The Effect of Selective Laser Trabeculoplasty on Intraocular Pressure in Patients With Intravitreal Steroid-induced Elevated Intraocular Pressure

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Purpose: To assess effectiveness of selective laser trabeculoplasty (SLT) in lowering intraocular pressure (IOP) in patients with steroid-induced elevated IOP.

Methods: Retrospective review of 7 patients (7 eyes) with IOP elevation after intravitreal triamcinolone acetonide (4.0 mg/0.1 mL) injections for macular edema (6 patients) or central retinal vein occlusion (1 patient). Three patients had preexisting open angle glaucoma; 2 patients had preexisting ocular hypertension. Time between intraocular corticosteroid injection and subsequent increased IOP ranged from 5 to 29 weeks. After unsuccessful maximum tolerated medical therapy, patients underwent unilateral SLT between April 2003 and June 2005. IOP was measured 4 weeks prelaser; on the day of laser; within 3 weeks, and at 1, 3, and 6 months postlaser. Two-sample t test was used for analysis.

Results: The pre-SLT and post-SLT IOP measurements were the major outcome measures used to define the relative success of the SLT procedure. Seven patients were taking 4.0 ± 0.8 ocular hypotensive medications before SLT. Preoperative IOP (mm Hg ± SD) 38.4 ± 7.3 decreased postoperative to 25.6 ± 7.1 within 3 weeks (P < 0.003), 25.9 ± 8.8 at 1 month (P < 0.007), 23.9 ± 10.6 at 3 months (P < 0.006), and 15.7 ± 2.2 at 6 months (P < 0.001). Four patients underwent a second SLT procedure. Two patients failed after the 3-month visit. IOP in fellow eyes of all patients was unchanged (P > 0.080).

Conclusions: SLT lowered (P < 0.007) IOP in 5 eyes of 7 patients with steroid-induced increased IOP from 3 weeks to 6 months postoperatively. Two patients required additional surgical procedures. Repeat SLT treatments may be necessary. SLT is a temporizing procedure to consider in patients with steroid-induced elevated IOP.

Key Words: intraocular pressure, glaucoma, elevated IOP, selective laser trabeculoplasty, triamcinolone acetonide

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It has been established that corticosteroids administered topically, by intravitreal injection, or systemically are associated with a rise in intraocular pressure (IOP) and the development of glaucoma. The rise in IOP has been shown to be related to the dose, duration of administration, type and route of administration of steroid.

Intravitreal injections of triamcinolone acetonide (TA) have recently become a frequently used treatment for various intraocular proliferative or edematous diseases, including diabetic macular edema and central retinal vein occlusion. There have been several recent studies demonstrating a rise in IOP and the development of secondary glaucoma after intravitreal TA injections. In some patients, postinjection IOP elevation has been unresponsive to maximum medical therapy, necessitating surgical intervention including removal of the corticosteroid, trabeculectomy, Ahmed valve placement, pars plana vitrectomy, or a combination of trabeculectomy and vitrectomy with removal of corticosteroid.

Selective laser trabeculoplasty (SLT) is an effective treatment modality for lowering IOP in patients with open angle glaucoma. It is a safe and potentially repeatable procedure that can be considered as a treatment in patients with open angle glaucoma who are noncompliant with their ocular medications or whose IOP is not adequately controlled by maximum tolerated medical therapy.

There have been several clinical studies evaluating the effectiveness of SLT in lowering IOP in patients with various glaucoma diagnoses, including primary open angle glaucoma, pigmentary glaucoma, pseudoxfoliation glaucoma, and normal tension glaucoma. Studies evaluating the effect of SLT on IOP in patients with intraocular steroid-induced elevated IOP have not been reported. The aim of this study is to assess the
The effectiveness of SLT in lowering IOP in patients who developed elevated IOP, after intravitreal injection of TA.

METHODS

From an SLT database of 182 patients compiled since April 2003, we retrospectively identified 7 patients (7 eyes) who had had an SLT laser performed for uncontrolled elevated IOP after intravitreal TA (4.0 mg/0.1 mL) injections. Six patients received the steroid injection for macular edema, and 1 patient received the steroid injection for central retinal vein occlusion. These 7 patients underwent an SLT in 1 eye between April 2003 and June 2005 at Glaucoma Consultants of Long Island, Bethpage, New York, by one of 3 surgeons, (R.F.R., C.H.M., and J.B.S.). Demographic information including age, sex, race, glaucoma diagnosis, prior ocular surgeries, and IOP-lowering medications were recorded (Tables 1, 2). Three patients had preexisting open angle glaucoma and 2 patients had preexisting ocular hypertension. The recorded details of the SLT procedures were the number of spots applied, the number of degrees of trabecular meshwork (TM) treated, and total energy (Table 3). The power was titrated to attain an end point of a small scattering of “champagne bubbles.” The SLT parameters ranged from 50 to 90 spots, and either 180 or 360 degrees of angle were treated. For the initial SLT, 5 patients were treated for 180 degrees and 2 patients were treated for 360 degrees. For the 4 patients requiring a second SLT, 3 patients were treated for 360 degrees and 1 patient was treated for 180 degrees. IOP was measured in the SLT-treated eye and the contralateral untreated eye at 4 weeks prelaser; on the day of laser just before the laser; and within 3 weeks, 1 month, 3 months, and 6 months postoperatively. The study was approved by the Institutional Board Review of the Mount Sinai School of Medicine and the requirement for informed consent was waived due to the retrospective nature of the study.

Statistical analysis was performed using a 2-sample t test for comparison between groups. All statistical tests were completed at a 5% level of significance.

RESULTS

The interval between intraocular corticosteroid injection and referral for subsequent IOP elevation in the 7 eyes ranged from 5 to 29 weeks. Mean IOP ± SD decreased after SLT from 38.4 ± 7.3 mm Hg preoperative to 25.6 ± 7.1 mm Hg (P < 0.003) within 3 weeks (9.4 ± 8.1) postoperative, to 25.9 ± 8.8 mm Hg (P < 0.007) at 1-month postoperative, to 23.9 ± 10.6 mm Hg (P < 0.006) at 3 months postoperative, and to 15.7 ± 2.2 (P < 0.001) at 6 months postoperative (Table 4, Fig. 1). Reviewing the IOP effects of each of the patients individually, the SLT was effective in 5 of the 7 patients at 6 months postoperative (Table 5).

Of the 4 patients who underwent 2 SLT procedures, the second SLTs were performed 1.5 weeks, 3 months,
3 months, and 5 months after the initial SLT. A sustained reduction in IOP was achieved in the patient who had the second SLT procedure performed 1.5 weeks after the initial SLT, and in one of the patients who had the second SLT performed 3 months after the initial SLT. The other 2 patients did not have an adequate response after the second SLT. One patient with preexisting ocular hypertension underwent a pars plana vitrectomy and lensectomy by the referring retina specialist. Postoperatively the IOP was controlled and vision was reduced to hand motion. The other patient, without a previous history of ocular hypertension or glaucoma, whose IOP remained elevated underwent an Ahmed seton procedure by our practice with IOP control and postoperative visual acuity similar to preoperative visual acuity.

The eyes included in this study were on a mean (± SD) of 4.0 ± 0.8 ocular hypotensive medications before the SLT, which was not statistically different 3.9 ± 0.5 (P = 0.67) at 3 months. The number of medications at 6 months postlaser (Table 4) was 2.4 ± 1.7. Although this number was not statistically different (P = 0.08) from pre-SLT, it is clinically relevant, and may have been statistically significant with a larger sample size. IOP in the fellow eyes of all patients was unchanged (P > 0.08) throughout the study (Table 4). Visual fields were not performed on these patients, as they were referred for acute IOP elevations, most did not have glaucomatous cupping, and some of the patients had other ocular diseases which could affect visual field testing and results.

**DISCUSSION**

It has been established that topical or systemic corticosteroid administration is associated with significant elevations in IOP in 18% to 36% of the general population. The response rate is increased to between 46% and 92% in patients with primary open angle glaucoma and to 87% in first-degree relatives of patients with open angle glaucoma. Several studies have documented dramatic elevations in IOP in a substantial portion of patients treated with intravitreal...

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**TABLE 4. Mean IOP and Number of Ocular Hypotensive Medications Pre-SLT and Post-SLT, in All Eyes Receiving SLT Treatment and Fellow Eyes Without SLT Treatment**

<table>
<thead>
<tr>
<th>Time After Initial SLT</th>
<th>Preoperative &lt; 4 wk</th>
<th>Preoperative (Day of SLT)</th>
<th>Postoperative &lt; 3 wk</th>
<th>Postoperative 1 mo</th>
<th>Postoperative 3 mo</th>
<th>Postoperative 6 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLT eye mean (mm Hg) IOP ± SD</td>
<td>38.2 ± 7.8</td>
<td>38.4 ± 7.3</td>
<td>25.6 ± 7.1</td>
<td>25.9 ± 8.8</td>
<td>23.9 ± 10.6</td>
<td>15.7 ± 2.2</td>
</tr>
<tr>
<td>P value of 2-sample t test</td>
<td>0.368</td>
<td>0.003*</td>
<td>0.007*</td>
<td>0.006*</td>
<td>0.001*</td>
<td></td>
</tr>
<tr>
<td>No. medications ± SD</td>
<td>4.0 ± 0.8</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>No. SLT eyes</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Fellow eye mean (mm Hg) IOP ± SD</td>
<td>18.8 ± 2.6</td>
<td>19.3 ± 4.4</td>
<td>16.8 ± 2.2</td>
<td>17.7 ± 2.6</td>
<td>16.1 ± 3.9</td>
<td>16.2 ± 3.0</td>
</tr>
<tr>
<td>P value of 2-sample t test</td>
<td>0.377</td>
<td>0.142</td>
<td>0.323</td>
<td>0.080</td>
<td>0.113</td>
<td></td>
</tr>
<tr>
<td>No. fellow eyes</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant (P < 0.05) result compared time point listed to mean preoperative IOP on the day of laser.
†No statistical difference (P = 0.67) 6 mo post-SLT in number of ocular hypotensive medications compared with preoperative number of medications.
‡No statistical difference (P = 0.08) 6 mo post-SLT in number of ocular hypotensive medications compared with preoperative number of medications.

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**FIGURE 1.** Effect of SLT laser in 7 eyes of 7 patients with elevated IOP after intravitreal TA injection. Four of the 7 eyes received 2 SLT treatments, 3 of the eyes received 1 SLT treatment.
injections of 4 mg TA (Table 6). In a study of 113 patients with subretinal neovascularization at 3 months after steroid injection, 32% had a rise of $\geq 5$ mm Hg and 11% had an increase of $\geq 10$ mm Hg above preinjection IOP. In a retrospective review of 89 patients, 40.4% of all patients and 50% of patients with a history of glaucoma experienced IOP elevation of 24 mm Hg or higher with the elevation occurring at a mean of 100.6 days after treatment. In 43 eyes of 38 patients within 12 weeks after injection, there was a 48.8% incidence of IOP elevation of 5 mm Hg or greater, and 27.9% incidence of a rise in IOP of 10 mm Hg or greater, with the rise of 5 mm Hg occurring at a mean of 4.1 weeks after steroid injection. There is also a case report that demonstrated an early rise in IOP up to 49 mm Hg within 1 week of a single 4-mg intravitreal TA injection. After intravitreal injections of 25-mg TA in 71 patients, 52% of eyes demonstrated a pressure elevation of greater than 21 mm Hg with the IOP elevation observed 2 months after injection. The proposed mechanism of steroid-induced elevated IOP relates to impaired outflow facility through the TM. Corticosteroids may decrease availability of catabolic enzymes and thus decrease breakdown of mucopolysaccharides that accumulate in the anterior chamber angle, retain water, and obstruct trabeculae.

<table>
<thead>
<tr>
<th>Study</th>
<th>No. Patients</th>
<th>% Incidence of IOP Elevation</th>
<th>Onset of IOP Elevation</th>
<th>Duration of IOP Elevation</th>
<th>Mean Follow-up Time</th>
<th>TA Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakri and Beer\textsuperscript{18}</td>
<td>38</td>
<td>48.8</td>
<td>4.1 wk</td>
<td>—</td>
<td>12 wk</td>
<td>4 mg</td>
</tr>
<tr>
<td>Jonas et al\textsuperscript{19}</td>
<td>71</td>
<td>52</td>
<td>2 mo</td>
<td>6 mo</td>
<td>6.9 mo</td>
<td>25 mg</td>
</tr>
<tr>
<td>Singh et al\textsuperscript{11}</td>
<td>3</td>
<td>—</td>
<td>1 wk</td>
<td>GS 12-26d</td>
<td>—</td>
<td>4 mg</td>
</tr>
<tr>
<td>Smithen et al\textsuperscript{2}</td>
<td>89</td>
<td>40.4</td>
<td>100.6 d</td>
<td>—</td>
<td>280 d</td>
<td>4 mg</td>
</tr>
<tr>
<td>Wingate and Beaumont\textsuperscript{16}</td>
<td>113</td>
<td>32</td>
<td>—</td>
<td>3 mo</td>
<td>—</td>
<td>4 mg</td>
</tr>
</tbody>
</table>

\textsuperscript{*}Four patients, No. 1, No. 5, No. 6, No. 7 had a second SLT at 5 mo, 1.5 wk, 3 mo, and 3 mo after initial SLT, respectively.

No. Meds indicates number of ocular hypotensive medications each patient was administering at each of the indicated time points; PPL, pars plana vitrectomy; PPV, pars plana lensectomy; Seton, Ahmed seton procedure.
Corticosteroids may also have a direct impact on trabecular cells through their interaction with cytoplasmic receptors and DNA binding sites.\textsuperscript{23} Corticosteroids inhibit phagocytosis by TM cells that may lead to accumulation of cellular debris and increased resistance to aqueous outflow.\textsuperscript{24} Corticosteroids also reduce outflow facility by increasing tight junctions between TM endothelial cells.\textsuperscript{25} The observed clinical efficacy of SLT in patients with steroid-induced ocular hypertension suggests that SLT may counteract the effects of corticosteroids on the TM. Proposed mechanisms by which SLT may reduce IOP in these patients include stimulation of migration of macrophages, which phagocytose debris and clear the TM.\textsuperscript{16} Additionaly, SLT may improve outflow facility by decreasing the number of tight junctions between trabecular endothelial cells\textsuperscript{26} and by stimulating the formation of healthy trabecular tissue.\textsuperscript{27}

SLT is an effective treatment modality in lowering IOP in patients with open angle glaucoma.\textsuperscript{13-15} In our study, after unsuccessful maximum tolerated medical therapy, patients underwent SLT in the hypertensive eye. IOP was rapidly reduced in 5 of 7 patients within 3 weeks of performing the SLT laser. IOP remained decreased in 5 of the 7 patients at 6 months postoperatively, successfully avoiding surgical intervention. The patients in this study, with the exception of patient no. 4, had minimal or no glaucomatous cupping (Table 2). Patients with advanced glaucomatous cupping may require a lower and more rapid reduction of IOP than was achieved within the first 3 weeks after SLT in the patients in this study.

This is a small number of patients, from a retrospective chart review, without a control group. A stronger study design might have been to match our cases with similar patients who did not receive SLT and assess the duration of IOP elevation after intravitreal TA injection. The IOP course of these patients if left untreated cannot be predicted, but a control group without treatment would probably be unethical in light of the degree of IOP elevation in these patients. Thus, all patients referred to our practice with elevated IOP after TA were treated. Similar findings of IOP reductions with SLT laser after intraocular steroid-induced ocular hypertension were reported at ARVO 2005 by another group.\textsuperscript{28} A case report in 1 patient suggested that argon laser trabeculoplasty was effective in reducing IOP after intravitreal TA.\textsuperscript{29}

The rapid reduction in IOP within 3 weeks after SLT laser suggests that the IOP reduction was neither due to a decrease in quantity of intraocular steroid nor to a decrease in the effect of the intraocular steroid on IOP, but rather to the SLT procedure. Two of the 4 patients receiving a second SLT achieved adequate IOP control, suggesting repeat procedures may be necessary and sometimes effective. SLT laser seems to effectively reduce IOP in some patients, thus avoiding surgery while waiting for the steroid-induced IOP increase to resolve. This study suggests that SLT can be considered as a temporizing procedure, allowing the effect of the steroid on the TM to dissipate, in patients with increased IOP after intravitreal steroid injections unresponsive to maximum tolerated medical therapy.

\textbf{REFERENCES}


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