

# World Journal of *Clinical Cases*

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## Retrospective Study

# Selective laser trabeculoplasty as adjunctive treatment for open-angle glaucoma vs following incisional glaucoma surgery in Chinese eyes

Jing Zhu, Juan Guo

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## Abstract

### BACKGROUND

Selective laser trabeculoplasty (SLT) is a relatively safe and effective therapy in lowering intraocular pressures (IOP) for glaucoma.

### AIM

To study the long-term effects of SLT on IOP and number of glaucoma medications used in Chinese eyes.

### METHODS

This is a retrospective study in which 75 eyes of 70 patients with open-angle glaucoma (OAG,  $n = 36$ ) and eyes with prior glaucoma surgery (PGS,  $n = 39$ ) were included. Changes in mean IOP and number of glaucoma medications used evaluated at 1 d, 1 wk, 1 mo, 3 mo, 6 mo, 12 mo, and 36 mo after laser treatment.

### RESULTS

All patients (33 male, 37 female) were Chinese. The mean age was  $44.34 \pm 16.14$  years. Mean pre-SLT IOP was  $22.75 \pm 2.08$  mmHg in OAG and  $22.52 \pm 2.62$  mmHg in PGS. Mean IOP was significantly reduced 1 d, 1 wk, 1 mo and 3 mo after laser treatment ( $P < 0.05$ , respectively). Whereas, there were no significant differences between baseline and SLT treated groups at the 6<sup>th</sup> month both in OAG ( $P = 0.347$ ,  $P > 0.05$ ) and in PGS ( $P = 0.309$ ,  $P > 0.05$ ). Six months after SLT treatment, some patients received retreatment of SLT or were given more topical IOP-lowering medication to control the IOP. By the end of our study, the average IOP decreased to  $20.73 \pm 1.82$  mmHg in OAG and  $20.49 \pm 1.53$  mmHg in PGS groups. The number of glaucoma medications used was significantly reduced until the end of 3 years compared to baseline.

## CONCLUSION

SLT could reduce IOP as adjunctive treatment both in OAG and PGS groups. SLT significantly reduced the number of glaucoma medications used 3-years following treatment in glaucoma patients.

**Key Words:** Selective laser trabeculoplasty; Open-angle glaucoma; Intraocular pressure; Prior glaucoma surgery; Adjunctive treatment

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**Core Tip:** Selective laser trabeculoplasty (SLT) could reduce intraocular pressure as adjunctive treatment both in open-angle glaucoma and prior glaucoma surgery groups of patients. SLT significantly reduced the number of glaucoma medications used 3-years following treatment in glaucoma patients.

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## INTRODUCTION

Selective laser trabeculoplasty (SLT) is a relatively safe and effective therapy in lowering intraocular pressures (IOP) for glaucoma which was first described in 1995 by Latina and Park[1]. This is an Nd:YAG laser improves aqueous outflow by selectively targeting the pigmented trabecular meshwork (TM) cells and presumably does not produce any damage to the microstructure of the TM[2].

SLT could be offered as initial treatment at decreasing IOP for open-angle glaucoma (OAG) and ocular hypertension. The Laser in Glaucoma and ocular Hyper Tension (LiGHT) study demonstrated that SLT could be offered as a first-line treatment of decreasing IOP without the adverse effects and costs of long-term medication use[3]. However, in the LiGHT study, nearly 15% of patients treated with SLT required additional IOP lowering interventions within 1 year, and some patients require retreatment to maintain IOP lowering[3]. SLT treatment can be particularly helpful for patients with poor compliance and drug intolerance[3]. A randomized clinical trial reported that there was no statistically significant difference between the SLT treated group and the drug therapy group after 1 year[4]. Ang *et al*[5] demonstrated that the rate of successful IOP reduction was higher in the medication group compared with SLT group at 24 mo. However, SLT did not cause any changes affecting ocular blood flow as does tropic intraocular pressure drugs[3]. It has been reported that repeated treatment of SLT safely provides significant IOP reductions in OAG through nearly 8 years of follow-up[6].

SLT could be used to reduce the IOP of patients who failed to achieve target IOP after receiving maximally tolerated medical therapy (MTMT). Previous studies have demonstrated significant reductions in mean IOP and the number of glaucoma medications used in patients who received SLT as a secondary treatment after receiving MTMT[7]. A 5-year study showed that although the long-term decrease of IOP after SLT treatment may not be obvious, the numbers of drug use were reduced[8].

SLT could reduce the uncontrolled intraocular pressure after glaucoma surgery. There are many anti-glaucoma surgeries including trabeculectomy, Ahmed glaucoma drainage valve, trabeculectomy combined with cataract extraction and other surgical methods[9]. In patients with prior glaucoma surgery (PGS), the IOP rises again due to glaucoma filtering bleb scar, inflammatory reaction, and other reasons. A prospective study reported that the IOP of 18 patients with uncontrolled IOP after trabeculectomy decreased by 24% treated with SLT for 9 mo[10]. Previous studies have also demonstrated that two groups of patients with PGS ( $n = 53$ ) and without operation history ( $n = 53$ ), the IOP reduction rates were 7.3% and 10.8% respectively after SLT treatment at 6 mo of follow-up ( $P = 0.42$ ,  $P > 0.05$ )[11].

Therefore, our aim was to determine the efficacy of SLT as adjunctive treatment in patients with previous incisional glaucoma surgery whose IOP remains or becomes uncontrolled, and the number of medications used up to 3 years.

## MATERIALS AND METHODS

Outpatients who underwent SLT were reviewed retrospectively at the Department of Ophthalmology, Third People's Hospital of Chengdu, Affiliated Hospital of Southwest Jiao Tong University from



September 2016 to January 2020. This is a single-center study. During this research, the ethical use of human subjects was approved by the Ethics and Research Committee of Chengdu Third People's hospital (Approval No. [2022]-S-5). All the patients signed written informed consent.

In our study, 75 consecutive eyes of 70 patients (33 male, 37 female) with OAG ( $n = 36$ ), and PGS ( $n = 39$ ) were enrolled. The information of patients is shown in [Table 1](#).

Inclusion criteria: Age  $\geq 18$  years, an increased IOP ( $> 21$  mmHg), open atrial angle and scleral process can be seen by gonioscopy, OAG diagnostic criteria are met. OAG diagnostic criteria: Glaucomatous optic nerve damage (cup-to-disc ratio, C/D  $> 0.5$ , or difference in the C/D  $> 0.2$ ), visual field defect, mean defect of visual field  $< -1.00$  DB[12]. Inclusion criteria of PGS group: Those diagnosed as OAG, who have undergone trabeculectomy, drainage nail implantation, Ahmed glaucoma valve implantation or trabeculectomy combined with cataract extraction ([Table 2](#)); These patients have been treated with MTMT, but fail to reach the target IOP[11]. Exclusion criteria consisted of patients who were, unable to have SLT successfully performed, history of uveitis, or lost to follow up before 1 mo. Also, patients with other prior major incisional eye surgeries were excluded apart from cataract surgery alone.

All patients received SLT more than 1 year after anti-glaucoma surgery. These patients agreed to SLT treatment and signed the consent form for laser surgery.

Eyes were pretreated with topical anesthesia of 0.4% obucaine hydrochloride (Benoxil). And Latina anterior chamber gonioscope was placed after anesthesia. SLT was performed with a q-switched, frequency-doubled 532 nm Nd: YAG laser (selecta duet, Lumenis, Israel) which has a spot size of 400  $\mu$ m and pulse duration of 3ns. Nonoverlapping  $100 \pm 10$  Laser spots were applied to 360 degrees of the TM. The initial energy level was set at 0.8 mJ. The energy was increased or decreased until cavitation bubbles within the TM were just noted. In this study, the therapeutic energy was 0.6-1.2 mJ. Pranoprofen eye drops were used as postoperative medications.

Detailed ophthalmic examinations including visual acuity, intraocular pressure, slit lamp microscope, gonioscopy, visual field, Optical Coherence tomography for retinal nerve fiber layer thickness, funduscopy examination was conducted both before SLT. After SLT, the patients were followed up regularly (1 d, 1 wk, 1 mo, 3 mo, 6 mo, 1 year and 3 year). Complications, IOP and C/D were observed at each follow-up time point. The IOP was measured by Goldmann applanation in all patients. The 3 years follow-up were monitored by National Institute for Health and Care Excellence guidance to avoid bias in clinical decision-making.

### Statistical analysis

SPSS 23.0 (version 23.0; IBM Corporation, Armonk, NY, USA) statistical software was used for statistical analysis. The means and standard deviation of IOP at different time points before and after SLT treatment was calculated. The paired t-test of two independent samples was used to compare the IOP between baseline and post treatment at different time points for statistical analysis; The statistical analysis of the number of medications used were analyzed using Wilcoxon signed rank test and tested using Generalized Estimating Equations and Poisson regression models. The variables that did not meet the normal distribution were analyzed using the Mann Whitney *U* test. The comparative evaluation of treatment effects between and within different types of glaucoma after SLT was tested by analysis of variance. The success rate was calculated with Kaplan-Meier survival curve analysis.  $P < 0.05$  was considered statistically significant.

## RESULTS

In this study, SLT was performed on 75 eyes from 70 OAG patients (33 males and 37 females) included. Before SLT treatment, all eyes were given glaucoma medications (1 to 4 drugs). The average age of patients receiving SLT was  $44.34 \pm 16.14$  yr ([Table 1](#)). The mean IOP before treatment was  $22.75 \pm 2.08$  mmHg in OAG and  $22.52 \pm 2.62$  mmHg in PGS ([Table 3](#)).

The average number of medications used before SLT treatment was  $3.39 \pm 0.69$  in OAG and  $2.97 \pm 0.74$  in PGS group ([Table 4](#)). The course of IOP over the 36 mo of the study is shown in [Table 3](#). 75 eyes were followed up for longer than 1 year, and 58 eyes were followed up for more than 3 years.

In the OAG group, IOP began to rise at the 6<sup>th</sup> month ( $P = 0.3465$ ,  $P > 0.05$ ). The mean IOP was  $22.59 \pm 2.26$  mmHg at the 6<sup>th</sup> month and there was no significant difference compared to baseline.

Six months after SLT treatment, 6 eyes undertook retreatment of SLT, 4 eyes were given more topical IOP-lowering medications to control the IOP in the OAG group.

In the PGS group, there was a statistically significant lower IOP in the study compared with pretreatment levels after SLT treatment at all points ( $P < 0.001$ ; [Table 3](#)) except for the 6<sup>th</sup> month ( $P = 0.309$ ,  $P > 0.05$ ). The average IOP was  $21.94 \pm 2.11$  mmHg at 6 mo and there was no significant difference compared to the baseline. At the 6<sup>th</sup> month, 4 eyes undertook retreatment of SLT and 2 eyes were given more topical IOP-lowering medications to control the IOP.

In this retrospective study, there was no statistically significant difference between the OAG and PGS groups at all time intervals ( $P > 0.05$ ; [Table 3](#)) except for the 3<sup>rd</sup> month ( $P = 0.0039$ ,  $P < 0.05$ ; [Table 3](#)).



**Table 1 Demographic and clinical characteristics of patients**

Characteristics	
Age (yr, mean $\pm$ SD)	44.34 $\pm$ 16.14
Gender	
Male ( <i>n</i> )	33 (3 both eyes)
Female ( <i>n</i> )	37 (2 both eyes)
Diagnosis	
OAG ( <i>n</i> )	36
PGS ( <i>n</i> )	39
Total	75

OAG: Open angle glaucoma; PGS: Prior glaucoma surgery.

**Table 2 Type of prior glaucoma surgery group**

Type of PGS	Trabeculectomy	Drainage nail implantation	Ahmed glaucoma valve implantation	Trabeculectomy combined with cataract extraction
Number of patients	18	2	4	15

PGS: Prior glaucoma surgery.

**Table 3 Evaluation of intraocular pressures and cumulative proportion of selective laser trabeculoplasty success**

Groups	Baseline	1 d	1 wk	1 mo	3 mo	6 mo	12 mo	36 mo
Eyes ( <i>n</i> )	36	36	36	36	36	36	35	28
OAG	22.75 $\pm$ 2.08	16.29 $\pm$ 3.62	18.97 $\pm$ 5.42	18.62 $\pm$ 4.39	21.32 $\pm$ 2.19	22.59 $\pm$ 2.26	20.13 $\pm$ 1.8	20.73 $\pm$ 1.82
<i>P</i> 1 value		< 0.0001	0.0005	0.0005	0.0020	0.3465	< 0.0001	0.0009
Cumulative proportion of SLT success (%)				87.13	76.81	68.27	47.66	24.96
Eyes ( <i>n</i> )	39	39	39	39	39	39	33	29
PGS	22.52 $\pm$ 2.62	16.45 $\pm$ 4.16	18.51 $\pm$ 5.09	18.80 $\pm$ 4.99	19.21 $\pm$ 3.82	21.94 $\pm$ 2.11	20.28 $\pm$ 1.61	20.49 $\pm$ 1.53
<i>P</i> 1 value		< 0.0001	0.0002	0.0002	0.0002	0.3086	< 0.0001	0.0002
Cumulative proportion of SLT success (%)				84.70	67.40	59.39	42.15	27.61
<i>P</i> 2 value	0.517	0.785	0.517	0.696	0.006	0.433	0.987	0.594

OAG: Open-angle glaucoma; SLT: Selective laser trabeculoplasty; PGS: Prior glaucoma surgery. *P*1: Repetitive measure analysis of variance (ANOVA), difference of intraocular pressures (IOP) between selective laser trabeculoplasty treatment and baseline group at different time points. *P*2: One way ANOVA, Comparison within groups, difference of IOP between open angle glaucoma and prior glaucoma surgery groups at different time points.

During the first 3 mo of follow-up, the IOP in the PGS group was 18.76  $\pm$  3.92 mmHg and that in the OAG group was 21.32  $\pm$  2.19 mmHg. The PGS group had a better and longer effect on IOP than the OAG group.

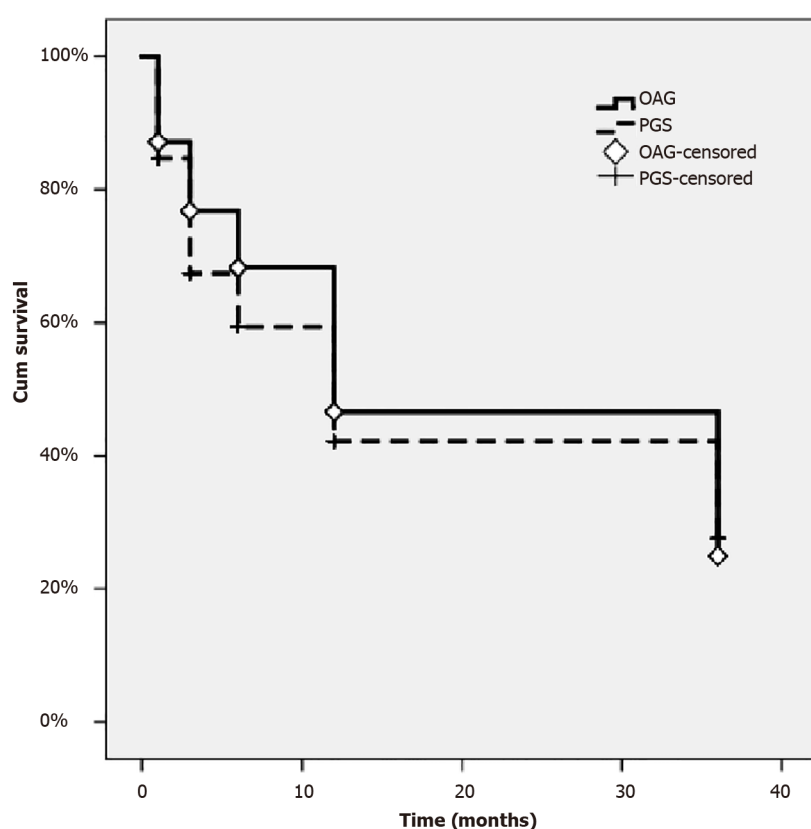
On the Kaplan-Meier survival analysis, the success rates after 1, 3, 6, 12, and 36 mo were 87.13%, 76.81%, 68.27%, 47.66% and 24.96% in the OAG group, and 84.70%, 67.40%, 59.39%, 42.15% and 27.61% in the PGS group, respectively (*P* = 0.320; Log-rank test) (Figure 1 and Table 3).

Table 4 presented the number of glaucoma medications used. There were no statistical differences on the 1<sup>st</sup> day after SLT treatment compared with the baseline (*P* = 0.083, *P* > 0.05). As the ocular spike was observed in part of patients at the 1<sup>st</sup> day after laser treatment, the number of anti-glaucoma drugs were not changed. The number of drugs was gradually reduced 1 wk after treated by laser and lasted for 36 mo.

**Table 4** Number of glaucoma medications used in patients undergoing selective laser trabeculoplasty

Number of medications	Baseline	1 d	1 wk	1 mo	3 mo	6 mo	12 mo	36 mo
OAG	3.39 ± 0.69	3.31 ± 0.82	2.75 ± 0.5	2.06 ± 0.79	2.19 ± 0.71	2.39 ± 0.64	2.34 ± 0.64	2.5 ± 0.69
P1 value		0.083	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
PGS	2.97 ± 0.74	2.85 ± 0.67	2.51 ± 0.56	1.33 ± 1.28	1.44 ± 1.23	1.77 ± 0.99	1.79 ± 1.02	1.9 ± 0.82
P1 value		0.025	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
P2 value	0.015	0.005	0.048	0.004	0.003	0.006	0.008	0.007

OAG: Open angle glaucoma; PGS: Prior glaucoma surgery. P1: Wilcoxon signed rank test, difference of medication quantity between selective laser trabeculoplasty treatment and baseline group at different time points. P2: Mann-Whitney test, Comparison within groups, difference of medication quantity between open angle glaucoma and prior glaucoma surgery group at different time points.



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**Figure 1** A graph revealing the cumulative success rate in selective laser trabeculoplasty using the Kaplan-Meier method. Log Rank (Mantel-Cox),  $P = 0.591$ .

Of the 70 patients, 5 had both eyes treated. Six eyes experienced IOP spikes on the 1<sup>st</sup> day after SLT. In these eyes, the IOP returned to baseline after the appropriate intervention. No other complications after SLT therapy occurred in any eye. In the span of 3 years, 10 eyes (12.99%) underwent a repeat SLT, 5 eyes (6.49%) underwent glaucoma surgery. At the 6<sup>th</sup> months point, two patients in the PGS group had been excluded because of the progression of visual field, and they underwent glaucoma surgery again.

Conjunctival hyperemia occurred in 56 eyes (72.7%), which disappeared after 1 d. There was an anterior chamber reaction in 49 eyes (50.51%). Tyndall ( $\pm$ ) ~ (+) in the anterior chamber was observed in 1 ~ 2 h after SLT and disappeared after 1 wk. A transient IOP elevation (spike) was observed 1 h after SLT, IOP  $\geq 5$  mmHg in 6 eyes (7.79%) and IOP  $\geq 1 \sim 4$  mmHg in 15 eyes (19.48%).

There were no severe complications in these patients, such as ocular inflammation, hyphemia, choroidal effusion, or retinal detachment.

## DISCUSSION

Due to the IOP spike after treatment, the number of drugs used on the 1<sup>st</sup> day after SLT treatment did not decrease. Whereas, on the 1<sup>st</sup> day after SLT treatment, the IOP was greatly reduced. The difference was statistically significant at different time points until the 6<sup>th</sup> month after SLT treatment. Two prospective studies have reported that SLT can effectively reduce IOP 4 years and 6 years after treatment in patients who have used the maximum dose of IOP reducing drugs. 44% and 59% of patients have at least 20% of an IOP reduction, respectively[6,13]. However, our results showed that the action time of SLT lasted about 6 mo. After the 6<sup>th</sup> month, the IOP of some patients increased again. Therefore, at the 6<sup>th</sup> month after SLT treatment, some patients underwent SLT treatment again or added the numbers of anti-glaucoma drugs to control IOP. This result is not consistent with the published results, which may be related to race, trabecular meshwork structure or the distribution of trabecular meshwork pigment. The effectiveness and safety of SLT was affected by pigmentation of trabecular meshwork and laser energy[14].

In our study, the PGS group was included. These patients had a history of previous glaucoma surgery, 39 eyes, including 18 eyes after trabeculectomy, 2 eyes after drainage nail implantation, 4 eyes after glaucoma valve implantation and 15 eyes after trabeculectomy combined with cataract extraction. The chamber angular structure was not changed except for the surgical site in the PGS group, which provided the conditions for the SLT treatment. As there was no significant difference in IOP after SLT treatment between OAG and PGS groups, the history of glaucoma surgery might have little impact on the results of SLT laser treatment. The residual function in the trabecular meshwork pathway still has potential to be modulated in a post-surgical eye, which provided the conditions for the SLT treatment.

The energy used was between 0.6-1.2 mJ in our study. High energy laser could cause transient high intraocular pressure. For patients with heavy pigmentation in trabecular meshwork, high energy laser may lead to continuous IOP[15]. It was reported that SLT with appropriate high energy (1.2-1.5 mJ) can effectively reduce IOP in patients with steroid-induced glaucoma[16]. It is also reported that low-energy SLT treatment is also effective. The results show that low-energy laser could also effectively reduce IOP in OAG patients for 2 years after 360° SLT with initial energy of 0.3 mJ[17]. In the future research, we could further analyze the impact on IOP with different laser energy.

Our study shows that SLT could reduce the number of drugs as an adjunctive therapy. Juzych reported that in another study of OAG, SLT could effectively reduce IOP and reduce the number of drugs used after 5 years[18]. In a prospective randomized controlled study, the number of drugs decreased in varying degrees 1, 3 and 5 years after SLT treatment[19]. These results suggest that SLT can be used in the treatment of glaucoma patients with poor drug or surgical control.

A limitation of this study is a retrospective study which may have selection bias. It would be a better control for this potential selection bias in a prospective study. There are more types of glaucoma that could be treated by SLT, such as glaucoma secondary to silicone oil eye after vitrectomy, steroid-induced glaucoma and so on[16].

## CONCLUSION

In summary, SLT may be efficacious in eyes with prior incisional glaucoma surgery and it provides an effective treatment option to lower IOP to avoid or postpone subsequent incisional glaucoma procedures.

## ARTICLE HIGHLIGHTS

### Research background

Selective laser trabeculoplasty (SLT) is a relatively safe and effective therapy in lowering intraocular pressures (IOP) for glaucoma. SLT could be offered as an initial treatment at decreasing IOP for open-angle glaucoma (OAG) and ocular hypertension. SLT could be used to reduce the IOP of patients who failed to achieve target IOP after receiving maximally tolerated medical therapy. SLT could reduce the uncontrolled intraocular pressure after glaucoma surgery.

### Research motivation

To find out whether SLT could reduce IOP in patients with prior glaucoma surgery.

### Research objectives

Our aim was to determine the efficacy of SLT as adjunctive treatment in patients with previous incisional glaucoma surgery whose IOP remains or becomes uncontrolled, and the number of medications used up to 3 years.

### Research methods

Outpatients who underwent SLT were reviewed retrospectively at the Department of Ophthalmology, Third People's Hospital of Chengdu, Affiliated Hospital of Southwest Jiao Tong University from September 2016 to January 2020. 75 consecutive eyes of 70 patients (33 male, 37 female) with OAG ( $n = 36$ ), and PGS ( $n = 39$ ) were enrolled. The IOP was measured both before and after SLT and followed up to 3 years.

The means and standard deviations of IOP at different time points before and after SLT treatment was calculated. The statistical analysis of the number of medications used were analyzed using the Wilcoxon signed rank test. The comparative evaluation of treatment effects between and within different types of glaucoma after SLT was tested by the analysis of variance. The success rate was calculated with the Kaplan-Meier survival curve analysis.

### Research results

The average age of patients receiving SLT was  $44.34 \pm 16.14$  yr (Table 1). The mean IOP before treatment was  $22.75 \pm 2.08$  mmHg in the OAG group and  $22.52 \pm 2.62$  mmHg in the PGS group (Table 3). The average number of medications used before SLT treatment was  $3.39 \pm 0.69$  in the OAG group and  $2.97 \pm 0.74$  in the PGS group (Table 4). 75 eyes were followed up for longer than 1 year, and 58 eyes were followed up for more than 3 years. There was no statistically significant difference between the OAG and PGS groups. The success rates after 1, 3, 6, 12, and 36 mo were 87.13%, 76.81%, 68.27%, 47.66% and 24.96% in the OAG group, and 84.70%, 67.40%, 59.39%, 42.15% and 27.61% in the PGS group, respectively. The number of drugs was gradually reduced 1 wk after being treated by laser and lasted for 36 mo.

### Research conclusions

SLT could reduce IOP as an adjunctive treatment both in the OAG and PGS groups. The residual function in the trabecular meshwork pathway still has potential to be modulated in a post-surgical eye, which provided the conditions for the SLT treatment. SLT significantly reduced the number of glaucoma medications used 3-years following treatment in glaucoma patients.

### Research perspectives

SLT may be efficacious in eyes with prior incisional glaucoma surgery and it provides an effective treatment option to lower IOP to avoid or postpone subsequent incisional glaucoma procedures.

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## FOOTNOTES

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**Author contributions:** Zhu J collected and analyzed the data; Guo J conceived and supervised the project; All authors have read and approved the article.

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