

PSS NEWS

A Distance Learning Format for Continuing Medical Education in Optometry

Guidelines for Laser Surgery for Glaucoma

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COPE 68157-GL

2.0 Hours

Learning Objectives:

1. To discuss management options for patients with glaucoma
2. To discuss the basic concept behind ophthalmic lasers
3. To discuss the role of laser trabeculoplasty in managing patients with glaucoma.

CASE STUDY:

RF was a 46-year old African American female who has been followed for primary open angle glaucoma for the past 5 years. During this time, she has demonstrated increasing levels of noncompliance which has led to slow and progressive deterioration of the optic nerve and subsequent visual field. Despite every effort to improve her compliance through patient education, simplification of her medical regimen she is still unable to take her medications. Finally a decision was made to send her for laser therapy. After a detailed discussion with both her and her husband, RF agreed to the procedure. 1 month later she went successful SLT in both eyes and remains at target IOP. She will be followed closely with a yearly comprehensive eye examination with dilation of pupils and fundus photography, a yearly visual field examination, and yearly nerve fiber analysis. Any changes in the above will warrant additional SLT treatment.

DISCUSSION OF CASE

I think many optometrists are pretty comfortable about sending glaucoma patients for laser therapy when things are getting worse for the patient. This can take the form of IOP that persistently stays high despite medical therapy, intolerance to medical therapy, or glaucoma that is progressing despite medical therapy. The one area where many optometrists are uncomfortable at sending patients for laser therapy is the non-compliant patient. Patients don't adhere to management options for a variety of reasons including inconvenience or scheduling issues, lack of perceived benefit, cost of medications, adverse reactions to the medications, difficulty instilling drops, and forgetfulness. In this case, you must remember your role as their primary eyecare provider: your job is to preserve their visual function at all costs! If it cannot be done medical therapy – regardless of the reason – it needs to be done surgically.

Basic Premise of Lasers

What we commonly call a laser actually stands for Light Amplification by Stimulated Emission of Radiation. When atoms absorb energy from an external energy source, they are excited from a lower to a higher energy level. When this happens, one excited atom can cause the release of a photon (a packet of energy) when it passes near a second excited atom, a process called stimulated emission. If there are significant number of atoms in this excited state, it is called a population inversion. The emitted photons stimulate the emission of more photons, leading to a chain reaction. If this system is placed between two mirrors, the photons will bounce back and forth, creating multiple stimulated emissions of light (light amplification). The parallel mirrors form the boundary of a space containing the medium and countless oscillating photons; this space is often referred to as the laser cavity. If one of the two mirrors is partially instead of fully reflective, when the light amplification has reached the appropriate level of energy, some photons are permitted to leave the system in the form of a laser beam. This laser beam can be delivered as a continuous wave or in a pulse mode, which involves very concentrated energy delivered in a matter of milliseconds. In addition, the laser output can be delayed by a method called Q-switching. This involves the use of an opaque shutter within the cavity, which allows the energy to build up within the cavity. When this shutter is removed, the result is a single, brief, pulse of laser energy.

Lasers have three basic characteristics: 1. They have a source of input energy 2. The medium is a characteristic substance

of gas, liquid or solid. 3. They have a cavity. The input energy in lasers usually comes from one of two methods – light (from a flash lamp) or an electric current.

Unlike the photons which are emitted from a light bulb which occur randomly in all directions, the resonator effect of the laser system causes the photons to be in phase with each other in time and space, called synchronized or coherent. Since light amplification occurs only for photons which are aligned with mirrors, the beam of energy which is produced is virtually parallel, as opposed to the diverging beam of an incandescent lamp. The energy released from a laser has a narrow range of wavelengths and has a high intensity of illumination. This energy that is released is usually based on the media on which the laser is based and may put out intermixed beams of more than one color. For example, an argon laser (using argon as the medium) emits many different colors, most notably the blue (488 nm) and green (514 nm) which are most useful clinically.

Lasers affect tissues in one of three ways. thermal, ionizing, and photochemical. The most common of these in glaucoma management are thermal effects. In this case, the energy from the laser is sufficient to produce temperatures high enough to induce either photocoagulation (local inflammation and scarring) or photo vaporization (vaporize intracellular and extra cellular fluids). Photocoagulation typically occurs at local temperatures between 55 degrees and 85 degrees Celsius, which is the temperature that causes denaturation of the proteins. Factors that influence the laser thermal effect include the wavelength of incident light, the amount of time of exposure, and the amount of light energy per area

of exposure. The most common target in most glaucoma procedures is melanin, which has a peak absorption in the blue-green portion of the visible spectrum. Thus, the most useful laser targeting melanin are ones with wavelengths between 400 and 600 nm, with the most common being the argon laser. The thermal effect of the laser tends to spread outward from the irradiated target. If the target temperature reaches 90 to 100 degrees, there will be some local disruption of tissue. If it reaches above 100, there will often be charring, burning, and evaporation of some tissue.

When a laser is applied to tissue, there is heat generated by the absorption of laser energy by the surrounding tissue. A short exposure time and a high concentration of energy generally reduces the conduction of heat to surrounding tissues and can often cause the tissue to reach the critical boiling point and undergo photo vaporization. At high energy levels, this reaction can be used to punch holes in some tissues, such as with laser iridotomy. At lower energy levels, this cause contraction of collagen, which may be the mechanism of action of laser trabeculoplasty.

Most laser units utilize a slit lamp biomicroscope to help deliver the laser beam into the patient's eye. Many of these systems utilize an optical pathway such as a fiber optic light guide to help deliver the laser. For lasers within the visual spectrum, an aiming beam of attenuated laser energy is often used to allow positioning and focusing of the laser beam on the intended tissue. For lasers with wavelengths which are outside the visible spectrum, a helium-neon (632 nm) or equivalent laser is utilized as the aiming beam. In most

cases, a foot pedal or finger trigger is used to release the laser energy onto the tissue and achieve the desired effect. The variables involved in such laser systems include spot size, duration, and energy or power. These variables are linked by the equation $\text{energy (joules)} = \text{power (watts)} \times \text{duration (seconds)}$.

Lasers Used in Glaucoma

Different lasers are based on various medium in which the atoms exist that produce the stimulated emission of photons. The ones most commonly used for ocular procedures are the argon, neodymium:YAG, and semiconductor diode. ALT procedures use the argon laser while SLT uses the neodymium:YAG.

Argon Lasers

These lasers use argon gas as the medium and an electrical discharge for the pump of electrons. These lasers operate at a wavelength between the blue (488 nm) and green (514 nm) which makes it ideal for absorption by melanin. Most of these lasers operate in the continuous wave mode and have maximum power levels of 2 to 6 watts, but there are some units which operate in the pulse mode, offering powers of 20-50 watts for 100 microseconds.

Neodymium: YAG Lasers

In this laser, a crystal of yttrium-aluminum-garnet (YAG) contains the neodymium atoms which are to be pumped by a xenon flash lamp. This laser operates at a wavelength of 1064 nm, which is the near infrared. These lasers are generally operated in the Q-switching mode to cause photo disruption, but can also be used in the

continuous wave made to cause photocoagulation.

Laser Safety

The use of laser energy for therapeutic has been very beneficial to many patients requiring treatment. However, the use of such powerful devices also poses a legitimate safety concern for incidents of electric shock, direct laser burns, explosions, and fires. Ophthalmic lasers can cause significant damage to the eye, cardiovascular system, and skin¹. In most ophthalmic systems, the laser beam emitted to air is either converging or diverging. A collimated beam, typical of many laser pointers, has the most potential for damage because the energy may be focused on the fovea. Many of the lasers are housed in electronic components which can store electric charges that might induce cardiovascular shock if accidentally contacted. Some of these charges remain in the capacitors even after the laser system is unplugged so extreme care must be exercised.

During the procedure itself, the greatest danger is to the patient for potential retinal damage to accidental exposure to the retina or crystalline lens. The following are 4 broad categories of lasers in relation to the hazards:

Class I: These pose no danger to human tissue

Class II: Visible-light lasers that are relatively safe to see for several seconds, but should not be stared into continuously

Class III: These are unsafe for even brief glimpses. They generally require safety equipment and procedural controls

Class IV: These pose significant fire and skin hazards. This is the class of lasers used most frequently by therapeutic lasers in glaucoma surgery

The surgeon is generally protected while treating patients in many slit lamp delivery systems by a filter which is built into the system. Although this is true in theory, there has been some recent evidence that subtle alterations are often seen in ophthalmic laser surgeons who are exposed to argon blue light for long periods of time². Since the advantage of using blue-green wavelength over green only is insignificant, it may be advisable to use green only whenever possible. Others at risk are primarily the ancillary personnel who might be in the laser room during treatment. These persons may suffer damage to their eyes from exposed reflected laser light. One study with argon lasers indicated that a hazard can exist for a bystander near the slit lamp being used if he or she is within 1 m of the contact lens³. To minimize this hazard, only antireflective coated contact lenses should be used and ancillary personnel should wear safety protective goggles.

LASER TRABECULOPLASTY

Argon Laser trabeculoplasty (ALT) is one of the most commonly performed glaucoma surgeries. It is the traditional form of laser therapy for our glaucoma

¹ Sliney DH. Laser Safety. *Lasers Surg Med* 1995;16:215-225.

² Gunduz K, Arden GB. Changes in colour contrast sensitivity associated with operating argon lasers. *Br J Ophthalmol* 73:241, 1989.

³ Sliney DH, Mainster MA. Potential laser hazards to the clinician during photocoagulation. *Am J Ophthalmol* 103:758,1987.

patients. The procedure entails the use of an argon laser (blue-green to green wavelength) to create small laser burns around the trabecular meshwork to increase aqueous fluid outflow. The procedure typically begins with the patient seated at the slit lamp after the instillation of topical anesthetic and the gonioscope positioned at 12 o'clock (inferior angle). Then, the lens is rotated clockwise, meaning the temporal portion of the right eye and the nasal portion of the left eye are photocoagulated first. In the vast majority of cases, half of the angle (180 degrees) is done and the other half is reserved for future treatment, if it becomes necessary. The laser spots are positioned at the junction of the pigmented and nonpigmented trabecular meshwork, with a gap of the diameter of two laser spots between spots. If the laser burn is placed too anterior, the treatment tends to be ineffective. If it is placed too posterior, there is a greater likelihood of inducing inflammation and peripheral anterior synechiae.

Laser trabeculoplasty was traditionally used when maximal medical therapy failed to adequately control IOP. More recently, however, the Glaucoma Laser Trial established the efficacy of ALT as a primary treatment in lowering IOP in open-angle glaucoma⁴. The studies reported that patients treated with ALT as a primary treatment had better IOP control and better visual field and optic disc status than ones treated initially with topical medications. Other indications for ALT include poorly controlled IOP due to poor efficacy from medications or from poor compliance.

⁴ Glaucoma Laser Trial Research Group. The Glaucoma Laser Trial and Glaucoma Laser Trial Follow-up Study: 7. Results. *Am J Ophthalmol.* 1995; 120:718-31.

ALT is contraindicated in complete angle closure and hazy media preventing sufficient visualization of the angle structures. In addition, the procedure may be contraindicated in one eye if there was a serious complication from laser treatment in the fellow eye. Secondary open-angle glaucomas, such as inflammatory glaucomas, generally do not demonstrate a good response to laser trabeculoplasty.

Complications

Complications of laser trabeculoplasty are relatively uncommon and usually short-lasting. They include elevated IOP, decreased vision, pain, corneal burns, hemorrhage, peripheral anterior synechiae, iritis, and adverse effects on filtration surgery⁵. In most patients, IOP following ALT rises less than 5 mm Hg, reaches its peak at 3 hours and resolves within 24 hours. However, a few patients will demonstrate larger, less transient IOP spikes that cause optic nerve damage and visual field loss. In one study, 3% of patients demonstrated a persistent elevation of at least 5 mm Hg after ALT⁶. The Glaucoma Laser Trial found that the strongest risk factor for IOP increase after ALT was moderate or heavy pigmentation of the trabecular meshwork. Other risk factors include the amount of treatment administered, the laser power used, and the placement of laser burns. The risk of IOP spikes can be greatly reduced with the instillation of a drop of

⁵ Koller T, Sturmer J, Reme C, et al. Membrane formation in the chamber angle after failure of argon laser trabeculoplasty: analysis of risk factors. *Br J Ophthalmol* 2000;J84(1): 48-53.

⁶ Thomas JV, Simmons RJ, Belcher CD. Complications of argon laser trabeculoplasty. *Glaucoma* 1982; 4:50.

Iopidine or Alphagan 1 hour before and immediately after the procedure⁷.

In terms of other complications, mild, transient decreased visual acuity usually results from the goniosolution and laser flash. In most cases, it resolves spontaneously. Ocular pain is usually minimal with laser trabeculoplasty; the vast majority of patients require only topical anesthesia to perform the procedure.

Efficacy

In most cases, it takes from 4 to 6 weeks for the full effect of the procedure to be evident. Factors impacting efficacy are age, race, and type of glaucoma. Patients older than 40 years of age typically respond better than younger patients. In fact, some doctors are hesitant about recommending ALT for POAG patients under 40. Race does not appear to impact the short-term efficacy of laser trabeculoplasty but African American patients do have a lower long-term success rate⁸.

Studies demonstrate that the efficacy of laser trabeculoplasty in controlling glaucoma decreases with duration of follow-up^{9 10}. Most researchers have

found a 6-10-mm drop (20 percent) in intraocular pressure during the first year after trabeculoplasty. In general, ALT controls IOP in 80 percent of eyes at one year, 50 percent at five years and 30 percent at 10 years. This means that laser trabeculoplasty provides adequate IOP control after 5 years for approximately half the patients. Unfortunately, this also means that half of your patients will need additional therapy after 5 years and 70% after 10 years¹¹. Some newer studies have found success rates as low as 10% after 5 years depending on the patient profile¹². This is a problem because coagulative damage to the trabecular meshwork from ALT may limit efficacy of further therapy.

SELECTIVE LASER TRABECULOPLASTY

Selective laser trabeculoplasty (SLT) is the most popular laser technique that selectively targets melanin within trabecular meshwork cells using a Q-switched frequency-doubled Nd:YAG laser. This is an improvement from ALT in which all cells, both pigmented and nonpigmented, are targeted¹³.

Due to this selective targeting of the laser energy, SLT does not cause thermal damage and subsequent scar formation to the trabecular meshwork. ALT works by placing multiple burns on the trabecular meshwork, which eventually result in the

⁷ Barneby HS, Robin AL, Zimmerman TJ, et al. The efficacy of brimonidine in decreasing elevatin in intraocular pressurre after laser trabeculoplasty. *Ophthalmology* 1993; 100:1083.

⁸ Bournias TE, Wang F, Javitt JC. Racial variation in outcomes of argon laser trabeculoplasty. *Invest Ophthalmol Vis Sci.* 1997; 38(Suppl).

⁹ Shingleton BJ, Richter CE, Belcher DC, et al. Long-term efficacy of argon laser trabeculoplasty. *Ophthalmology.* 1987; 94:1513-18.

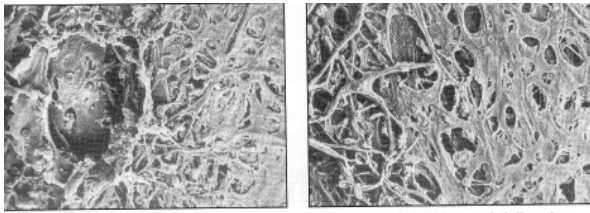
¹⁰ Spaeth GL, Baex KA. Argon laser trabeculoplasty controls one third of progressive, uncontrolled, open angle glaucoma for 5 years. *Arch Ophthalmol* 1992; 100:491-4.

¹¹ Shingleton BJ, Richter CU, Dharma SK, et al. Long-term efficacy of argon laser trabeculoplasty: A 10-year follow-up study. *Ophthalmology* 1993; 100:1324.

¹² Agarwal HC, Sihota R, Das C, et al. Role of argon laser trabeculoplasty as primary and secondary therapy in open angle glaucoma in Indian patients. *Brit J Ophthal* 2002; 86(7):733-6.

¹³ Latina MA, Sibayan SA, Shin DH, et al. Q-switched 532-nm Nd:YAG laser trabeculoplasty: multicenter, pilot, clinical study. *Ophthalmology.* 1998; 105(11):2082-90.

formation of many tiny scars. In fact, the heat produced at the laser impact site also spreads into surrounding untreated tissues, producing a thermal injury that is larger than the target tissue. SLT limits the diffusion of heat into adjacent tissues because the laser energy is applied as a brief pulse, lasting a few nanoseconds¹⁴.



Comparison of ALT and SLT:
Left you can see the thermal damage
Right there is no thermal damage.

Efficacy

In a randomized study comparing ALT or SLT as a second procedure after a failed initial ALT, IOP reduction was better after SLT than repeat ALT. These studies demonstrate that 70% of the patients had an IOP reduction of at least 3 mm Hg and an average IOP reduction of 5 mm Hg to 6 mm Hg¹⁵. One of the nice features of SLT is that it can be used as a first laser treatment option. It is believed that SLT does not efficacy of ALT or other surgical glaucoma procedures if SLT does not adequately control IOP, but this theory has not been proven as of this date. The chief advantage this procedure offers over the more conventional ALT is that it is potentially repeatable. In terms

of efficacy, the short-term data is about the same as an ALT. However, after 5 years after SLT, if the patient required additional IOP lowering, the clinician could perform additional treatment with an SLT. In addition, SLT remains an option for patients who had already undergone ALT treatment. For this reason alone, SLT is fast becoming the laser therapy of choice for many patients with glaucoma.

Conclusion

Despite recent advances in surgical techniques for treating glaucoma and despite several studies advocating laser as first line of therapy, I think many clinicians (including myself) still prefer to initiate treatment with medical therapy. Surgical intervention is generally reserved for patients who are refractive to medical therapy or who are unable to follow the treatment protocol.

¹⁴ Kramer TR, Noecker RJ. Comparison of the morphologic changes after selective laser trabeculoplasty and argon laser trabeculoplasty in human eye bank eyes. *Ophthalmology* 2001; 108(4):773-779.

¹⁵ Latina MA. The US multicenter study of the effectiveness of SLT. *Ocular Surgery News*. 2000;19(suppl):15-16.

CONTINUING EDUCATION QUIZ

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Multiple Choice Questions

1. Argon Laser Trabeculoplasty (ALT) decreases intraocular pressure by which method?
 - a. Decreases aqueous inflow
 - b. Increases aqueous inflow
 - c. Decreases aqueous outflow
 - d. Increases aqueous outflow
2. During the ALT procedure, how much of the angle is usually done at one time?
 - a. 45 degrees
 - b. 90 degrees
 - c. 180 degrees
 - d. 360 degrees
3. During the ALT procedure, where are the laser spots positioned?
 - a. At the junction of the pigmented and nonpigmented trabecular meshwork
 - b. Anterior to Schwalbe's line
 - c. Posterior to Schwalbe's line
 - d. Into deep layers of the trabecular meshwork
4. Which of the following studies mentioned in the article help establish ALT as a primary treatment in lowering IOP in open angle glaucoma?
 - a. Ocular Hypertension Study
 - b. Glaucoma Laser Trial
 - c. Early Manifest Glaucoma Trial
 - d. Beaver Dam Study
5. Which of the following is a contraindication for ALT?
 - a. A patient with 5.0 diopters of corneal astigmatism
 - b. A patient with severe corneal edema preventing visualization of the angle structures
 - c. A patient with mild cataracts with adequate retinal views
 - d. A patient with diabetic retinopathy

6. What is the typical time period for an IOP spike following ALT in most patients?
 - a. 1 hour
 - b. 2 hour
 - c. 3 hour
 - d. 4 hour
7. The Glaucoma Laser Trial found that the strongest risk factor for IOP increase after ALT was which of the following?
 - a. Moderate to heavy pigmentation of the trabecular meshwork
 - b. Light pigmentation of the trabecular meshwork
 - c. No pigmentation of the trabecular meshwork
 - d. A closed angle
8. Which of the agents below is commonly used to decrease the incidence of IOP spikes associated with ALT?
 - a. Xalatan
 - b. Travatan
 - c. Lumigan
 - d. Alphagan
9. Which of the following is the typical anesthesia used for ALT?
 - a. General anesthesia
 - b. Oral Benadryl
 - c. Topical anesthesia
 - d. IV sedation
10. What is the typical time period to evaluate efficacy of ALT?
 - a. 4 to 6 minutes
 - b. 4 to 6 hours
 - c. 4 to 6 days
 - d. 4 to 6 weeks
11. According to the article, what is the percentage of patients whose IOP will be controlled 1 year following ALT?
 - a. 80
 - b. 50
 - c. 30
 - d. 0
12. According to the article, what is the percentage of patients whose IOP will be controlled 5 years following ALT?
 - a. 80
 - b. 50
 - c. 30
 - d. 0
13. According to the article, what is the percentage of patients whose IOP will be controlled 10 years following ALT?
 - a. 80
 - b. 50
 - c. 30
 - d. 0
14. Which factor limits the repeatability of ALT?

- a. Patient compliance
 - b. Insurance coverage
 - c. Coagulative damage to the trabecular meshwork
 - d. Availability of the laser
15. Selective Laser Trabeculoplasty (SLT) uses which type of laser?
- a. Argon Red
 - b. Cyanine Green
 - c. A Thermal laser
 - d. Q-switched frequency-doubled Nd:YAG laser
16. SLT targets which cells to achieve its effect?
- a. Melanin within trabecular meshwork cells
 - b. Macrophages
 - c. Eosinophils
 - d. Basophils
17. How does efficacy of SLT compare to that of an ALT?
- a. Worse
 - b. About the same
 - c. Better
 - d. There are no comparative studies
18. From a procedural point of view, how is SLT performed differently than ALT?
- a. Uses a different gonioscope to view angle structures
 - b. Doctors using SLT must be specially trained
 - c. Aside from the laser, the procedure is basically the same
 - d. Patient selection is different
19. According to the article, what is the chief advantage of using the SLT over ALT?
- a. The SLT is potentially repeatable
 - b. There is no advantage
 - c. The ALT is actually better
 - d. SLT has a broader indication in managing glaucoma
20. According to the author, which of the following is the preference for optometrists for initiating treatment for patients with glaucoma?
- a. Medical therapy
 - b. Laser therapy
 - c. Trabeculectomy surgery
 - d. Cyclodestructive procedures