negative effect on the IOP lowering effect of iStent inject® implantation [29]. Lia et al. have found that the pressure-lowering effect is rapid and, in the majority of cases, is maintained for up to 5 years [30].

Our findings suggest that SLT is a simple, safe, and effective procedure for managing IOP to attain the targeted levels of IOP and/or reduce the reliance on antiglaucoma medications in eyes affected by POAG following viscocanalostomy or phacoviscocanalostomy with Ologen implant. The overall success rate of SLT in this context reached 85%, with a mean IOP reduction of 5.64 mmHg and the mean decrease in the number of antiglaucoma medications was 1.0. The limitations of the study were its retrospective design, small sample size, and short follow-up period. Larger-scale randomized studies with larger sample sizes and extended follow-up durations may be necessary to validate the sustained efficacy of SLT over the long term.

Abbreviations

SLT	Selective laser trabeculoplasty
POAG	Primary open-angle glaucoma
IOP	Intraocular pressure
ALT	Argon laser trabeculoplasty

Acknowledgements
The authors extend their appreciation to Taif University, Saudi Arabia, for supporting this work through project number (TU- DSPP- 2024- 54).

Author contributions
AAMG played a significant role in conceiving and designing the work, making substantial contributions to the acquisition, analysis, and interpretation of data, conducted preoperative and postoperative evaluations of the cases, contributing in performing surgeries and SLT participated in the manuscript's drafting, and critically revised it for important intellectual content. He also read and approved the final version for publication, acknowledging sufficient participation in the work to take public responsibility for relevant content portions. AAMG agreed to be accountable for all aspects of the work, ensuring the appropriate investigation and resolution of any questions related to accuracy or integrity.BHA made significant contributions to designing the work and the revision and analysis of data. He was actively engaged in drafting the manuscript and critically revising it for important intellectual content. He also had read and approved the final version intended for publication. AFG contributed in designing the work and the revision and data analysis. She was actively participating in drafting and writing the manuscript and critically revised it for important intellectual content. She also had read and approved the final version intended for publication.
AMM played a key role in the conception and design of the work, providing substantial contributions to the acquisition, analysis, and interpretation of data. He conducted preoperative and postoperative evaluations of the cases and actively participated in performing surgeries and Selective Laser Trabeculoplasty (SLT). Additionally, AMM contributed to the drafting of the manuscript and critically revised it for important intellectual content. He also reviewed and approved the final version for publication.

Funding
This research was funded by Taif University, Saudi Arabia, through Project No. (TU-DSPP-2024-54)

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author (Ahmed AM Gad) on reasonable request.

Declarations

Ethics approval and consent to participate
1. This study was conducted in accordance with ethical principles outlined in the Declaration of Helsinki and applicable national and institutional guidelines. Prior to initiating this research, the study protocol was reviewed and approved by the Ethical Committee Board of the Faculty of Medicine at Suez University. As this was a retrospective study utilizing pre-existing data, informed consent from patients was waived by the Ethics Committee in compliance with regulatory requirements. All data collected were anonymized and de-identified to protect patient confidentiality. Measures were implemented to ensure the privacy and security of the data throughout the research process. No additional interventions or patient contact were required, minimizing risks to participants. The findings of this study aim to contribute to improved clinical practices and patient care, ensuring a balance between research benefits and ethical responsibility.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 22 February 2024 / Accepted: 28 January 2025
Published online: 05 February 2025

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