Anterior Segment Laser Procedures

R. Michelle Welch, OD
Aaron McNulty, OD

Nd: YAG Laser
Laser Type: A Solid State Laser
- Nd: YAG Laser
- Neodymium: Yttrium aluminum garnet Laser
- The lasing substance is a small amount of neodymium which is in the yttrium aluminum garnet crystal
- 1064 nm Infrared wavelength

Argon or Frequency Doubled YAG
- Argon or Solid state laser
- Around 532 green or blue-green wavelengths
- Photocoagulation

SLT Laser
- Frequency Doubled YAG
- 3 Nanosecond duration

Laser Safety Considerations
- Know the Nominal Hazard Zone for each laser
- Know which type glasses and when to wear

Laser Light Characteristics
- Single Wavelength
- Low divergence
- Highly energized
- Highly focusable
- Highly controllable

Laser Variables that Influence Interactions
- Wavelength
  - Different tissues and pigments absorb different wavelengths of light
  - Excimer is 193 nm, cornea absorbs well, Ultraviolet
  - Longer wavelengths penetrate deeper
  - Xanthophyll near fovea - best to use longer wavelength, or argon green - not blue

Laser Tissue Interactions
R. Michelle Welch, O.D.
NSU College of Optometry

Laser Variables that Influence Interactions
- Wavelength
  - High powered infrared waves (Nd:Yag) are effective in photodisruption
  - Used for membrane cleaving
Laser Variables that Influence Interactions

- **Spot size**
  - Nd: Yag has fixed spot size
  - Others have adjustable spot size
  - Can influence spot size by using contact lens
    - Increases the cone angle to "tighten" the spot size
  - Smaller spot size has a greater energy density

Laser Variables That Affect Interactions

- **Energy Delivered**
  - Risk of complications increase in proportion to cumulative energy delivered into the eye
  - Best rule of thumb: Use the lowest energy setting, the least number of shots, and the lowest duration possible to accomplish the desired affect

Laser Variables That Affect Interactions

- **Spot size**
  - Laser lens increases the cone angle to "tighten" the spot size
  - Smaller spot size has a greater energy density
  - So the desired level of impact would require less power when the spot is smaller
  - Decreasing spot size without decreasing power will lead to overtreatment

Laser Variables That Affect Interactions

- **Energy Delivered**
  - Most photocoagulation laser systems have power control setting
  - Most Photodisruptive lasers have energy setting since duration is fixed
  - Power is energy delivered per unit time
  - Low energy produce acoustic "pops"; higher energy produces "thunderclaps"

Laser Variables That Affect Interactions

- **Mode of energy delivery**
  - Continuous wave modes
    - Result in constant energy emission with ongoing laser action
  - Used in procedures requiring longer duration burns

Laser Variables That Affect Interactions

- **Transparency**
  - Biologic tissue are opaque to 300nm and shorter wavelengths
  - There the energy passes through less and is absorbed more by the cornea and lens
  - Eximer is 193 nm (Ultraviolet)
  - Healthy ocular media pass 400 nm blue through 700 nm red effectively

Laser Variables That Affect Interactions

- **In thermal (photocoagulation systems), the duration of the burn is variable**
  - Brief burns deliver a concentrated bolus of light in a powerful pulse
  - Longer burns at same power result in less concentrated stream of photons onto the tissue
Tissue Variables That Affect Interactions

- **Transparency**
  - Short Infrared is transmitted through the ocular media
  - As IR wavelength lengthens the lens and cornea absorb more energy (glassblower's cataract)
  - Lens sclerosis and brunescence reduce the transmission of laser light directed toward the retina

- **Pigmentation**
  - Absorbs blue and green wavelengths very effectively
  - Yellows and oranges are less efficiently absorbed
  - Reds and infrareds are the least absorbed and are therefore preferred for photocoagulating targets deep to regions of hemorrhage

- **Water content**
  - IR wavelengths (>1300nm) are absorbed by water and converted into heat
  - Actual bond cleaving does not take place
  - Water is turned to steam and propels microscopic tissue bits into environment
  - Is photovaporization, rather than photoablative

- **Pigmentation - Melanin**
  - Absorbs across the entire visible spectrum
  - Absorbs infrared less effectively
  - The less efficient the absorption of a wavelength, the deeper its penetration into the tissue
  - Less efficient absorption also means more powerful of longer duration burns are required

- **Pigmentation - Hemoglobin**
  - Absorbs blue and green wavelengths very effectively
  - Yellows and oranges are less efficiently absorbed
  - Reds and infrareds are the least absorbed and are therefore preferred for photocoagulating targets deep to regions of hemorrhage

- **Pigmentation - Xanthophyll**
  - Brownish-yellow pigment concentrated within the plexiform layers of the retina at the fovea.
  - Absorbs blue wavelengths very well
  - Does not absorb wavelengths as they are lengthened from green to red and infrared
  - When treating lesions deep to the fovea, a red or IR wavelength should be selected (CNVM)

- **Photocoagulation**
  - Is a pigment dependent interaction
  - Melanin is the primary ocular pigment
  - Hemoglobin also can be targeted to coagulate vascular lesions of fundus, iris, and angle
  - Light energy is converted into heat
  - When 10 – 20 degree C increase, photoacogulation occurs

- **Specific Laser-Tissue Interactions**
  - Denaturing of proteins, blood is coagulated and moderate inflammation is induced
  - The inflammatory response, if controlled, can be very beneficial, and may serve to create desired scarring and adhesions
  - Tissue atrophy arises surrounding each spot, when controlled this can be helpful in reducing the relative oxygen demand of poorly perfused ischemic tissue

- **Specific Laser-Tissue Interactions**
  - Also involves the warming of collagen
  - Causes the collagen to contract, thus altering structural relationships
  - Helpful in changing the micromontomy within the trabecular meshwork during trabeculoplasty
  - Also desirable when attempting to draw the peripheral iris out and away from the angle
  - Not desirable when treating pre-retinal membranes, can produce traction on the retina
  - Focal photocoagulation is blood coagulation and collagen shrinkage of vessel wall leading to occlusion
Specific Laser-Tissue Interactions

- Photovaporization
  - Thermal laser procedure
  - Depends upon absorption of light by pigment
  - Melanin the primary pigment involved
  - Tissues warmed by 65 - 100 degree C
  - Reduces tissue to CO$_2$ and H$_2$O
  - Vapor is created

- Photodisruption
  - Involves optical breakdown - light energy causes tissue to be reduced to plasma
  - Produces hydrodynamic waves and acoustic pulses whose majority of energy is back toward the physician
  - When attempting to photodisrupt an opacified membrane behind an IOL, the focus point should be just deep the capsule
  - Does not coagulate blood vessels, so could lead to bleeding if a vessel knicked

- Photoablative decomposition
  - Is NOT pigment dependant
  - Is true non-thermal process
  - Involves cleavage of molecular bonds
  - Excimer removes .25um per pulse (Human hair around 50 microns)

SLT PROCEDURE

SLT Basics
- Uses Frequency Doubled, Q-Switched ND:YAG
- Wavelength output is 532 nm green
- Burn time is 3 ns – why?
- Spot size is 400 micron – easier to focus than ALT

SLT Mechanism
- Thermal Relaxation Time
  - Amount of time it takes melanin to convert light energy to heat
  - 1 microsecond
- SLT pulse duration is 3 nanoseconds
**SLT Mechanism**
- Targets intracellular melanin
- Does not affect adjacent non-melanin containing cells
- Target cells activate cytokines which in turn activate macrophages
- Macrophages clean area decreasing outflow resistance
- No endothelial cell membrane formed as can happen with ALT

**SLT Contraindications**
- Not for angle closure
- Caution in cases where could be trabeculitis
- Neovascular glaucoma
- Hazy media
- Relative Contraindications
  - Angle recession
  - Under age 40

**SLT Potentially Repeatable**
- 70-80% effective at 1 yr
- 40-50% at 5 yrs
- 5-30% at 10 yrs
- Expected IOP reduction: 20-30%

**SLT Indications**
- Various approaches
- When patient ready for second medication
- First line treatment in other countries
  - Non-compliance
  - Cost of meds
- SLT/Med Study
- POAG, NTG, PDG, PXE

**Pre-Op**
- Basic exam components
  - VA, IOP, etc.
- Gonioscopy
  - Assess angle structure
  - Assess pigmentation
- 1gt Iopidine or Alphagan
- Pilo 1% if need to pull iris out of angle to better visualize TM for treatment

**Latina SLT Gonio Lens**
- Designed specifically for Selective Laser Trabeculoplasty. 1.0x magnification maintains laser spot size and 1 to 1 laser energy delivery. Tilted anterior lens surface corrects astigmatism to maintain circular laser beam profile and give sharp images for examination. Suitable for standard laser trabeculoplasty.

**Ritch Trabeculoplasty Lens**
- Designed with two 59° degree and two 64° mirrors. A 1.4x magnifying button is placed over each of the 59° and 64° mirrors. The magnifying button reduces the laser spot size by 30% and increases the laser power by 2x.
Procedure Technique
- Insert gonio lens (cushioning solution)
- Visualize angle
- Establish a system when performing these procedures and always do it the same (i.e., start at 6 and rotate clockwise)
- Before rotating lens, identify a landmark

Procedure Technique
- Place approximately 100 treatment spots per 360°
- Treatment spots should be right next to each other
- Most people are currently treating 360° of one eye for first procedure
  - 180° considered to be "partial" tx
  - 180° + 180° = "complete" tx
  - 360° + 180° = "re-treatment"

Post-Op
- 6 – 8 week post-op visit to evaluate effect in that eye, if good, treat other eye
  - Therapeutically could see some effect in nontreated fellow eye due to macrophages moving systemically
  - If good effect observed can then consider dropping a medication, but get proof SLT is effective first – don’t need to "wash out meds" before SLT

Procedure Technique
- Want to paint entire meshwork with the treatment, so put HeNe in that area
- Focus not as critical as with the ALT
- Spot size is 400 micron

Procedure Technique
- If patient had PDS – you may want to only treat 180° of one eye initially
  - Have seen cases of IOP increase in PDS patients due to excess pigment – extra inflammatory response
  - Some are treating only 180° then wait for to see what response is obtained
  - Rule of thumb of more pigment use less energy still applies with SLT

Post-Op
- Check IOP 30 – 45 minutes after procedure
- If any increase second drop of Iopidine or Alphagan
  - Acular/Voltaren qid x four – seven days – some are giving Rx but telling patient not to fill/use unless intense pain experienced
  - RTC one week – some are not having patient return at one week

Complications
- IOP spike
  - Generally 24 hrs or less
  - 5-25% of patients
- Mild Inflammatory response
  - 50% or more
  - Should be quiet by 1 week
Issues
- Treatment after failed trabeculectomy
- Treatment after PI – only do 180°
- Treatment for those having IOP increase post kenalog injection
- When not to perform SLT?

Posterior Capsular Opacification
- YAG Capsulotomy
  - The lens capsular bag has an anterior and posterior surface.
  - A hole is made in the anterior surface through which the natural lens is removed and IOL is inserted.
  - A PCD is the formation of a membrane on the posterior surface of the capsular bag following extracapsular cataract extraction.
  - Also known as a secondary cataract

Prevention and reduction
- Intraoperatively: Primary capsulotomy
  - A hole is made in the posterior capsule during the cataract extraction
  - Not considered the standard of care
  - Studies show the risk of retinal breaks, CME, and vitreous prolapse increase with primary capsulotomies

Posterior Capsular Opacification
- Etiology:
  - Natural lens cells remain in the capsule post lens extraction
  - Anterior and Peripheral natural lens epithelium migrate onto the posterior capsule and continue to proliferate and accumulate forming Elschnig’s Pearls
  - Metaplasia of lens epithelium cells into myofibroblasts which cause fibrosis upon capsular contracture.
  - Elaboration of a basement membrane and collagen synthesis leading to whitish fibrotic opacification

Incidence:
- Is most common complication post ECCE (extracapsular cataract extraction)
- Incidence ranges from 40 - 50% post surgical.
- PCD’s can form days to years post surgical
- When < 40 years old the incidence of development increases

Prevention and reduction
- Intraoperatively: Posterior capsular polishing
  - The posterior capsule is cleaned with a polisher before the IOL is inserted
  - Studies have shown that there is no statistically significant decrease in PCD formation with capsular polishing

IOL Selection and Fixation
- PMMA vs. silicone vs. acrylic
- Angulated haptics
- In the bag vs. Sulcus fixation
Patient Symptoms

- Blurred Vision
- A haze or cloud over the vision
- Loss of acuity
- Decreased contrast sensitivity
- Glare at night
- Halos at night
- Double Vision
- Asthenopia

Evaluating the Patient

- Subjective
  - Best Visual Acuity
  - Contrast Sensitivity
  - Glare acuity
  - PAM
- Objective
  - Slit lamp exam
  - Dilated Retinal Exam

Patient Education

- Auditory and Visual Expectations
  - White and red flashes of light
  - Sparks of light
  - "Snap" and "clap" of laser
- Length of procedure
- Importance of head position
- Risks and possible complications
- Contact lens insertion
- One eye at a time – 1 week apart
- Presence of floaters initially until tissue settles

Indications for Treatment

- When acuity becomes compromised to the point that a patient’s activities are limited.
- Variables to consider include:
  - Patient’s Complaint
  - Visual Acuity
  - Contrast Sensitivity
  - Glare testing
  - Ocular health (corneal & retinal)
  - Medicare “Recommendations”

Capsulotomy Contraindications

- Corneal Opacities – rendering it difficult to see through
- Corneal scars
- Corneal edema
- Corneal surface irregularities
- Intraocular inflammation
- CME
- A “hot eye” – red eye
- Pt unable to hold still or fixate

YAG Capsulotomy

Using the Nd: YAG Laser, the lowest energy level to achieve tissue disruption and least number of shots are used to create a hole in the posterior capsular opacification through which better acuity can be achieved.

Preparation

- Comprehensive Exam
- Dilation (same pupil dilation first)
- Topical 1% Iopidine 1 hour prior to treatment
- History and Physical Info
  - Allergies
  - Medications
  - Systemic Disease
  - Blood Pressure
  - Temp
- Consent form – explain complications
- Contact lens – + or - need?
- Topical anesthetic
  - Topical 1% tropicamide

YAG Cap Techniques

- Number of shots
- Record in chart
  - Number of shots
- Energy used
  - Total energy in eye
  - Protective Glasses NOT needed
- Contact lens (+/-)

Rule of Thumb: Use the lowest energy setting, least number of shots & lowest duration (fixed for YAG) possible to get the job done!
Contact Lens
- Advantages
  - Stabilizes eye
  - Lid control
  - Increases cone angle
  - Promotes target
  - Stable pupillary image
  - Does not alter the λ of light
- Disadvantages
  - Complicates the procedure
  - Slows the procedure
  - Reflections
  - Bubbles

YAG Cap Techniques
- Focus Helix beam
- Push in towards the retina, position the beams behind the posterior capsule

Capsulotomy Complications
- IOL Insults ("Pits")
  - Visual significance?
  - Laser focused too anteriorly
  - Refocus posteriorly or increase offset
- IOL decentration/subluxation
  - Rare
  - Greater risk if capsulotomy very large

YAG Cap Techniques
- Initial shot (central pilot mark)
  - Cruciate pattern – most common & effective.
  - Start at center, move along the horizontal then downwards
- Other Patterns
  - Homogeneous
  - Circular

Capsulotomy Complications
- The most common complications are general to all anterior segment laser procedures
- Specific to Yag Cap
  - IOL insults
  - IOL decentration
  - Vitreous Prolapse

Capsulotomy Complications
- Vitreous Prolapse
  - Large capsulotomy with large anterior capsulorrhexis can create potential pathway for vitreous into anterior chamber
Post-Operative Management
- Patient education
- Topical steroid – Pred Forte QID x 1 week
- Topical IOP control medication
  - 2% brimonidine, recheck IOP 1 hr post-op
- Continue all pressure lowering medications
- Common RTC 1 week for follow up
  * Acuity & IOP check, DFE

Angle Closure Pathophysiology
- Anatomic Disorder Characterized by Peripheral Iris/TM apposition
- 4 Basic Forms: from most common/least complicated to least common/most complicated
  - Pupillary block (iris)
  - Plateau iris (CB)
  - Phacomorphic Glaucoma (lens)
  - Malignant Glaucoma (vitreous)

Yag Cap & Accommodating IOLs
- Small and central
- Circular; avoid acute angles at edges

Peripheral Iridotomy

PI Indications
- Primary Angle Closure (Pupillary Block)
  - Acute or intermittent
  - Prophylastic
  - Narrow angle or Previous attack in other eye
- Plateau Iris Syndrome/Configuration
- Secondary Pupillary Block
  - Phacomorphic, malignant glaucomas
- Pigmentary Glaucoma
- Nanophthalmos

PI Contraindications
- Corneal non-transparency
- Iris in contact with endothelium
- Angle Closure Secondary to Neovascular or inflammatory glaucomas
- Intraocular Inflammation
- Macular disease?
### PI Alternatives
- Surgical iridectomy
  - Equal results to laser PI
  - Increased risk
  - Intracocular heme
  - Infection
  - Malignant glaucoma
- If concurrent surgery not occurring, choose laser PI

### PI Procedure
- Insert contact lens using cushioning agent
- Deliver energy to create patent PI of approximately 1mm size. Different approaches... may want larger at times.
- Pigment plume = patency
- 100-150 mJ max/session
- Remove lens
- 1% apraclonidine
- IDP/post-op vitals at 1 hour

### PI Laser Selection
- Nd:YAG
  - Penetration rate 95%
  - Photodisruption (non-pigment dependant)
  - Initial energy 1.5 to 2.0 mJ
  - Least energy with successful interaction max of ~6mJ
  - Focus carefully (remember laser offset)
  - Increased risk of bleeding
  - More likely to be hindered by debris
- Argon
  - 80% success (more difficult to penetrate thick iris)
  - Pigment dependant
  - Spot size 50um, Duration 0.1sec, 600-1200mW
  - Less bleeding and debris issues
  - Requires more shots than YAG
  - Argon pre-treat before YAG had advantages

### PI Complications
- Non-perforation – most common
  - Transient blur
  - Uveitis and A/C debris
  - JOP Spike (10-50%) (10-18mmHg)
  - Hyphema – from 35 to 50% of cases
  - Synchiae formation
  - Inflammatory glaucoma
  - Others: Monocular diplopia, Peaked pupil, Corneal/lens/retina damage, RD, CME

### PI Techniques
- Direct
- Linear incision
- Humping
- Drum
**Pi Pearls**
- Penetrate iris is first order of business
- Careful selection of treatment location
- Use Contact Lens
- Tilt lens to clear reflections and achieve tight focus of laser aiming beam
- Titrate total energy depending on history (uveitis, corneal health, glaucoma, CME)
- Avoid treating loose strands
- Assessing patency
  - Retroillumination not sufficient

**Common Complications**
- With minimized risks, side-effects:
  - Mild
  - Short duration
  - Insignificant consequence
  - Ocular health and visual function sound
  - Refractive status unchanged
  - Invasive surgical risk is avoided

**Pi Success**
- Patent PI at 6 weeks
  - Remember greater success with Yag than with Argon
- Deepening of anterior chamber
- IOP control
- No persistent complications

**Common Complications**
- All laser procedures have risk of severe complications.
  - Minimize risk:
    - Patient education
    - signed informed consent
    - Proper pre-op, surgical and post-op techniques
    - Appropriate follow-up appointments

**Risk Management**
- With each patient and with each procedure:
  - Know what can go wrong,
  - Know when to look for it,
  - Know what to do when it occurs.

- Must know potential complications with each laser procedure
- Must know patient specific characteristics that put that patient at increased risk
  - Diabetes mellitus
  - High myopia
  - Retinal health
  - Glaucoma
  - Ocular hypertension
Risk Management

Knowing the patient and the laser procedure will allow
- Accurate diagnosis of complication
- Immediate treatment
- Appropriate referral when indicated
- Follow high risk patients more closely

General Complications

ALL anterior segment laser procedures are associated with transient:
- IOP elevations
  - ~50% are statistically significant
- Inflammation
  - ~50% post-procedural cell and flare
  - Iritis, iridocyclitis, uveitis, CME

Follow high risk patients more closely

Complications increase with increased cumulative amounts of laser energy
- Inflammatory responses
  - Iritis, cycitis, iridocyclitis
  - Synechiae, posterior and peripheral anterior
  - Cystoid macular edema
- Elevated IOP

Elevated IOP
- Underlying inflammatory mechanism
- Mediators alter TM and aqueous dynamics
- "Spike" 1-3 hrs following procedure
  - 2 to 10 mmHg or higher
  - "Spike" dissipates in 24-48 hrs
- POAG is pre-existing risk factor
- Existing pressure induced ONH damage
- Pre- and post-treat with aqueous suppressors
  - Apraclonidine or Brimonidine
  - Beta-blockers
  - Carbonic anhydrase inhibitors (consider)
  - New glaucoma meds

Use minimum amount of energy required to accomplish procedure
BUT, use power and shots necessary to accomplish objective

Inflammation - iritis
- Iris intensity directly associated with total cumulative energy delivered to eye
- Increased inflammation increases risk of inflammatory adhesions and permanent structural damage

Inflammation - uveitis
- IF > 10 cells/ SLE view or aqueous flare/haze, then initiate treatment
- i.g 0.4ml then taper when controlled
  - Topical steroids: prednisolone acetate, fluoromethalone acetate
  - Topical NSAIDs: diclofenac sodium
General Complications

Inflammation - cystoid macular edema
- Inflammatory mediators circulate posteriorly through the vitreous affecting the parafoveal vascular network
- Mechanical irritation from acoustic waves
- Blurred vision occurs days to weeks after procedure

Identification with stereo-biomicroscopy
Diagnosis confirmed with fluorescein angiography or OCT
Manage with topical and systemic anti-inflammatories
Consider oral CAI

Procedure Billing

- 65855 – SLT/ALT code
  - 10 day global period
  - Oklahoma allowable is $308.98
- 66761 – PI code
  - 90 day global period
  - Oklahoma allowable is $295.50
- 66821 – YAG Cap code
  - 90 day global period
  - Oklahoma allowable is $295.53

Charting Data

- Items to be recorded in the chart:
  - Enter the total energy and shot data
  - Use of the signed informed consent form
  - Information used to inform/educate the patient if other than from consent form
  - Education on possible emergency complications and follow-up care procedures