Does SLT only affect trabecular meshwork outflow facility?

“Does SLT affect only trabecular meshwork outflow facility?”. This is one of the questions addressed by Sheng Lim, MD FRCOphth, a consultant Ophthalmic Surgeon at St. Thomas’ Hospital, London, in a prospective randomized clinical trial. This trial, titled “Mechanism of Action of Selective Laser Trabeculoplasty (SLT),” commenced in October 2006. Along with co-authors Saurabh Goyal, Safina Khan, Shaheen Shah, Laura Beltran-Aguullo, Remin Nath and Adanna Obi, Sheng Lim recently presented preliminary results from this study at the Royal College of Ophthalmology (RCO) meeting in the United Kingdom.

“It is important to understand the mechanism of action of SLT to refine the...”

On target: Sheng Lim measures tonographic outflow by electronic Schiotz tonometry following SLT therapy.

Questions and Concerns from the Patient’s Point of View

In this issue, we provide a unique perspective on SLT – from the point of view of a patient, as well as that of the SLT expert she consulted via email prior to making her treatment decision. Their email dialogue, along with the accompanying article authored by the patient, presents SLT users with a valuable inside look at an SLT candidate’s thoughtful and reasoned approach to gathering information, as well as the extent she went to locate expert advice and educate herself before giving SLT the green light.

It also points out the value to the physician of making a variety of educational resources available to patients who are SLT candidates – especially those who, for whatever reason, may not be as inclined to ask questions or express concerns.
Most ophthalmologists use SLT as they previously used ALT in their open angle glaucoma (OAG) treatment paradigm – that is, either when drug therapy becomes insufficient, or before resorting to surgery. This approach doesn’t take into account that SLT, contrary to ALT, assures a significant reduction in intraocular pressure (IOP) that is virtually free from side effects in most patients, and doesn’t interfere with the degree of success of future medical or surgical treatment. It seems logical, therefore, to use SLT as the initial glaucoma therapy in order to avoid the quality of life issues associated with chronic eye drop therapy and to help solve the grave prognostic issues resulting from non-compliance.

The efficacy of SLT as initial therapy for glaucoma is becoming apparent as the results of more clinical trials are published. This data is available in full-scale, peer-reviewed articles in premier ophthalmic journals, as well as in conference abstracts, the forerunners of full-fledged publications.

In one of the early articles attesting to the efficaciousness of SLT, Shlomo Melamed1 reported the treatment of 45 eyes of 31 patients suffering from OAG or ocular hypertension. In all but eight eyes, SLT was used as the first IOP-lowering therapy. Post-SLT, mean IOP decreased from 25.5±2.5 mmHg preoperatively to 17.9±2.8 mmHg at last follow-up, with a mean reduction of 7.7±3.5 mmHg (30 percent) one year after treatment.

In a second study, Lai et al2 reported treating 29 Chinese patients newly diagnosed with POAG or ocular hypertension with no previous anti-glaucoma treatment. One eye of each patient underwent 360-degree SLT, and the other received topical medical treatment. Success was defined as IOP 21 mmHg or less. Twenty-four patients completed five-year follow-up, during which time eight eyes (27.6 percent) treated with SLT required the addition of medications to maintain IOP lower than 21 mmHg.

Other than this, there was no significant difference in mean IOP reduction between the two treatment modalities at all time points. After five years, the mean IOP reduction was 8.6±6.7 mmHg (32.1 percent) in the eyes treated with SLT and 8.7±6.6 (33.2 percent) in the medically treated eyes. Five eyes in the SLT group and eight eyes in the medical treatment group required filtration surgery.

Recently, McIlraith3 reported a prospective, one-year study of 100 eyes of 61 patients with OAG or ocular hypertension. The patients elected whether to receive either SLT or Latanoprost as an initial therapy, regardless of the degree of angle pigmentation. Both modalities of treatment were equally effective. The authors concluded that SLT can be considered as first-line treatment for newly diagnosed open-angle glaucoma.

The conclusions from these studies are also supported by a larger study undertaken by Drs. Jindra and Gupta from Columbia University, New York. In it, they reported on SLT as primary treatment of 474 eyes with a mean follow up of just over one year during the recent ARVO 2006. Mean IOP decrease was 35 percent. Sixty of the eyes were followed over three years with maintenance of a similar degree of pressure decrease.

What all these clinical studies have in common is ample evidence for the feasibility and advantages of SLT as first-line therapy for both OAG and ocular hypertension.

References:


“...SLT can be considered as first-line treatment for newly diagnosed open-angle glaucoma.”
Making the SLT Decision, continued

The Patient’s Perspective
Gaela Hilditch

A couple of years ago my eye pressure was slowly creeping up when my ophthalmologist suggested I undergo trabeculectomy surgery. I was apprehensive about the surgery – I had read about the diminishing results over time (the effects of surgery only last a few years) and the risks of infection and blindness. After being booked in for the procedure several times over a period of nine months, and canceling several times, I decided to get another opinion. I ended up discussing my options with a glaucoma specialist in Sydney, whom I had read about in the “Australian Glaucoma News”. It was through consultation with this specialist that I learned about SLT for the first time. SLT had never been mentioned at any of the glaucoma support meetings I previously attended, and no ophthalmologist in Perth had ever mentioned SLT.

During consultation, it was suggested I try SLT. I had nothing to lose, and if SLT therapy was successful, it could potentially delay the need for a trabeculectomy. On top of this, SLT is non-invasive and involves less risk than surgery, so I decided it must be a worthy consideration.

I returned to my ophthalmologist with the intention of undergoing SLT. He agreed, but was cautious, suggesting the results may be short-term, and that I would probably need to continue with my current drug regime. He also advised that he was not aware of any clinics in Perth offering SLT.

Eager to undergo the treatment close to home, I decided to go on the Internet in search of information about SLT. I came across a doctor based in the United Kingdom, Ms. Madhu Nagar, who offered SLT therapy at Maidstone Hospital, Kent. I rang the hospital, only to find that Ms. Nagar was on vacation. Despite this, the hospital administration gave me her mobile phone number! I got through to Ms. Nagar while she was on vacation and she was most helpful, advising me that the company Ellex, based in Australia, actually produced the SLT devices. She was quite surprised that she was the first person to convey this to me, especially since she was across the other side of the world.

Ms. Nagar put me in touch with the Ellex head office in Adelaide. From here I liaised directly with Ellex to learn that SLT was available throughout Australia - including Perth! By this time I had already booked my flight and scheduled an appointment with the glaucoma specialist in Sydney.

It was decided that SLT would initially be applied to half the eye, and the second half of the eye treated when necessary – if pressures started to creep up again or the field of vision tests indicated loss of vision, for example.

Since undergoing the first stage of SLT treatment in January 2007, my eye pressures have remained fairly stable – ranging between 13 mmHg and 18 mmHg. I have continued with my drug regime of Alphagan, Nyogel and Travatan to help better maintain IOP control.

My most recent field of vision test in April of this year indicated that there had not been significant loss of peripheral vision. Based on these results, my ophthalmologist concluded that my current situation does not warrant further SLT. Plus, he has not mentioned the need for me to undergo a trabeculectomy – something I am very happy about!

The Physician’s Perspective
Madhu Nagar

I was surprised to receive a phone call from a very pleasant but apprehensive Australian woman on the other side of the world. Suffering from uncontrollable glaucoma despite taking medication for the past five years, Gaela Hilditch was anxious to determine if SLT would help bring her glaucoma under control. I tried to reassure her about SLT, and suggested she send me her queries via email so that I could address them in more detail. The following is a transcript of this email correspondence:

Gaela: Is it worth considering treating 180-degree of the trabecular meshwork (TM) with SLT with follow-up treatment for the other 180-degree a few weeks later to test the eye’s reaction, rather than have two treatments in one week?

Madhu: If angles are not very heavily pigmented then 360-degree in one session is an option. Otherwise, two sessions of 180-degree one to two weeks apart, second session to follow if first one demonstrated IOP drop. If going ahead with 360-degree treatment your doctor can start you on acetazolamide capsules for 2 days in order to prevent IOP spike.

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Does SLT only affect trabecular meshwork outflow facility?

This comment refers to the fact that while SLT is recognized as an effective primary and adjunctive treatment for ocular hypertension (OHT) and primary open-angle glaucoma (POA), the mechanism of IOP reduction following SLT treatment is still not well understood. Current publications propose a mechanism of cellular and biological effects leading to increased outflow², but there is no published clinical study on the effect of SLT on the outflow facility.

Prasad and Latina (ARVO 2007) found a 31 percent reduction in IOP and 66 percent increase in outflow facility six weeks after 180-degree/360-degree SLT in 9 eyes of 7 patients with OHT/POAG (6 primary and 3 adjunctive treatment)⁴.

In Sheng Lim’s study, newly diagnosed, untreated adult OHT/POAG patients with an IOP between 21-35 mmHg and no previous intraocular laser or surgery were included. Primary angle closure, secondary glaucomas (including pigmented, uveitic, traumatic, etc) and advanced glaucoma - VA<6/36 or C/D ratio ≥0.9 were excluded from the patient cohort. Patient recruitment was performed at the Glaucoma Clinic of St. Thomas’ Hospital. Forty consecutive patients were invited to participate; out of these, two declined to participate and 38 were treated.

The eyes were randomized to receive either 180-degree or 360-degree SLT. Where both eyes were eligible and treated by SLT, only one eye was randomly selected for analysis after eyes with poor tonography were excluded.

SLT treatment was performed by Saurabh Goyal (50-100 shots, starting at 0.7mJ, end-point “champagne” bubbles). Three IOP measurements were performed using a Goldmann tonometer by Safina Khan. Trabecular outflow was measured by Sheng Lim using four-minute electronic Schiotz tonography, between 9.30-11:00 a.m. at baseline and four weeks after SLT. (Please refer to Table 1 for a summary of results).

Nine-point measurements from the tonography printout were input in the McLaren tonography computer program, and the value for the trabecular outflow (TOF) was calculated using the 1955 scale approved by the Committee on Standardization of Tonometers.

Of the 36 patients (POAG=25, OHT-11) analyzed, 18 eyes of 18 patients were included in the 180-degree SLT group, and 18 eyes of 18 patients in the 360-degree SLT group. No patients were lost to follow-up at one month.

The results of the study demonstrated that SLT is effective in reducing IOP (by 29 percent overall) in POAG and OHT patients. There was no statistically significant difference between the 360-degree and 180-degree treatment groups, with each

### Table 1: Baseline and one-month median IOP (mmHg) and trabecular outflow (TOF, µl/min/mm) and difference between the 180° and 360° treatment groups.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>180° SLT (n = 18)</th>
<th>360° SLT (n = 18)</th>
<th>p value* (between 2 groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-SLT IOP</td>
<td>24.4 (4.1)</td>
<td>25.7 (2.1)</td>
<td>0.8</td>
</tr>
<tr>
<td>Post-SLT IOP</td>
<td>19.0 (5.2)</td>
<td>16.7 (3.0)</td>
<td>0.27</td>
</tr>
<tr>
<td>Decrease in IOP from baseline (p value)</td>
<td>6.1 (4.0); p &lt; 0.001</td>
<td>9 (3.6); p &lt; 0.001</td>
<td>0.18</td>
</tr>
<tr>
<td>Median % change in IOP</td>
<td>23.5%</td>
<td>35%</td>
<td>0.44</td>
</tr>
<tr>
<td>Pre-SLT TOF</td>
<td>0.08 (0.04)</td>
<td>0.08 (0.05)</td>
<td>0.5</td>
</tr>
<tr>
<td>Post-SLT TOF</td>
<td>0.11 (0.04)</td>
<td>0.13 (0.09)</td>
<td>0.13</td>
</tr>
<tr>
<td>Increase in TOF from baseline (p value)</td>
<td>0.03 (0.05); p = 0.003</td>
<td>0.05 (0.09); p = 0.005</td>
<td>0.113</td>
</tr>
<tr>
<td>Median % change in TOF</td>
<td>37.5%</td>
<td>52.3%</td>
<td>0.476</td>
</tr>
</tbody>
</table>

*Kruskal Wallis Test
The goal of any type of filtrating glaucoma surgery is to create a bleb, through which 100 percent of the aqueous will flow after the operation. As a result, the remainder of the 360 degrees of the trabecular meshwork is no longer called upon to function, which may result in the collapse of Schlemm’s canal, followed by fibrosis that can cause the eye’s natural evacuation paths to become non-functional. Stegman’s very effective surgical technique, viscocanalostomy, avoids this risk by dilating the canal; however, this is not a commonly performed procedure.

Performing selective laser trabeculoplasty (SLT) prior to filtrating surgery may offer several advantages:

1. In some cases, it may obviate the need for surgery by reducing the IOP to an acceptable level

2. It may reduce the pressure sufficiently for the surgeon to plan ahead for what otherwise would have been an emergency operation

3. By stimulating a renewal of the trabecular meshwork’s natural function, it may:
   - encourage partial evacuation of the aqueous humour via the natural outflow paths, thus preserving their integrity;
   - avoid the collapse of Schlemm’s canal, which remains patent; and
   - enable a further reduction in IOP, both immediately after the operation and in following months.

For cases where we are not performing an emergency procedure, we have achieved excellent results using SLT prior to surgery. SLT is a gentle treatment with no risk for the patient and multiple potential benefits.

Looking ahead, controlled clinical trials on a larger series of patients are required to validate our preliminary clinical experience, but the role of SLT prior to surgery appears promising.

Based on the results of this study, Sheng Lim and his colleagues concluded that aqueous dynamics parameters other than outflow facility (i.e. aqueous production \( F \), uveoscleral outflow \( U \) or episcleral venous pressure \( P_v \)) may be affected by SLT. This hypothesis requires further investigation.

According to study co-author Saurabh Goyal, “this is the first study that systematically investigates the effect of SLT on trabecular outflow facility as a step to understand its mechanism of action.”

References

Acknowledgements: The study participants thank Ellex for providing the SLT system (Solo) to St. Thomas’ Hospital for the purpose of this study.
Selective Laser Trabeculoplasty (SLT) figured prominently in the 2008 annual meeting of the Association for Research in Vision and Ophthalmology (ARVO), which recently took place in Fort Lauderdale, Florida. The results from several SLT research projects were among more than 6,100 presentations during the meeting.

Results from each of these research projects point to SLT as an improved glaucoma treatment that overcomes the compliance issues that are the most critical problem in the failure to eliminate most glaucoma blindness and visual impairment.

The leading SLT research projects presented during the meeting can be summarized as follows:

### SLT as Secondary Therapy

Murthy and Latina, Massachusetts Eye and Ear Infirmary, retrospectively tested the efficacy of SLT as a secondary treatment by analyzing 75 eyes of 75 consecutive patients uncontrolled on medical therapy. The end points were IOP reduction and rate of glaucoma surgical intervention following SLT (180-degree) in patients with early versus moderate to severe POAG over five years. The study found that IOP reduction after SLT was similar in both groups.

However, in patients with moderate/severe OAG, the rate of glaucoma surgery following SLT was significantly higher. This finding suggests that, despite the similar efficacy of SLT in both groups, patients with moderate/severe OAG are less likely to achieve target IOP in order to prevent surgical intervention.

From this study it appears that SLT is effective for postponing surgery in patients whose IOP is uncontrolled by drugs. SLT, however, is more effective if used early in the disease progression.

### SLT for Medically Uncontrolled Patients

The lesson learned from Murthy and Latina’s presentation – that SLT can be used to effectively treat medically uncontrolled patients – was reinforced by Malen and Lai, New York, who retrospectively reviewed SLT’s effect on the IOP (100 spots, 360 degree) of 29 POAG eyes on maximum medical therapy. From a level of 18.97 mmHg, IOP was effectively reduced at one year by 2.48 mmHg. This study provides further proof that SLT is easy to perform even by relative novices. It is worth noting that the presenters found considerable IOP reduction even at relatively low baseline IOP, while it was previously shown that the only factor determining SLT success is the pre-treatment IOP: the higher it is, the better the reduction.

### Efficacy of SLT for Advanced POAG

Ozaki and colleagues from the University of Fukuoka, Japan, shared results from their study investigating the efficacy of 180-degree SLT for well-advanced POAG in 42 eyes of 34 patients over a six-month period. Success, defined as 20-percent reduction, was achieved in 60 percent of POAG patients at the three-month mark, where the initial IOP was 21.3 mmHg. Success was not achieved for the normal tension glaucoma eyes, which had a 14.3 mmHg baseline IOP. SLT was less successful with patients under more drugs, probably also as a result of lower initial IOP. This presentation again emphasizes the fact that SLT, like medical therapy, is more effective at higher initial levels of IOP.

### SLT for Chronic Primary Angle Closure Glaucoma

Reish et al., from New Orleans, reported on a retrospective study investigating the efficacy of SLT for poorly controlled POAG (53 patients) and Chronic Primary Angle Closure Glaucoma (CPACG) (26 patients). SLT treatment was performed following iridotomy and in the presence of 270-degree open-angle, whilst ocular drug therapy was held constant over an 18-month period. In all
patients SLT produced a significant IOP decrease of 18.83 percent (p < 0.0001). In patients with POAG the decrease was 20.06 percent, and in CPACG it was 16.91 percent.

This report supports the results of the clinical study attesting to the efficacy of treating CPACG reported by Barkana et al. at the 2007 ARVO meeting. Since CPACG is very difficult to treat and causes blindness and visual impairment in millions of people, SLT should be tried in appropriate cases of the disease – those patients with a patent iridotomy and over 90-degree visible angle. SLT will overcome, at least temporarily, the grave problem of drug availability and patient compliance.

Repeat SLT

There is no doubt that SLT is effective for lowering IOP in the large majority of glaucoma cases at least once. Unlike ALT, it causes no permanent histologically visible lesions in the trabecular meshwork, and can be safely repeated. However, the extent of this repeatability is yet uncertain.

The efficacy of second SLT was retrospectively studied by Rudavska, Iwach, Hetherington and colleagues from San Francisco in 44 eyes of 38 patients with POAG. Of the patients, 43.2 percent achieved target IOP at last follow up (average 34.5 weeks). It seems therefore that repeat SLT is effective in almost half of POAG cases. Since the procedure is without serious or permanent side effects, it is worth trying before reverting to drug therapy or surgery.

The effect of third and fourth SLT on IOP in 20 and 7 (respectively) eyes with glaucoma of various types uncontrolled by extensive medical therapy was studied retrospectively by Janet Serle and her group in New York. At six months following SLT, approximately half of the patients were controlled by a third course of SLT treatment, and only 25 percent by fourth SLT treatment. In this small series of patients on maximal medical therapy, a third course of SLT appears to be moderately successful, and the fourth course provided additional benefit in IOP control for a quarter of the patients. It therefore appears that for patients who are uncontrolled medically, undertaking a third course of SLT treatment is worthwhile. It is not clear from these two studies what is the effect of repeat SLT on eyes not under chronic intense medical therapy.

SLT After Triamcinolone Acetonide Injections

The results of SLT treatment following IOP elevation after triamcinolone acetonide injection were studied retrospectively by Hirahara et al. from Nagoya, Japan. SLT was performed on 7 cases (7 eyes) with severe IOP elevation, followed for a median of 33 months (range, 13 to 40 months). SLT effectively decreased IOP from 28 - 46 mmHg (mean 34.3 mmHg) to 9 - 16 mmHg (mean 14.2 mmHg) (p<0.01). Overall success rate (IOP <20 mmHg with or without medications and no subsequent surgery) was 86 percent (6 eyes). It seems that SLT can be used safely and successfully for treating this rather common condition, although much larger studies are required to prove efficacy.

Histology

Katz et al., from the Wills Eye Institute in Philadelphia examined human cadaver trabecular meshwork by scanning electron microscopy to confirm that Micropulse Diode Laser (MLT) and SLT have similar, non-discernable effects on the trabecular meshwork structure, in contradistinction to the craters produced by ALT.

“... research projects point to SLT as an improved glaucoma treatment that overcomes the compliance issues that are the most critical problem in the failure to eliminate most glaucoma blindness and visual impairment.”
Making the SLT Decision, continued

Gaela: What are the risks associated with SLT and especially when there has been prior traumatic injury to the eyes - in my case a squash ball injury to the right eye more than 30 years ago.

Madhu: If TM is non-functioning it may not work and there is a risk of IOP spike.

Gaela: Considering that I have 360-degree angle recession in the right eye, am I more likely to sustain damage to the TM or making it worse as a result of SLT because of this prior injury and therefore compromising future drainage options in the future?

Madhu: No. SLT will not damage the meshwork and future drainage surgery will not be compromised due to SLT.

Gaela: Am I more likely to experience elevated ocular pressure because of prior traumatic injury?

Madhu: Only if TM is non-functioning or is heavily pigmented.

Gaela: Can SLT be repeated if the pressure begins to rise again in the future or would I have to opt for a trabeculectomy in this instance?

Madhu: It is a repeatable procedure.

Gaela: For SLT to be successful is there an expectation that I should need follow-up treatments at the place of the initial treatment and how often.

Madhu: Your surgeon’s choice but I believe your local ophthalmologist can do IOP checks.

Gaela: Do you know the success rate of SLT for people with traumatic injury?

Madhu: I have treated three. All have responded really well but all have 120-180 degree of non-recessed angles; in other words, functioning angles.

correction. In the March 2008 volume of Regenerate we reported on a case series which demonstrated the effectiveness of SLT for pseudophakic secondary glaucoma - “SLT in Pseudophakic Secondary Glaucoma: A Case Series”. The article omitted reference to some of the study authors. Please refer to the complete list of study authors as follows:

- Madhu Nagar FRCS (Ophth) Ed, MS (Ophth)
- Nimish Shah MRCOphth, MS (Ophth)
- Bharat Kapoor MRCOphth, MS (Ophth)
- Rahul Yadav MRCOphth, MS (Ophth)