• Clinical Research •

Short-term results of 360° selective laser trabeculoplasty in patients with failed deep sclerectomy

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Abstract

● **AIM:** To evaluate the short-term results of 360° selective laser trabeculoplasty (SLT) in the treatment of patients with previously failed deep sclerectomy (DS).

● **METHODS:** Patients with open angle glaucoma with prior failed DS and insufficient postoperative intraocular pressure (IOP) control were enrolled. Preoperative and postoperative IOP were measured using a Goldmann applanation tonometer. One hundred non-overlapping laser shots were applied over 360°. IOP was measured before SLT and 1h after SLT. Follow-up was scheduled at the first week and at the first, third, and sixth months thereafter.

● **RESULTS:** A total of 22 eyes (13 patients) were included in the study with a male:female ratio of 1:1 and a mean age of 51.73±13.51y (28-73y). The mean IOP prior to SLT was 18.41±5.24 mm Hg, which decreased to 15.91±3.56 (*P*=0.071), 15.05±4.53 (*P*=0.097), 13.91±2.67 (*P*<0.001) and 13.95±1.84 mm Hg; (*P*<0.001) at 1wk, 1, 3, and 6mo of follow-up, respectively. This change was statistically significant at the 3mo and 6mo follow-up. The number of anti-glaucoma medications dropped significantly throughout the follow-up period (*P*=0.014).

● **CONCLUSION:** 360° SLT can be an effective complementary treatment after failed DS to decrease IOP and anti-glaucoma medications, thus improving patient compliance and tolerance.

● **KEYWORDS:** deep sclerectomy; glaucoma; intraocular pressure; selective laser trabeculoplasty; anti-glaucoma medication

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INTRODUCTION

Glaucoma is a progressive optic neuropathy that is the second leading cause of blindness worldwide[1]. Several management strategies have been developed for this purpose. However, to date, the only definitive treatment has been to lower intraocular pressure (IOP). This is achieved either medically by incisional surgery (*e.g.*, trabeculectomy and non-penetrating deep sclerectomy) or laser (*e.g.*, trabeculoplasty). Many different laser trabeculoplasty techniques have been attempted, including argon laser trabeculoplasty (ALT)[2], diode laser trabeculoplasty (DLT)[3], and micropulse laser trabeculoplasty (MLT)[4]. Since its introduction in 1995, selective laser trabeculoplasty (SLT) has offered similar efficacy to ALT, while minimizing damage to the trabecular meshwork (TM) by selectively targeting pigmented cells using the frequency-doubled short pulse (Q-switched) neodymium-doped yttrium aluminum garnet (Nd:YAG) laser[5-6].

Deep sclerectomy (DS) was introduced as a safer technique than trabeculectomy. Its success depends on surgical removal of the inner wall of the Schlemm's canal and filtration through the trabeculo-Descemet's membrane (TDM)[7-8]. This lamella can be too thick due to insufficient surgical dissection or postoperative fibrosis. When IOP is high after DS, laser goniopuncture is usually performed to allow increased percolation of aqueous humor through TDM[9-12].

The IOP-lowering effect of limited SLT (8-10 shots over the TDM; modified goniopuncture) in patients with high IOP or shallow bleb after deep sclerectomy with collagen implant (DSCI) was assessed[13-14]. The results concluded that SLT was an effective and safe alternative to the traditional Nd:YAG laser for goniopuncture in eyes after DSCI, with potential advantages related to non-perforation of TDM[13-14].

In this study, we aimed to evaluate the efficacy of performing a 360° SLT procedure as a complementary treatment in patients with prior failed DS.

PARTICIPANTS AND METHODS

Ethical Approval The study protocol was approved by the Research Ethics Committee of the Faculty of Medicine at

Cairo University (code: N-182-2024), and written informed consent was obtained from all participants.

This prospective study included 22 eyes (13 patients) with open angle glaucoma who underwent DS with insufficient postoperative IOP control. All patients were recruited from glaucoma outpatient clinics at Kasr Alainy Hospital, Cairo University, between April 2024 and November 2024.

Based on evidence from a previous study[14] and by considering the mean postoperative IOP after SLT in patients with failed DS as the primary outcome. The Epi-Calc 2000 was used to calculate the sample size in this prospective clinical study. Assuming 80% power, 0.05 level of significance, 14.7 mm Hg null hypothesis value, a standard deviation of 3.2 mm Hg and estimated mean of 12.7 mm Hg, a sample size of 21 participants is adequate. Considering a drop-out rate of 10%, a final sample size of 22 participants was calculated. The study included patients of both sexes, aged over 18y, of Caucasian ethnicity, diagnosed with either primary or secondary open angle glaucoma (pigmentary glaucoma or pseudo-exfoliation glaucoma), moderate to severe glaucoma (mean deviation worse than -6 decibels) and failed DS surgery. All participants showed evidence of failed DS. 1) Persistent elevated IOP following DS that required initiation of antiglaucoma medications, yet the IOP remained uncontrolled despite treatment with or without evidence of visual field progression. 2) Elevated IOP post-surgery that was controlled with antiglaucoma medications, but the patient experienced one or more of the following: ocular side effects from topical medications, poor compliance to medical treatment due to intolerable side effects or patients' non-adherence or desire to discontinue topical therapy due to pregnancy planning (in female patients). Uncontrolled IOP was defined as a pre-SLT IOP>21 mm Hg measured at any time of the day or higher than the individualized target IOP with medications measured on at least two different occasions. Gonioscopy of the included eyes showed open angles with moderate to intense trabecular pigmentation, with or without evidence of YAG-laser goniopuncture.

Patients with a previous history of laser treatment apart from laser goniopuncture were excluded. We also excluded patients who underwent any intraocular surgery except for non-complicated cataract surgery (performed >6mo before SLT).

Patients meeting the inclusion criteria were subjected to full history taking (including time to failure after DS) and ophthalmological examination, including best-corrected visual acuity using logMAR, slit lamp examination, and gonioscopic examination of the anterior chamber angle using 4-mirror gonio lens, with assessment of the retina and optic nerve.

SLT was performed using a Tango Reflex™ Neo laser system (Ellex Medical Corporation, USA) and a specific SLT lens with a flange (Ocular Latina SLT with Flange, Ocular Instruments, WA, USA). A fixed 400-μm spot size, 3-ns duration, and laser energy levels ranging from 0.3 to 0.9 mJ per pulse were used and adjusted according to TM pigmentation in 0.1-mJ increments. If no cavitation bubbles are observed at the initial energy level, the energy is increased to the lowest possible level to produce "champagne" bubbles. During laser treatment, the formation of large bubbles was monitored, and the energy level was titrated downward as necessary.

For 360° treatment, 100 non-overlapping shots were performed apart from the site of DS, and all treated cases were conducted by glaucoma consultants. The IOP measurements were scheduled in the morning from 8:00 *a.m*. to 11:00 *a.m*., during each of the following visits: at baseline (immediately before the procedure) and 1h after treatment, then, after 7d, 1, 3, and 6mo. During each visit, two consecutive Goldmann applanation tonometry measurements were obtained per eye, and the average of these values was used for statistical analysis.

A single brimonidine 0.2% drop was applied immediately after treatment, and non-steroidal anti-inflammatory eye drops were prescribed twice a day for 7d. Patients were instructed to continue their current anti-glaucomatous medication until a clinical indication for therapy adjustment based on IOP reduction was determined.

Statistical Analysis Data was tabulated using Microsoft Excel. Numerical data was expressed as mean, standard deviation, minimum, and maximum. Qualitative data was expressed as frequency and percentage. Comparison of quantitative variables between two groups was done using Mann-Whitney test (non-parametric *t*-test) for not normally distributed numerical data. All tests were two-tailed. A *P*-value <0.05 was considered significant.

RESULTS

A total of 22 eyes (13 patients) were included in the study with a male:female ratio of 1:1 and a mean age of 51.73±13.51y (28-73y). Among the eyes examined, 9 were right eyes (40.91%), while 13 were left eyes (59.09%). Ten eyes (45.45%) were pseudophakic, and 12 eyes (54.55%) were phakic. Five eyes (22.73%) had a history of laser gonio puncture. The clinical data of the patients were summarized in Table 1.

All eyes were treated with 100 shots of SLT over a 360° angle. The average power used was 0.54±0.13 (0.4-0.9).

The mean IOP of participants prior to SLT treatment was 18.41±5.24 mm Hg, which decreased to 15.91±3.56 (*P*=0.071), 15.05±4.53 (*P*=0.097), 13.91±2.67 (*P*<0.001), and 13.95±1.84 (*P*<0.001) at 1wk, 1, 3, and 6mo of follow-up, respectively. This change was statistically significant at the 3mo and 6mo follow-up.

Following SLT treatment, the percentage of IOP reduction was statistically significant throughout the study period

Table 1 Clinical data of post deep sclerectomy patients

Items	Mean	SD	Minimum	Maximum
BCVA (logMAR)	1.17	0.92	0.1	3.3
C/D	0.80	0.21	0.4	1
Duration between deep sclerectomy and starting medications (mo)	10.32	15.33	0	48
Time interval between deep sclerectomy and SLT (mo)	76.05	32.63	3	120

BCVA: Best corrected visual acuity; C/D: Cup to disc ratio; SLT: Selective laser trabeculoplasty; SD: Standard deviation.

Table 2 Changes in IOP pre and post SLT treatment throughout the follow-up period with the percentage reduction of IOP

Follow-up	IOP (mm Hg)				*P*-value compared to baseline	Percent of IOP reduction	*P*-value of the percent reduction of IOP
	Mean	SD	Minimum	Maximum			
Pre SLT IOP	18.41	5.24	10	28	-	-	-
1h	17.68	5.25	10	29	-	-	-
1wk	15.91	3.56	10	24	0.071	8.63%±26.15%	0.028
1mo	15.05	4.53	9	28	0.097	13.96%±26.41%	0.010
3mo	13.91	2.67	9	18	<0.001	19.32%±25%	<0.001
6mo	13.95	1.84	11	17	<0.001	19.26%±21.16%	<0.001

IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty; SD: Standard deviation.

compared with the baseline IOP. The reduction of IOP was maximum at the 3rd month of follow up, with an average IOP of 13.91±2.67 mm Hg (19.32%±25% reduction). By the end of follow-up period, the average IOP was 13.95±1.84 mm Hg (19.26%±21.16% reduction). Table 2 and Figure 1 provided details of the change in IOP, as well as the percentage of IOP reduction throughout the follow-up period.

As IOP decreased following SLT treatment, the researchers waited for one month to ensure stabilization of IOP and to exclude any IOP fluctuation before gradually reducing medications. Early reduction of medications (at 1wk post SLT) from 4 to 3 medications was performed for only one patient who experienced an early IOP drop from 17 to 10 mm Hg in the first week of follow-up.

The number of anti-glaucoma medications dropped significantly throughout the follow-up period from 2.36±1.22 medications prior to SLT treatment to 1.41±1.26 medications by the end of 6mo of follow-up (P=0.014). Changes in the number of anti-glaucoma medications are shown in Figure 2.

Regarding SLT complications, only one eye developed an IOP spike with an elevation of IOP from 12 mm Hg prior to SLT to 21 mm Hg 1h after the session. The patient was already on topical anti-glaucoma medications (alpha-2 agonist and fixed combination of dorzolamide and timolol), and IOP returned to normal levels within hours with regular treatment. Three eyes were non-responders to SLT with nearly the same IOP before and 6mo after the laser session and the same number of anti-glaucoma medications. No redo-SLT sessions were required during the follow-up period. No other SLT complications such as iritis or hyphemia have been reported.

On comparing the response to SLT between pseudophakic (10 eyes) and phakic (12 eyes) eyes, no statistically significant differences were reported throughout the follow-up period.

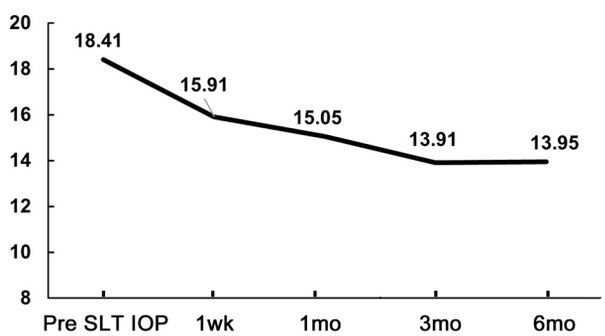

Figure 1 Changes in the mean IOP throughout the follow-up period IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty.

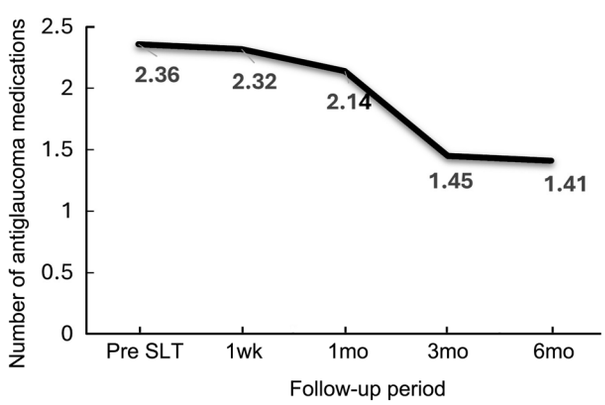

Figure 2 Reduction of the number of antiglaucoma medications during the follow-up period SLT: Selective laser trabeculoplasty.

In addition, statistically significant differences were reported between those who underwent YAG-laser goniopuncture (5 eyes) and those who did not (17 eyes), regarding IOP drop throughout the follow-up period. A significantly better IOP response was reported in those who did not undergo goniopuncture (Figure 3 and Table 3).

Table 3 Difference between patients who did gonio puncture and those who didn't, in response to SLT

Follow-up	Gonio puncture			No gonio puncture		
	Mean IOP	SD	*P*	Mean IOP	SD	*P*
Before SLT	15.8	2.68	-	17.94	5.32	-
1wk	17.6	3.72	0.848	15.41	3.47	0.055
1mo	17.2	6.42	0.800	14.41	3.84	0.015
3mo	16.2	1.10	0.461	13.24	2.63	0.001
6mo	14.8	1.64	0.234	13.71	1.86	0.001

IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty; SD: Standard deviation.

Table 4 Comparison of SLT response between eyes with early failure versus late failure following deep sclerectomy

Follow-up	Early failure			Late failure		
	Mean IOP	SD	*P*	Mean IOP	SD	*P*
Before SLT	20	5.64	-	17.08	4.72	-
1wk	16	3.37	0.070	15.83	3.86	0.485
1mo	13.9	5.76	0.028	16	3.13	0.515
3mo	14	2.83	0.008	13.83	2.66	0.153
6mo	13.35	1.90	0.010	13.42	1.68	0.019

IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty; SD: Standard deviation.

By comparing the response to SLT with respect to the timing of DS failure, there was a statistically significant difference between those with early failure (who started anti-glaucoma medications immediately after DS; 10 eyes) and those with late failure (who started anti-glaucoma medications at least 9mo post DS; 12 eyes) regarding IOP readings in the 1st week, 1st month and 3rd month of the follow-up period, with better IOP response found in the early failure group. However, in the 6th month of follow-up, both groups showed a significant drop in IOP with nearly the same *P*-value (0.010 for the early failure group and 0.019 for the late failure group; Figure 4 and Table 4).

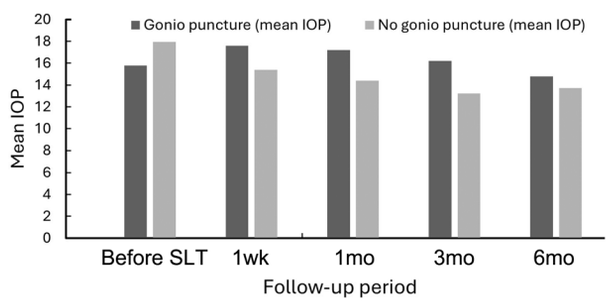

Figure 3 Difference between patients who did gonio puncture and those who didn't, in response to SLT IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty.

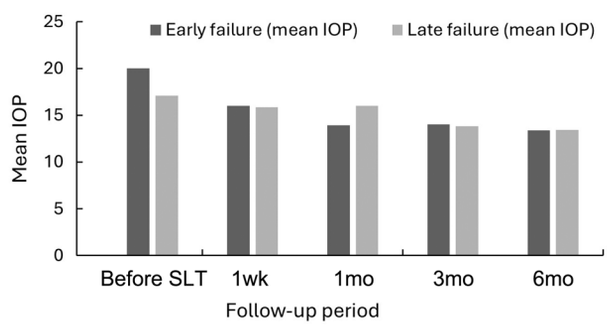

Figure 4 Difference in SLT response between eyes with early failure versus late failure following deep sclerectomy IOP: Intraocular pressure; SLT: Selective laser trabeculoplasty.

DISCUSSION

The results of the current study demonstrate that 360° SLT is an effective complementary treatment after failed DS. The mean IOP before SLT significantly decreased at 3 and 6mo of follow-up ($P<0.001$). In addition, it is worth mentioning that patients who were controlled on full anti-glaucoma medications were included in this study to decrease their side effects and improve their tolerance and compliance.

In the current study, the IOP course was smooth, with no evidence of an IOP spike at the 1-week follow-up. IOP decreased from 18.41±5.24 mm Hg to 15.91±3.56 mm Hg at 1wk. This contrasts with previously published studies, which reported an increase in IOP from 16.5±4.2 mm Hg on day 1 to 20.2±5.7 mm Hg at 1wk[15], and from 11.2±2.5 mm Hg to 14.9±3.3 mm Hg in another study[16]. This could be attributed to the anatomical and physiological changes induced by the prior DS. Although the procedure was deemed a failure in terms of long-term IOP control, DS may still have left behind a partially functioning filtration pathway or residual structural modifications—such as a decompressed Schlemm's canal or a thinner TDM—that facilitate aqueous outflow. After 360° SLT, the percentage of IOP reduction was statistically significant throughout the study period. It was maximum at 3rd month of follow up (19.32% reduction). The maximum IOP-lowering effect of SLT typically occurs approximately 3mo post-treatment because this is the time required for the biological and chemical changes induced by the laser to fully manifest

and stabilize[17-19].

Also, the number of anti-glaucoma medications has been reduced significantly from 2.36±1.22 prior to SLT to 1.41±1.26 by the end of 6mo of follow-up (*P*=0.014). This could decrease the financial burden and ocular side effects of multiple topical anti-glaucoma medications, thus improving patient compliance and tolerance.

Minimal SLT complications were reported in our study, including an IOP spike in one eye and the presence of three non-responders. No iritis or hyphaemia was observed.

Statistically significant differences were reported between those who underwent YAG-laser goniopuncture (that was done in the early postoperative period; 6-8wk due to early IOP elevation after DS) and those who did not (due to late IOP elevation post DS in which goniopuncture will not be effective), regarding IOP drop throughout the follow-up period. A significantly better IOP response was observed in patients who did not undergo goniopuncture. This could be attributed to the structural changes and scarring in the TM caused by goniopuncture, which can reduce the effectiveness of SLT by limiting the laser's ability to target and stimulate the TM cells effectively. Another possible explanation is that the initial mean IOP for patients who underwent goniopuncture was 15.8 mm Hg, whereas that of the non goniopuncture group was 17.9 mm Hg; Studies have shown that an initial higher pre-SLT IOP is a better indicator of response[20-22], so it might be feasible to say that the non-goniopuncture group exhibited a better drop in IOP as they had a higher initial pre-SLT IOP. However, this comparison may be prone to error due to the limited sample size—only 5 eyes underwent goniopuncture, while 15 did not. Further studies involving larger cohorts are needed to investigate and validate this observed difference more comprehensively.

We found no statistically significant difference in IOP readings between pseudophakic eyes/phakic eyes, and older studies conducted on the effect of SLT on pseudophakic and phakic eyes showed no significant difference between the two groups[23-25].

By comparing the response to SLT with respect to the timing of DS failure, a statistically significant difference was observed between the early and late failure groups regarding IOP readings in the 1st week, 1st month, and 3rd month of the follow-up period. The early failure group exhibited a better IOP response during this period. However, by the 6th month of follow-up, both groups showed a significant IOP drop with similar *P*-values: 0.010 for the early failure group and 0.019 for the late failure group. This could be attributed to the higher initial IOP in the early failure group, which resulted in a better response[20-22].

Two previous studies were performed using SLT post-failed DS but with different techniques. In both studies, the authors used SLT as a modified goniopuncture by applying 8-10 shots of SLT on the surgical site only (over the TDM)[13-14] with a sample size of 12 eyes and follow-up of 3mo in one study[14] and the other was performed in 10 eyes and a follow-up period of 6mo[13]. Both studies have shown that SLT is a safe and effective alternative to the traditional Nd:YAG laser for goniopuncture following failed DS with potential advantages related to non-perforation of the TDM[13-14].

Few studies have evaluated the effectiveness of SLT post-trabeculectomy and post-glaucoma drainage devices. They proved its effectiveness in significantly lowering the IOP in both groups[20,26].

To our knowledge, this is the first study to investigate the effect of a 360° SLT post DS. Despite the valuable insights provided by this research, several limitations should be acknowledged. First, the relatively small sample size may restrict the generalizability of the findings. With only a limited number of eyes included, statistical power is reduced, and subtle differences or trends may not be adequately detected. Larger, multicenter studies would be beneficial to validate and expand upon these results. Second, the short follow-up period—limited to 6mo—may not fully reflect the long-term therapeutic efficacy of SLT. It is well-documented that the effects of SLT can diminish over time, and without extended follow-up, it is difficult to assess the durability of treatment outcomes or the potential need for retreatment. Together, these limitations underscore the need for further research involving larger cohorts and extended follow-up durations to confirm the findings and better understand the long-term role of SLT following failed DS.

The current study concluded that 360° SLT could be an effective complementary treatment after failed DS to decrease the financial burden and side effects of multiple anti-glaucoma medications, thus improving patient compliance and tolerance. Those who did not undergo goniopuncture and those with early failure of DS may have a better response to SLT.

Using 360° SLT, post-failed DS appears to be a safe and effective procedure that can be performed on an outpatient basis; however, long-term follow-up of a large sample size is recommended to assess long-term efficacy.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: Eltanamly R, None; **Allam RSHM,** None; **Radwan R,** None; **Albadawi MA,** None.

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