LASER THERAPY FOR THE OPEN ANGLE GLAUCOMAS

Cliff M. Caudill, O.D., FAAO
OPEN ANGLE GLAUCOMA

• Primary Open Angle, aka Chronic Open Angle
  • POAG/COAG

• Secondary Open Angle Glaucoma
  • Pigmentary Glaucoma
  • Exfoliative Glaucoma
  • Traumatic
  • Uveitic
  • Congenital
  • Neovascular
OBJECTIVE VISUAL FIELD?

• This just in….OBJECTIVE visual field testing

• Konan Engineering
  • https://konanmedical.com/objectivefield/
  • Uses pupil response to stimuli to assess retinal function
  • Kinda like mfERG but uses pupil response instead of electrical response
TRADITIONAL GLAUCOMA FLOWCHART

Meds  LTP  Surgery
PARADIGM SHIFTING

LTP  Meds  Surgery
TYPICAL BEST CANDIDATES FOR LTP

- POAG, of course
- Ocular Hypertensives
- Pigmentary Dispersion syndrome (maybe LPI too…talk about that later)
- Non-compliant patients
  - Sometimes not by choice
- Patients unable to afford meds
LASER THERAPY IN GLAUCOMA
GONIOSCOPY REVIEW
GONIOSCOPY
GONIOSCOPY REVIEW
GONAK IS BACK!

• Contact/Interface Solutions
  • Goniosol: Hydroxypropyl Methylcellulose 2.5%
    • traditional solution of choice for 3 mirror gonioscopy
    • Advantage: clear view, less bubbles
    • Disadvantage: allergic/toxicity reactions to high % of methylcellulose results in disruption of corneal epithelium, reduced VA, discomfort; requires rinsing
GONIOSCOPY REVIEW

• Contact Solutions, continued

• Celluvisc (Carboxymethylcellulose Sodium 1%)
  • Advantages: readily available, disposable single use vials, easier on corneas, does not require rinsing
  • Disadvantages: doesn’t “stick” as well, more prone to bubbles

• Genteal Gel: equivalent to Celluvisc here
Anterior Chamber Angle

- Scleral spur
- Anterior trabeculum
- Schwalbe's line
- Ciliary body
- Closed
GONIOSCOPY REVIEW
TRABECULOPLASTY

• “plasty” suffix definition
  • "molding, formation, or surgical repair on a (specified) body part or by (specified) means"
  • Compare to trabeculectomy, i.e. "act of cutting out". It means surgical removal of something, usually from inside the body.
TRABECULOPLASTY
SOME HISTORY

• The initial attempts in the 1970's involved using laser energy to form holes from the anterior chamber, through the trabecular meshwork, and into Schlemm’s canal

• Labeled variously as trabeculopuncture, trabeculotomy, laseropuncture, or goniopuncture

• Interest waned when researchers discovered glaucoma could be created with high energy argon laser exposure
HISTORY

• In 1979, Wise and Witter reported promising results by using low-energy argon laser exposures to the trabecular meshwork; using about 100 burns over 360° of the meshwork at 1000mW, .1 sec duration with a 50 micron spot size.¹

• The technique became known as laser trabeculoplasty (LTP) and rapidly gained acceptance
LASER TRABECULOPLASTY

Glaucoma Laser Trial

• 271 patients with previously untreated primary open angle glaucoma randomized to ALT or medication
• 2 yr f/u, ALT patients had lower IOP than medication-treated eyes
  • 25% did not require Rx
• At 7 years: in 203 of the original 271 patients, ALT-treated eyes had lower IOP, better visual field, and optic disc status than eyes in the medication group
SELECTIVE LASER TRABECULOPLASTY
IN VITRO STUDIES

• Pigmented TM cells can be selectively targeted without damage to adjacent non-pigmented cells

• Optimal laser is a Q-switched Frequency Doubled 532 nm Nd:YAG laser (3 nsec pulse)
HISTORY

• Selective Laser Trabeculoplasty (SLT) gained acceptance in the mid to late 1990’s as an alternative to argon laser trabeculoplasty (ALT)
SELECTIVE LASER TRABECULOPLASTY

• Laser – 1995
• FDA approval – 3/2001
• Q-switched Nd:YAG laser
  • Frequency doubled
  • 532 nm
• 3 nanoseconds
• no heat transference
• Shift has occurred from ALT to SLT
• Settings: .8-2.0 mJ, Spot size is fixed
PRINCIPLES OF SLT

• Mechanisms are still not fully understood
• Cell stimulation by biophotoactivation triggers cytokine response
• Cytokines recruit macrophages
• Macrophages help clear cellular debris
HOW DOES “SLT” WORK…

• Selective Photothermolysis
  • Intracellular target chromophore (melanin)
  • Laser pulse duration time is shorter than the thermal relaxation time of the pigmented trabecular meshwork cells (no thermal damage)
  • Only pigmented cells within the irradiation zone will be targeted
SELECTIVE PHOTOTHERMOLYSIS

- Only pigmented cells absorb the laser light
- Laser energy evokes cellular cavitation
- Thermal transfer to surrounding tissue is minimized
SELECTIVE LASER TRABECULOPLASTY

- Targets intracellular melanin
  - Destroys pigmented cells without damage to non-pigmented cells or TM collagen

- Stimulates cytokines
  - Recruits macrophages
  - Stimulates release of additional cytokines
DIFFERENCES IN CELLULAR RESPONSE

- **ALT:** High thermal absorption
- **SLT:** Only pigmented cells are affected

*Thermal transfer indicated in red with thermal absorption*

*SLT shows only melanin containing cells*
RECRUITED CYTOKINES…

• Induce cell division
• Up-regulate of MMPs
  • Responsible for ECM turnover
• Increase porosity of endothelial cells
• Stimulates re-synthesis of ECM
• Bottom line… increased outflow
BIOLOGICAL RESPONSE TO SLT

- Biological response improves outflow facility
- Fluid is allowed to flow freely through the TM
RATIONALE FOR SLT

- Limitations of argon laser trabeculoplasty (ALT)
  - Post-treatment increase in IOP
  - PAS
  - ALT attrition rate: 6-10% per year
    - Reduced effectiveness after 5 years
  - Limited efficacy of ALT re-treatment
    - Coagulative damage to the trabecular meshwork (TM)
SELECTIVE LASER TRABECULOPLASTY

- ALT: crater formation at pigmented and non-pigmented TM; coagulative damage; disruption of collagen beams…

- SLT: minimal mechanic damage; no coagulative damage
Comparison of SLT vs ALT

<table>
<thead>
<tr>
<th></th>
<th>SLT</th>
<th>ALT</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of spots</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>0.8-1.4 mj</td>
<td>400-600 mw</td>
<td>1:100</td>
</tr>
<tr>
<td>Fluence (mj/mm²)</td>
<td>6</td>
<td>40,000</td>
<td>1:6000</td>
</tr>
<tr>
<td>Exposure Time</td>
<td>3 nsec</td>
<td>0.1 sec</td>
<td></td>
</tr>
</tbody>
</table>
Human TM (organ system)
ALT 50 um spot
Human TM (organ system)
SLT 400 um spot, 0.8 mJ/pulse
COMPLICATIONS OF THERMAL TRABECULOPLASTIES

- Anterior uveitis
  - can lead to PAS or inflammatory glaucoma
  - avoid excess treatment
  - avoid burns too far posterior
- Corneal burns
  - improper focus / patient moving
- Intraocular bleeding
  - rare
IN-VIVO STUDIES

• “The comparison at 12 months following the laser therapy showed that both modalities lowered the IOP with approximately 3mmHg, yet essentially all of the time-to-failure analyses favored SLT over ALT. The repeat effect was found to be half of the initial treatment.”

IN-VIVO STUDIES

• “ALT and SLT are equivalent in lowering IOP at 6 months posttreatment in patients with PXF.”

IN-VIVO STUDIES

• “Primary SLT achieved comparable early absolute IOP-lowering in OHT versus OAG eyes…”

IN-VIVO STUDIES

- Patients with higher baseline IOPs had greater success rates and mean IOP reduction at both 2 and 6 months following SLT. Age, type and severity of glaucoma, pigmentation of TM, or total energy delivery had no association with procedural success or IOP spikes. Patients with higher baseline IOP may experience greater lowering of IOP after SLT. However, SLT may be equally successful for patients with a variety of other characteristics.

IN-VIVO STUDIES

• “Two SLT treatments of the same TM area do not have a significant effect on IOP compared to two SLT treatments in two different areas”.

LIGHT STUDY

- Laser in Glaucoma and Hypertension
- Earlier this year, *The Lancet* published the results of the LiGHT trial, comparing selective laser trabeculoplasty and eye drops to treat patients with open-angle glaucoma, which found SLT provided more robust IOP lowering while being a more cost-efficient first-line treatment
- Ocular Surgery News, September 2019
Overall, 95% percent of eyes in the SLT group, with and without IOP-lowering medication, were at target IOP at 36 months, while 93.1% of eyes in the eye drop group were at target IOP. No SLT patients required glaucoma surgery to lower IOP compared with 11 patients who required surgery in the eye drop group.

Use of SLT as first-line treatment resulted in reduced cost of surgery as well as for medications.

Ocular Surgery News, September 2019
LIGHT STUDY

• Disruptive studies that alter conventional, and for some nearly automated, clinical practice patterns tend to be few and far between in medicine. The LiGHT trial is one such study. Impeccable in its design and execution, LiGHT utilizes consensus guidelines from the world’s most respected glaucoma organizations to help guide glaucoma staging, severity and treatment escalation to effectively compare SLT and drop therapy for the initial treatment of glaucoma. The results of this trial should challenge clinicians to reassess their approach to clinical practice. Indeed, this trial is worthy of careful consideration.

• **Thomas W. Samuelson, MD, OSN Glaucoma Section Editor**
COAST STUDY

• “Clarifying the Optimal Application of SLT” or COAST—will compare standard SLT to low energy SLT and will also compare retreatment performed as needed when the effect wears off to retreatment annually to maintain eye pressure control without the need for medical therapy.
TRANSSCLERAL SLT?

- Study in Israel shows promise that SLT applied directly to sclera may be efficacious…more work to be done…

SUMMARY

• Repeat SLT 50% effective
• SLT = ALT in PXF
• SLT as effective in OHT and OAG
• SLT more effective with higher pre-treatment IOP
• Retreat of same area of TM versus new area equivalent
• **SLT as first line well supported**
IN THE WORKS

• Transscleral SLT
• Possible recommendation for annual treatment
TRANSSCLERAL SLT OR DIRECT SLT (DSLT)

- **Belkin Laser**
  - Directly treats TM through the cornea, sclera, and or limbus with precise application of 100 shots in 1 sec!!!
  - Currently in FDA human trials
  - Early data suggests power needs to about 3x regular setting to achieve desired effect
4. Treatment Location

Instructions

The Red Treatment Ring indicates the treatment location. If the location is accurate - click Next.

To edit - go to location settings.

Location Settings

BELKIN LASER
SLT LASERS

• Available as self-contained units, combo with 1064 YAG, and portable units
SLT COMBO LASERS
SLT COMBO LASERS

- New kid on the block
  - Nidek YC-200 S Plus
SLT-NAVI

The SLT-NAVI feature presents an intuitive display on the progress of laser treatment, providing the surgeon with important feedback.
NIDEK: YC-200 PLUS
SLT-NAVI FEATURE
NIDEK: YC-200 PLUS
SLT-NAVI FEATURE
SELECTIVE LASER TRABECULOPLASTY

- Target is junction of the Ant/Post Trabecular Meshwork
- 400 micron spot
- $\leq 1 \text{ mJ} / \text{ shot}$
- 50 shots to 180 degrees
  - Or treat all 360 degrees (usually)
ALT spot vs. SLT spot size

Courtesy M. Berlin, M.D.
SLT vs. ALT Treatment

Courtesy M. Berlin, M.D.
SELECTIVE LASER TRABECULOPLASTY
AFTER SLT...

- Iopidine
- Post-op medication?
- continue glaucoma medications
- RTC 1 week
  - check IOP
  - gonioscopy
    - rule out peripheral anterior synechia
APPLICATION PATTERNS
COMPLICATIONS OF TRABECULOPLASTIES

- IOP spike
  - most common complication
  - resolves in 1-3 days
  - higher if you treat 360 at one time
  - prophylaxis
  - check IOP at 1-3 hours
WHAT IS THE FUTURE OF LTP

• TSLT (Titanium Sapphire Laser Trabeculoplasty)
  • TSLT uses a 790 nm wavelength laser that emits near-infrared energy in pulses ranging from 5 ms to 10 ms. This is believed to allow deeper penetration, about 200 µm, into the juxtacanalicular meshwork and the inner wall of Schlemm’s canal. Energy is selectively absorbed by pigmented phagocytic cells, preserving the trabecular meshwork tissue.
• Pattern Laser Trabeculoplasty
  • PLT provides a computer-guided treatment method to apply a sequence of pattern laser spots onto the trabecular meshwork. Automatic rotation with calculated alignment of each pattern allows consecutive treatment of the entire trabecular meshwork without overlapping or excessive gaps. It is a continuous wave light with a green wavelength of 532 nm and a yellow wavelength of 577 nm.
PATTERN LASER
TRABECULOPLASTY

PSLT not available in the U.S.
LSPE EXAM
REFERENCES