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REVIEW

A Review of Selective Laser Trabeculoplasty: Recent Findings and Current Perspectives

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ABSTRACT

Selective laser trabeculoplasty (SLT) has been widely used in the clinical management of glaucoma, both as primary and adjunctive treatment. As new evidence continues to arise, we review the current literature in terms of indications and efficacy, surgical technique, postoperative care, repeatability, and complications of this therapy. SLT has been shown to be effective in various glaucomas, including primary open-angle glaucoma (POAG), normal-tension glaucoma (NTG), steroid-induced glaucoma, pseudoexfoliation glaucoma (PXFG), and primary angle-closure glaucoma (PACG), as well as other glaucoma subtypes. Relatively high preoperative intraocular pressure (IOP) may predict surgical success, while other parameters that have been studied do not seem to affect the outcome. Different techniques for performing the procedure have recently been explored, revealing that minor modifications may lead to a more favorable or safer clinical outcome. The utilization of postoperative medications remains controversial based on the current evidence. A short-term IOP increase may complicate SLT and can also persist in certain cases such as in exfoliation glaucoma. The efficacy and safety of repeat SLT are shown in multiple studies, and the timing of repeat procedures may affect the success rate.

Keywords: Glaucoma; Intraocular pressure; Laser; Selective laser trabeculoplasty

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INTRODUCTION

Intraocular pressure (IOP) reduction is the mainstay of therapy for glaucomatous optic neuropathy. Selective laser trabeculoplasty (SLT) has been widely employed for this purpose over the past several years as both a primary and adjunctive treatment [1].

In recent years, there has been a surge in literature regarding the utilization of SLT in patients with glaucoma. The procedure may address issues with topical medication compliance and side effects [1], and it is considered a cost-effective treatment [2]. Although the effect of SLT wanes over time, repeating the procedure may lead to clinical success comparable to that achieved with the initial treatment [3–5].

In a study by Bovell and colleagues comparing SLT to argon laser trabeculoplasty (ALT), SLT lowered IOP by over 6.5 mmHg at 3 years of follow-up [6]. Efficacy results were similar to those achieved with ALT, with waning efficacy and a 50% failure rate after 2 years. The potential repeatability of SLT is thought to be one of its advantages over ALT [5], which was shown to have a success rate of only 14% after re-treatment [7].

Globally, SLT also plays an important role as adjunctive or primary therapy for open-angle glaucoma. Realini demonstrated a prompt and sustained reduction in IOP after SLT therapy in patients from St. Lucia that were washed out from all medical therapy. Mean IOP reductions ranged from 7.3 to 8.3 mmHg (34.1–38.9%) through 12 months of follow-up [8].

Although SLT is considered a relatively safe procedure, risks of complications remain [9]. Furthermore, follow-up visits are required to monitor for adverse events, and additional treatment with medications or incisional procedures ultimately may be required [10, 11].

There is an increasing need for better understanding of SLT and how it fits within the picture of treating glaucoma. In this article, we will review recent findings pertaining to SLT, including its indications and efficacy, surgical technique, postoperative care, and complications.

This article is based on previously conducted studies, and does not involve any new studies of human or animal subjects performed by any of the authors.

INDICATIONS AND EFFICACY

Various glaucoma subtypes may be amenable to treatment with SLT in order to reduce baseline IOP and/or medication burden. A recently published review investigating SLT outcomes in the Hong Kong Chinese population reports that expected efficacy may depend on the underlying glaucoma subtype [12]. Most studies define successful SLT treatment as a reduction in IOP >20% from baseline levels. Recent data pertaining to SLT efficacy are summarized in Table 1.

Primary Open-Angle Glaucoma and Ocular Hypertension

The efficacy of SLT in patients with POAG or OHT has been demonstrated in numerous studies. It has great therapeutic potential when used as a primary or adjunctive treatment modality. Kadasi et al. have suggested that the efficacy of SLT is at least comparable to that of topical medications, and SLT may be preferred when considering the potential adverse systemic and local adverse effects as well as compliance issues associated with long-term medication use [1].

A recent study investigated the use of SLT in early and advanced open-angle glaucoma (OAG), where the glaucoma staging was based on the vertical cup-to-disc ratio. SLT was shown to be successful in reducing IOP by more than 20% in both early and advanced OAG. Furthermore, functional and/or structural progression was not detected in treated patients for up to 12 months post-operation. The success rates were 63% and 59.1% for early and advanced OAG, respectively. Results from this study allow clinicians to consider SLT as an alternative to higher-risk incisional therapies in advanced stages of OAG [13].

Kerr et al. used the water-drinking test (WDT) to demonstrate that SLT is effective in reducing both peak IOP and IOP fluctuation in patients with OAG or ocular hypertension. Following SLT, there was a significant reduction in both baseline and peak IOP, and the percentage rise from baseline after the WDT was significantly lower as well. Since WDT provides an accurate prediction of diurnal IOP spikes, SLT would be expected to minimize IOP fluctuations outside of the clinic when IOP measurement is not attainable [14].

Primary Angle-Closure Glaucoma

Traditionally, clinicians have not considered SLT in angle-closure glaucomas, as the procedure requires visualization and treatment of the trabecular meshwork. However, recent studies have investigated the efficacy and safety of SLT

Table 1 Summary of indications and efficacy of SLT

Paper	Design	Diagnosis	Number of eyes (n)	Postoperative follow-up	Definition of success	Success rate	Average IOP reduction or medication reduction	Additional outcomes
Schlote et al. [13]	Retrospective chart review	Early stage of OAG (vCDR < 0.8 and GSS 0–1)	$n = 27$	12 months	Eyes with elevated IOP prior to SLT: reduction in IOP < 21 mmHg and >20% of the initial IOP Or Eyes with discomfort to anti-glaucoma medication but controlled IOP: reduction in the number of medications ≥1 and an IOP < 21 mmHg	63%	N/A	Re-treatment in 7.4% of eyes
		Advanced stage of OAG (vCDR ≥ 0.9, GSS 2 ≥ 3, or vCDR 0.6–0.8 and GSS2 ≥ 2)	$n = 44$		Definition 1: Reduction in IOP < 21 mmHg and >20% of the baseline IOP Definition 2: IOP reduction <18 mmHg and no additional glaucoma medication at all time points after SLT Definition 3: IOP reduction <18 mmHg and >30% of the baseline IOP	Definition 1: 59.1% Definition 2: 65.9% Definition 3: 50%	N/A	Additional glaucoma surgery in 18.2% of eyes
Kerr et al. [14]	Retrospective cohort study	OAG or OHT	$n = 20$	At least 6 weeks	Significant reduction in baseline IOP, peak IOP, and % rise in IOP from baseline induced by the water drinking test	N/A	Reduction in mean baseline IOP from 16.9 ± 2.4 to 14.2 ± 2.3 mmHg ($P < 0.001$)	Peak IOP decreased from 21.9 ± 3.7 to 16.9 ± 3.1 mmHg ($P < 0.001$) and rise in IOP from baseline reduced from 5.0 ± 2.5 to 2.6 ± 1.8 mmHg ($P < 0.002$)

Table 1 continued

Paper	Design	Diagnosis	Number of eyes (n)	Postoperative follow-up	Definition of success	Success rate	Average IOP reduction or medication reduction	Additional outcomes
Ali Aljasim et al. [15]	Retrospective case–control study	PAC/PACG, POAG	$n = 96$ (SLT), $n = 99$ (PGA)	PAC/PACG: 6–20 months POAG: 6–17 months	IOP reduction ≥20% without further medical or surgical intervention or a reduction in the number of glaucoma medications by ≥1 while maintaining the target IOP	PAC or PACG: 84.7%, POAG: 79.6% ($P = 0.47$)	IOP reduction in patients with uncontrolled IOP: 38% (PAC/PACG) vs. 32.7% (POAG), $P = 0.08$ Number of medications reduction in patients with controlled IOP: 1.6 (PAC/PACG) vs. 1.5 (POAG), $P = 0.4$	N/A
Narayanaswamy et al. [16]	Randomized clinical trial	PAC/PACG	$n = 20$, (PXFG), $n = 28$ (POAG)	6 months	Complete success: IOP <21 mmHg and without any additional IOP-lowering medications Qualified success: IOP <21 mmHg who required IOP lowering medication	Complete success: 60% (SLT) vs. 84% (PGA), $P = 0.008$ Qualified success: 18% (SLT) vs. 6% (PGA), $P = 0.06$	IOP reduction: 16.9% (SLT) vs. 18.5% (PGA), $P = 0.52$	No patient required glaucoma surgery Additional medication: 22% (SLT) vs. 8% (PGA), $P = 0.05$
Miraftabi et al. [17]	Prospective non-randomized comparative study	PXFG, POAG	$n = 94$ (PXFG), $n = 250$ (non-PXFG)	12 months	IOP reduction ≥20% from baseline without additional IOP-lowering medications	At 6 months, 75% (POAG) vs. 94.1% (PXFG), $P = 0.08$ At 12 months, 29.1% (POAG), 25% (PXFG), $P = 0.9$	Significant IOP reduction up to 6 months post-operation	N/A

Table 1 continued

Paper	Design	Diagnosis	Number of eyes (*n*)	Postoperative follow-up	Definition of success	Success rate	Average IOP reduction or medication reduction	Additional outcomes
Lindegger et al. [18]	Retrospective chart review	PXFG	$n = 41$	60 months	N/A	N/A	Significantly greater IOP reduction in PXFG than non-PXFG eyes at 1 year follow-up, $P = 0.01$ PXFG: significant IOP reduction up to 21 months, 12.4%, $P = 0.01$ Non-PXFG: significant IOP reduction up to 30 months, 9.6%, $P = 0.01$	N/A
Lee et al. [19]	Prospective cohort study	NTG	$n = 34$	12 months	Absolute success: IOP reduction ≥20% after SLT compared to baseline without any additional anti-glaucoma medication Qualified success: IOP reduction ≥20% compared to baseline, with additional anti-glaucoma medication	Absolute success: 22%, qualified success: 73.2%	At 12 months, IOP reduction: 14.7%, medication reduction: 26.7%	N/A
Lee et al. [20]	Prospective cohort study	NTG	$n = 15$	24 months		Absolute success: 11.1%	At 24 months, IOP reduction: 11.5%, medication reduction: 41.1%	N/A
Maleki et al. [21]	Retrospective case series	Steroid-induced glaucoma	$n = 42$	12 months	IOP < 22 mmHg and/or >20% IOP reduction	46.7%	At 12 months, IOP reduction: 50.4%	N/A
Zhang et al. [22]	Retrospective chart review	Silicone oil-induced glaucoma	$n = 19$	12 months	IOP reduction of ≥20%, without additional medications, repeat laser trabeculoplasty, or glaucoma surgery	59.5%	At last visit, IOP reduction: 20.3%, medication reduction: 2.17 ± 1.21 to 1.25 ± 0.89 ($P < 0.05$)	N/A

Table 1 continued

Paper	Design	Diagnosis	Number of eyes (*n*)	Postoperative follow-up	Definition of success	Success rate	Average IOP reduction or medication reduction	Additional outcomes
Sluch et al. [23]	Retrospective chart review	Post-canaloplasty	$n = 18$	N/A	IOP reduction >20% at 2–4 weeks or a decrease in the number of medications 3 months after SLT	5 of 19 eyes (26.3%)	N/A	N/A
Zhang et al. [24]	Retrospective study	Post-trabeculectomy advanced POAG		9 months	IOP reduction >20% from baseline IOP at 6 and 9 months after the laser treatment date	100% 1 day after SLT; 77.7% at the last follow-up	IOP reduction of 16.7% in patients with pre-SLT IOP > 18 mmHg	IOP fluctuation reduced from 4.1 ± 1.4 to 2.6 ± 1.1 mmHg, $P < 0.05$

GSS glaucoma staging system, *IOP* intraocular pressure, *NTG* normal-tension glaucoma, *OAG* open-angle glaucoma, *OHT* ocular hypertension, *PAC* primary angle closure, *PACG* primary angle-closure glaucoma, *PGA* prostaglandin *POAG* primary open-angle glaucoma, *PXFG* pseudoexfoliation glaucoma, *SLT* selective laser trabeculoplasty, *vCDR* vertical cup-to-disc ratio

in cases where portions of the anterior chamber angle remain open and amenable to treatment.

Ali Aljasim et al. conducted a retrospective case–control study to compare the efficacy of SLT in eyes with primary angle closure or primary angle-closure glaucoma (PAC or PACG, respectively; 59 eyes) and POAG (59 eyes), with an average of 10 and 11 months of follow-up, respectively. In patients with poorly controlled preoperative IOP, SLT resulted in a mean IOP reduction of 38% following treatment in the PAC/PACG group. In patients who had controlled IOP of PAC/PACG under medication but were intolerant of the medications, SLT achieved a reduction of 1.6 medications. The success rate of SLT in reducing IOP by at least 20% was 84.7% in the PAC/PACG group, and the clinical outcomes were comparable to those in the POAG group [15].

Narayanaswamy and colleagues performed a randomized clinical trial that evaluated the efficacy of SLT in comparison to topical prostaglandin analog (PGA) medical therapy in patients with PAC/PACG. After 6 months of follow-up, the mean IOP in both groups was significantly reduced from baseline, and the reduction was comparable between the two groups. The overall success rate of SLT was 60%, which was significantly less than the 84% success rate achieved in the PGA group ($P = 0.008$). More medications were required to control IOP in the SLT group than in the PGA group (22% increase, $P < 0.05$), and these patients experienced a decrease (4.8%, $P < 0.001$) in endothelial cell count as well. In this study, SLT demonstrated effectiveness in treating PAC/PACG, but its overall efficacy and safety profile seemed less favorable than that for PGA [16]. This study suggests that SLT may be effective in patients with PAC and PACG with some portion of the anterior chamber angle (ideally more than 180°) open to trabecular meshwork after performance of laser iridotomy.

Pseudoexfoliation Glaucoma

In a recent prospective comparative study, Miraftabi and colleagues investigated SLT efficacy results in pseudoexfoliation glaucoma (PXFG) vs. POAG. The authors noted a significantly higher percentage reduction in IOP in the first 6 months following SLT in PXFG eyes when compared with POAG (29% vs. 19%, $P = 0.02$), while the efficacy of SLT in both types of glaucoma had decreased at the 12-month follow-up, with no significant difference in IOP reduction between the two types (16% vs. 16%, $P = 0.9$) at this time point. The success rates for SLT in achieving an IOP reduction >20% at 6 and 12 months post-operation were comparable between the types of glaucoma. There was no significant reduction in the number of glaucoma medications in either glaucoma type [17].

Lindegger et al. conducted a large-scale retrospective chart review of 394 eyes with different types of glaucoma that had undergone SLT. The study included 94 eyes with PXFG. Patient gender and age were taken into consideration in the efficacy analysis, as PXFG is associated with advanced age and female gender. Twelve months following SLT, PXFG eyes showed superior IOP reduction efficacy compared to non-PXFG glaucomas, which included POAG, normal-tension glaucoma (NTG), and pigmentary glaucoma. The investigators noted significant IOP reductions (12.3% and 9.6%) up to 21 and 30 months postoperatively in PXFG and non-PXFG eyes, respectively [18].

Normal-Tension Glaucoma

Lee et al. have conducted two prospective studies demonstrating favorable clinical outcomes using SLT in Chinese patients with NTG at 1- and 2-year follow-up. Patients enrolled in the studies underwent medication washout prior to determining their baseline IOP level. An IOP reduction of >20% from the baseline washout IOP without the addition of medication was considered absolute success [19, 20].

Forty-one right eyes were used in the analysis of the 1-year study and 34 right eyes from the same subject pool were included in the 2-year study. Except for an occasional IOP spike at 1 week post-operation, IOP measured at all post-operative time points was significantly reduced compared with the pre-study level [19, 20]. At 12-month follow-up, the average IOP reduction was 14.7% and medication reduction was 26.7% from pre-study levels, and the absolute success rate was 22% [19]. At 24-month follow-up, there was an 11.5% reduction in IOP and 41.1% reduction in glaucoma medication usage compared with pre-study levels, and the absolute success rate was 11.1% [20]. Although these studies demonstrate a beneficial IOP-lowering response in NTG, the efficacy remains lower than what may be achieved in POAG, PXFG, and pigmentary glaucoma.

Other Secondary Glaucomas

Several retrospective studies have demonstrated the efficacy and safety of SLT in treating various types of secondary glaucoma [21–24].

In a small retrospective study including 15 eyes with steroid-induced glaucoma in uveitic eyes, SLT demonstrated a 46.7% success rate in achieving IOP < 22 mmHg and/or >20% IOP reduction at all follow-up points up to 12 months. The mean reduction in IOP at 12 months was 50.4% [21].

Another retrospective study of 42 eyes showed that SLT can be effective in treating silicone-oil induced glaucoma. At 12-month follow-up, 59.5% of eyes achieved >20% IOP reduction without the addition of medications or additional laser procedure or surgeries. The mean IOP reduction was 20.3%, and the mean number of glaucoma medications was significantly reduced, from 2.17 ± 1.21 to 1.25 ± 0.89 ($P < 0.05$) [22].

Two smaller studies by Sluch et al. and Zhang et al. suggested a beneficial effect of SLT after canaloplasty and trabeculectomy surgical procedures, respectively [20, 21]. Larger studies with longer-term follow-up are needed to clarify the role of SLT after incisional glaucoma surgery.

PROGNOSTIC FACTORS

Several studies have investigated potential factors contributing to SLT success or failure in various types of glaucoma.

Miki et al. conducted a retrospective study that looked at success rate and factors contributing to treatment success in Japanese patients with open-angle glaucoma and receiving maximum-tolerable medical therapy. The medical charts of 75 eyes of 59 patients were reviewed up to 1 year postoperatively. The results indicated that SLT achieved higher success in patients with POAG than those with secondary open-angle glaucomas (SOAG; $P < 0.01$). In addition, patients with lower preoperative IOP ($P < 0.01$) and fewer preoperative glaucoma medications ($P < 0.01$) experienced greater IOP reductions [25]. In contrast, in another study that looked at the relationship between preoperative IOP and SLT efficacy, a mean preoperative IOP of > 18 mmHg was associated with a greater IOP reduction ($P = 0.002$) than an IOP of 14–18 mmHg, and a preoperative IOP of 14–18 mmHg led to better IOP reduction ($P = 0.03$) than IOP < 14 mmHg [26]. Chun et al. also demonstrated higher baseline IOP as a predictor of success [27]. After adjusting the post-laser IOP of the treated eye with the untreated eye in the same patient, the IOP reduction was not as prominent, although higher baseline IOP was predictive of significant IOP reduction in both adjusted and non-adjusted eyes (IOP reduction of 23.1 ± 14.3% and 26 ± 12.6%, respectively) [27]. Lee et al. reported that in Hong Kong Chinese patients, higher pre-SLT IOP was associated with treatment success, although extremely high pressure may not be effectively managed by SLT [12].

Most of the recent evidence points to a higher success rate and/or greater IOP reduction in eyes with higher baseline IOP up to a certain level. The energy level employed in SLT therapy may also be an important prognostic factor [28]. Age, gender, race, central corneal thickness, history of ALT, history of cataract surgery, and standard automated perimetry mean deviation were not found to be associated with greater IOP reduction after SLT [25–27]. Further study is likely necessary to explore other potential prognostic factors contributing to success after SLT therapy.

SURGICAL TECHNIQUE

Standard SLT therapy employs an Nd: YAG laser system with 400 μm spot size and three nanoseconds of laser duration. An initial energy level of 0.7–0.8 mJ is typically used, with upward energy titration until bubble formation becomes manifest. This energy level is considered the threshold energy. Recommended energy settings for conventional treatment are levels 0.1 mJ less than the threshold energy [28, 29].

A recent prospective cohort study investigated the optimal total SLT energy in 24 OAG and 25 NTG eyes of Chinese patients. Total SLT energy was defined as the number of SLT spots multiplied by the mean energy level for the treatment session. Here, 360-degree SLT was performed in all subjects, with a mean of 171.5 ± 41.2 laser spots, mean energy level per spot of 1.0 ± 0.06 mJ, and mean total energy of 167.1 ± 41.4 mJ. The average IOP reduction at 1 month following SLT was 20.2 ± 14.6%. A total energy level of 226.1 mJ (95% confidence interval: 214.58–234.87 mJ) was found to result in a significant reduction in IOP greater than 25% [28]. Results from this study suggest that a total SLT energy level in the range of 214.6–234.9 mJ may lead to higher success rates.

In another study investigating energy usage in SLT, Zhang et al. treated two groups of patients with 360-degree SLT with either conventional energy levels or sub-threshold energy (two-thirds of the conventional energy) levels. The total energy was 51.8 ± 5.7 mJ in the conventional treatment group and 37.6 ± 3.3 mJ in the sub-threshold treatment ($P = 0.036$) group. The IOP reduction and success rate following SLT treatment at all follow-up visits was comparable between the two groups up to 12 months postoperatively. In addition, no significant difference was detected between the two groups in the degree of anterior chamber inflammation as measured by the total protein content and cell density for up to 1 month post-operation [29].

Geffen et al. studied transscleral SLT without the use of a gonioscopy lens in patients with POAG or PXFG in a prospective randomized clinical trial. The study group received SLT without a gonioscopy lens, and the control group received conventional SLT therapy. After 6 months of follow-up, the mean postoperative IOP and success rates of IOP reduction >15% or >20% were similar between the two groups. However, the study group demonstrated fewer side effects, including anterior chamber inflammation and superficial punctate keratitis. The authors suggest that transscleral SLT without the use of a gonioscopy lens may be a more efficient and safer technique, with therapeutic potential comparable to that of the conventional method [30].

There are limited data for comparing same-day bilateral laser trabeculoplasty and sequential therapy [31]. An analysis of the use of laser trabeculoplasty in Ontario during 2000–2013 showed that after the introduction of SLT, there was a coincident increase in the number of same-day bilateral laser trabeculoplasty procedures in patients with POAG (4.9-fold increase). However, sequential therapy is typically considered safer, as it gives treating physicians opportunities to assess the efficacy and side effects of the procedure on one eye before treating the fellow eye [31].

In another prospective cohort study, 84 eyes of 42 subjects with POAG or NTG underwent bilateral SLT. The bilateral success rate was 42.9%, and there was a strong correlation between the two eyes, while 38.1% of eyes had bilateral non-success, with a moderate correlation between the two eyes. Interestingly, if success was achieved in one eye but not in the fellow eye, there was strong negative correlation between the two eyes. In the majority of eyes, the success or non-success of one eye may predict the clinical outcome of the fellow eye [32].

Greninger et al. investigated efficacy and safety outcomes after SLT performed by resident physicians. The investigators recruited 15 resident physicians to perform SLT in 81 patients. There was significant IOP reduction ($P < 0.001$), ranging from 12% to 19%, and success rates ranging from 36% to 50% after 3–24 months of follow-up. An IOP spike following the procedure was seen in 7% of the eyes. Both efficacy and complication rates were comparable to attending-performed SLT in the literature, regardless of whether the resident had had experience with SLT prior to this study [33].

POSTOPERATIVE CARE

No consensus statement exists regarding the postoperative management of patients after SLT therapy. Some ophthalmologists choose to use a short course of anti-inflammatory medications, but such practice has not been validated [34, 35].

Two randomized clinical trials have investigated the use of anti-inflammatory eye drops, including non-steroid anti-inflammatory drugs (NSAIDs) and steroid medications, after SLT. Neither of these studies found a significant difference in postoperative outcome among patients randomized to postoperative anti-inflammatory medications vs. either placebo (artificial tears) or no treatment [34, 35]. In the study by De Keyser et al., patients with POAG, NTG, or OHT served as their own self-control, and both eyes received 360-degree SLT treatment within a 1-week period. The study group reported that the use of indomethacin or dexamethasone was not associated with a significant difference in patients' postoperative comfort level, conjunctival hyperemia, rate of IOP spike at 1 h, or efficacy of treatment [34]. In the second trial, Jinapriya et al. investigated the effect of prednisone 1% and ketorolac 0.5% compared with placebo eye drops on IOP reduction in patients with open-angle or pseudo-exfoliation glaucoma after 180-degree treatment of SLT. Reduction in IOP at 1 month post-operation, treatment failure rates, and anterior chamber inflammation were not found to be significantly different across the groups. The investigators emphasized that the mean baseline IOP of the patients was 19.1 mmHg, which they considered a relatively low baseline, but that it should not have altered the comparison of treatment efficacy among the groups [35].

Given the findings to date, it is still too early to conclude whether anti-inflammatory medications should be used in the postoperative care of patients undergoing SLT. Larger studies that include a variety of glaucoma subtypes and different surgical techniques may be necessary to further investigate this issue.

REPEATABILITY

As IOP reduction wanes after initially successful SLT therapy, questions remain regarding the utility of repeat treatment. Three recent retrospective studies sought to answer this question by investigating the safety and efficacy of repeat SLT treatments. All three studies showed that mean IOP following both initial and repeat SLT was significantly reduced from baseline IOP, although there were discrepancies in the magnitude of IOP reduction and the success rate of repeat SLT compared to the initial SLT treatment. Neither initial nor repeat SLT resulted in a significant reduction in the number of glaucoma medications among the studies [3–5].

Francis et al. studied 137 eyes of 137 patients, which was a much larger number of subjects than in the other studies. The investigators defined success of repeat SLT therapy as either (1) an IOP between 5 and 21 mmHg, with at least 20% IOP reduction and with no addition of glaucoma medications, or (2) an IOP between 5 and 21 mmHg, with IOP reduction of at least 20% or reduction in glaucoma medication use, without other procedures. With different IOP baselines ($P = 0.03$) between initial (SLT1) and repeat (SLT2) SLT, initial treatment seemed to have a higher success rate than repeat treatment by both definitions. However, when the baseline IOP of initial and repeat SLT were matched, the IOP reduction and success rate did not differ significantly between treatments (definition 1: SLT1—43% at 6 months and 20% at 12 months, SLT2—44% at 6 months and 20% at 12 months; definition 2: SLT1—57% at 6 months and 33% at 12 months, SLT2—52% at 6 months and 28% at 12 months). The percentage IOP reductions at 12-month follow-up for SLT1 and SLT2 were similar regardless of whether the baseline IOP values were matched. The success rate by both definitions was significantly higher when there was a shorter interval between initial and repeat SLT at all follow-up visits ($P < 0.01$). In one of their sub-analyses, the investigators reported that the reduction in IOP after either initial or repeat SLT was not affected by whether the patients had undergone ALT, which provides more insight into treating patients who have had ALT with SLT in the past [3].

In a study by Khouri et al., repeat SLT was effective in lowering IOP up to 24 months after treatment, and the IOP reduction was similar to that of the initial treatment. However, at 4, 8, and 12 months post-operation, there was greater reduction ($P < 0.05$) with the initial treatment than with the repeat treatment. In addition, a lower success rate was achieved ($P < 0.05$) for eyes experiencing an IOP reduction >20% and 15% from baseline with repeat treatment at all time points except 18 and 24 months post-operation, where the effect of both initial and repeat treatments wore off. At 24 months, there was a 29–30% success rate after repeat SLT therapy [4].

Polat et al. also studied repeatability of selective laser trabeculoplasty and defined success as either (1) IOP control without additional glaucoma medication or other procedures, or (2) IOP reduction by at least 20%. In 38 eyes with OAG uncontrolled on maximum medical therapy, the median survival rate with repeat SLT treatment (definition 1: 1054 days; definition 2: 360 days) was found to be longer than with the initial SLT treatment (definition 1: 570 days; definition 2: 270 days) by both definitions. Efficacy of both initial and repeat SLT was present throughout the 24-month follow-up. The IOP reduction was not significantly different between initial and repeat SLT at any time point. This study also demonstrated the relative safety of repeat SLT, as it was not associated with an IOP spike of more than 10 mmHg or anterior chamber inflammation [5].

COMPLICATIONS

A recent review study summarized some of the reported complications of SLT. These include transient IOP spike, iritis, hyphema, macular edema, foveal burn, and corneal haze [9]. In addition, some uncommon complications of SLT have been discussed in case reports [10, 11, 36]. Recent data pertaining to complications related to SLT are summarized in Table 2.

Several original studies have elucidated possible transient changes in the cornea following SLT [11, 37–39]. These include changes in corneal thickness, corneal hysteresis, and endothelial cell function [10, 11, 37–39]. Anterior chamber volume (ACV) and macular

Table 2 Complications of SLT

Paper	Design	Diagnosis	Number of eyes (*n*)/patients	Complications
Chadha et al. [10]	Case report	OAG	Two patients	Corneal edema secondary to herpetic stromal keratitis without known history of herpes ophthalmicus or oral ulcers prior to the SLT treatment
Bettis et al. [11]	Case series	Exfoliation glaucoma	Five patients	Postoperative corneal edema, corneal endothelial injuries. IOP elevation persisting weeks to months and up to 39–48 mmHg
Ali Aljasim et al. [15]	Retrospective case–control study	PAC/PACG, POAG	$n = 59$ (PAC/PACG), $n = 59$ (POAG)	IOP increase of 10 mmHg in 10% of PAC/PACG patients and 5% of POAG patients 1 h after SLT
Narayanaswamy et al. [16]	Randomized clinical trial	PAC/PACG	$n = 96$ (SLT), $n = 99$ (PGA)	IOP increase >5mmgHg in 2% of PAC/PACG patients 30–60 min following SLT
Zhang et al. [22]	Retrospective chart review	Silicone oil-induced glaucoma	$n = 42$	IOP increase >6 mmHg of 26.2% of eyes on the same day as SLT treatment
De Keyser et al. [34]	Prospective randomized clinical trial	POAG/NTG/OHT	$n = 132$	SLT induced little inflammation (e.g. pain, redness, cells in anterior chamber, transient IOP spike)
				Transient IOP increase >5 mmHg in 3–8.5% of patients
Baser et al. [36]	Case report	POAG	Two patients	PAS following repeat SLT
Atalay et al. [37]	Retrospective chart review	POAG	$n = 33$	3–6 months following SLT, significant changes in CCT, thinnest point of cornea, and posterior corneal asphericity at 5 and 8 mm ($P = 0.03$, 0.01, 0.02, and 0.04, respectively)
Guven Yilmaz et al. [38]	Prospective study	POAG and OHT	$n = 45$	1 month following SLT, significant increase in CCT and decrease in ACV ($P < 0.05$); both returned to baseline at 3 months
Pillunat et al. [39]	Prospective case series	OAG	$n = 52$	Significant increase in CH ($P = 0.028$) and decrease in CRF ($P = 0.037$); neither is significant after adjusting for IOP reduction
Koc et al. [40]	Prospective randomized clinical trial	POAG	$n = 40$	Temporary increase in macular thickness in three quadrants, which returned to baseline at 1-month follow-up

ACV chamber corneal volume, *CCT* central corneal thickness, CH corneal hysteresis, CRF corneal resistance factor, *IOP* intraocular pressure, *NTG* normal-tension glaucoma, *OAG* open-angle glaucoma, *OHT* ocular hypertension, *PAC* primary angle closure, *PACG* primary angle-closure glaucoma, *PAS* peripheral anterior synechiae, *PGA* prostaglandin, *POAG* primary open-angle glaucoma, *SLT* selective laser trabeculoplasty thickness have also been shown to change transiently after SLT [38, 40]. Baser et al. reported on two cases of peripheral anterior synechiae (PAS) as a complication of SLT. In the two patients with POAG, there were no PAS noted after successful initial SLT. The PAS were detected 3-6 months following the repeat SLT treatment [36].

The incidence of a transient IOP spike after SLT has been investigated in several studies. In the majority of these, an increase in IOP was detected only on the day of the SLT procedure and was controlled by medications and not considered a long-term complication. Roughly 2–26.2% of glaucoma patients experienced a temporary postoperative IOP spike [15, 16, 22, 34]. In Ali Aljasim et al.'s study, an IOP spike of 10 mmHg was detected in 10% of PAC/PACG patients and 5% of POAG patients 1 h after the procedure [15]. Narayaaswamy et al. reported an increase in IOP greater than 5 mmHg in 2% of PAC/PACG patients 30–60 min following SLT [16]. A transient IOP spike greater than 5 mmHg 1 h following SLT was detected in 3–8.5% of patients in a study by De Keyser et al. [34]. In patients with silicone oil-induced glaucoma, 26.2% of eyes experienced an IOP spike greater than 6 mmHg on the same day as the treatment [22]. Longer-term IOP elevation was reported in a case series of five patients with exfoliation glaucoma, with IOP elevation persisting weeks to months and up 39-48 mmHg. All patients required surgical intervention with trabeculectomy with mitomycin C and/or aqueous shunt implantation [11].

CONCLUSION

Recent findings pertaining to SLT therapy have demonstrated its benefits and advantages in treating glaucoma, yet there are still unanswered questions. Its effectiveness in various types of glaucoma has tremendous clinical value. Studies that have examined the postoperative care and repeatability of SLT provide insight in terms of the long-term application of this procedure in glaucomatous individuals. Physicians should be familiar with common and rare but significant complications of SLT in order to provide comprehensive information to the patients and to be prepared to address possible issues following the procedure. As SLT remains a powerful tool in treating glaucoma, more evidence will emerge to further improve clinical outcomes and patient care.

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