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
- 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
- Therefore the desired level of impact would require less power when the spot is smaller
- Decreasing spot size without decreasing power could 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

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

- 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
Laser Variables That Affect Interactions

Energy delivered

- Brief duration burns (.02 - .05sec) usually result in photovaporization or photodisruption
- Intermediate duration burns (.1 - .2 sec) tend to produce photocoagulation
- Long duration burns (.2 - .5 sec) result in an uneven treatment due to center zone become hot with vaporization and charcoaling
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

Mode of energy delivery

- Pulsed lasers
  - Pulsing increases the power of the burn by shortening the duration
  - Q-switching or mode-locking
  - Newer laser systems permit up to five pulses per laser burst.
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
- Healthy ocular media pass 400 nm blue through 700 nm red effectively.
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
Tissue Variables That Affect Interactions

Transparency

- Yellowish pigment may absorb significant levels of blue region light
- The lens absorbing more can increase thermal effects and speed cataract progression
- Corneal scarring, infiltration and edema will also affect transmission. The hazier the cornea the greater the absorption and less transmission, and higher risk of corneal burn
- Loss of aqueous or vitreal transparency due to inflammatory cells, flare, hyphema, and vitreous hemorrhage are all light absorbing entities. Heating these protein-rich fluids can cause them to denature or coagulate, thus complicating the situation
Tissue Variables That Affect Interactions

Pigmentation - Absorption of light with conversion to heat is affected by melanin, hemoglobin, and xanthophyll

Melanin
- absorbs across the entire visible spectrum
- Also 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. Burns longer than .2sec produce pain
Tissue Variables That Affect Interactions

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
Tissue Variables That Affect Interactions

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)
Tissue Variables That Affect Interactions

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
Specific Laser-Tissue Interactions

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

Photocoagulation

◦ 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

Photocoagulation

- Also involves the warming of collagen
- Causes the collagen to contract, thus altering structural relationships
- Helpful in changing the microanatomy 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 60 - 100 degree C
- Reduces tissue to CO$_2$ and H$_2$O
- Vapor is created
Specific Laser-Tissue Interactions

Photovaporization
- Is desired when trying to burn a hole or channel through a pigmented tissue
- Useful in thermal laser iridotomies
- Not desired when attempting photocoagulation - could obliterate Bruch’s leading to CNVM
Specific Laser-Tissue Interactions

Photodisruption

- Is pigment INDEPENDENT
- Delivers large amounts of energy into very small focal spots in very brief duration of time
- Instantaneous, localized temperature rise occurs
- Tissue warmed by over 15,000 Degrees C
- Involved molecules stripped of their electrons
Specific Laser-Tissue Interactions

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
Figure 3–6  Posterior YAG offset

Treatment beam positions at detent dial settings

MIN  +150  +250

Aiming beam 1

Aiming beam 2

Focal plane

150 # Micron  100 # Micron

250 # Micron

# Note that distances shown reflect measurements in air.
Specific Laser-Tissue Interactions

Photoablative decomposition
- Is pigment INDEPENDENT
- Is true non-thermal process
- Highly localized laser-tissue impact occurs
- 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

- 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 Potentially Repeatable

- TM after ALT burn placement
- TM after SLT burn placement
SLT Indications

- Various approaches
- When patient ready for second medication
- First line treatment in other countries
  - Non-compliance
  - Cost of meds
SLT Contraindications

- Not for angle closure
- Caution in cases where could be trabeculitis
Pre-Op

- Basic exam components
  - VA, IOP, etc.

- Gonioscopy
  - Assess angle structure
  - Assess pigmentation

- 1 gt Iopidine or Alphagan

- Pilo 1% if need to pull iris out of angle to better visualize TM for treatment
SLT Procedure

Will use lens to treat angle
  ◦ Ritch Lens
  ◦ Latina Lens

Don’t want to use a lens with a magnification button or can alter the beam diameter and energy
The Latina SLT Gonio Laser Lens was 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 one 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 9 and rotate clockwise)
- Before rotating lens identify a landmark
Procedure Technique

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

- **Recommended initial power setting**
  - 0.8 – 1.0 mj (won’t need to go more than 1.1 or 1.2 – go up in very small increments if needed)

- Desired tissue response will be subtle to see – a slight change in the surface of the TM is adequate treatment

- A small amount of bubble every few pulses appropriate
Procedure Technique

- Place approximately 100 treatment spots per 360°
- Place each treatment spot adjacent to the next – no skipped space
- Most people are currently treating 360° of one eye for first procedure, many doing both eyes
- 180° considered to be “partial” tx
- 180° + 180° = “complete” tx
- 360° + 180° = “re-treatment”
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
Post-Op

6 – 8 week post-op visit to evaluate effect in that eye, if good, treat other eye

Theoretically could see some affect 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
Re-Treatment

If desired effect not observed at 6-8 week follow up visit can consider retreatment of 180°

Repeat the treatment using the same power as was used in the initial treatment
Issues

Treatment after failed trab
Treatment after PI – only do 180°
Treatment for those having IOP increase post kenalog injection
When not to perform SLT?
YAG Capsulotomy
Posterior Capsular Opacification

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 PCO is the formation of a membrane on the posterior surface of the capsular bag following extracapsular cataract extraction.

Also known as is a secondary cataract
Posterior Capsular Opacification
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
Posterior Capsular Opacification

Incidence:

Is most common complication post ECCE (extracapsular cataract extraction)

Incidence ranges from 40 - 50% post surgical.

PCO’s can form days to years post surgical

When < 40 years old the incidence or risk of development increases
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
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 PCO formation with capsular polishing
Prevention and reduction

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
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”
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.
Evaluating the Patient

Subjective
- Best Visual Acuity
- Contrast Sensitivity
- Glare acuity
- PAM

Objective
- Slit lamp exam
- Dilated Retinal Exam

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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
Preparation

Comprehensive Exam

Dilation (note pupil location first!)
- 2.5% Phenylephrine
- 1% tropicamide

History and Physical Info
- Allergies
- Medications
- Respiration
- Pulse
- Blood Pressure
- Temp

- Consent form – explain complications
- Contact lens – to use or not??
- Topical anesthetic
- Brimonidine or 1% Iopidine – 30 mins to 1 hour prior to treatment
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
YAG Cap Techniques

Power/Energy settings vary with lasers (.8 to 2.0mj)
Spot size is fixed
Duration is fixed
Pulse setting recommended at 1

Offset of Laser
- Purpose is to set the place of treatment relative to the energy level and position of the aiming laser HeNe beams
- The greater the power, the greater the offset needed
- Each laser is different – one laser offset of +2.50, and push towards the retina a little.
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
- Magnifies target
- Stabilizes purkinje images
- Does not alter the $\lambda$ of light

Disadvantages
- Complicates the procedure
- Slows the procedure
- Reflections
- Bubbles
YAG Cap Techniques

Focus HeNe beam

Push in towards the retina, position the beams behind the posterior capsule
YAG Cap Techniques

- Postage Stamp – alternating corners, may leave floating capsule
- Horseshoe – folds downward
- Lazy T – two flaps fold backward
- Cruciate – down then from middle outward on each side
YAG Cap Techniques
Post-Operative Management

Patient education

Topical steroid – Pred Forte QID x 1 week

Topical IOP control medication
  ◦ 1% Iopidine or Brimonidine, recheck IOP 30 min - 1 hr. post-op

Continue all pressure lowering medications

Common RTC 1 week for follow up
  ◦ Acuity & IOP check, DFE
Peripheral Iridotomy
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)
PI Indications

Primary Angle Closure
- Acute or intermittent

Plateau Iris Syndrome/Configuration

Prophylaxis
- Narrow angle or Previous attack in other eye

Secondary Pupillary Block
- Phacomorphic, etc.

Pigmentary Glaucoma

Nanophthalmos
PI Contraindications

Corneal non-transparency

Iris in contact with endothelium

Angle Closure Secondary to Neovascular or inflammatory glaucomas
PI Alternatives

Surgical iridectomy
- Equal results to laser PI
- Increased risk
  - Intraocular heme
  - Infection
  - Malignant glaucoma

If concurrent surgery not occurring, choose laser PI
PI Precautions

ASA
Lid Position
Shallow Anterior Chamber
Corneal status
Uveitis and CME history
Glaucoma status
Monocularity/Nystagmus
PI Procedure

Confirm diagnosis, comprehensive exam

Informed consent

Pretreat with brimonidine or 1%
Apraclonidine and 1 -2% Pilocarpine one hour before procedure

Pre-op vitals

Prepare laser (choices in a moment) and Abraham iridotomy laser lens

Select PI location
  ◦ Lid location, crypt, multiple 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.

Remove lens

Brimonidine or 1% apraclonidine

IOP 30 min to 1 hour after procedure
PI Follow-up

Continue routine glaucoma meds (caution with Xalatan and Pilo)

Pred-Forte qid for 1 week

Exams at 1 day, 1 week, 1 month
PI Complications

- Non-perforation – most common issue
- Transient blur
- Uveitis and A/C debris
- IOP Spike (30-50%) (10-18mmHg)
- Hyphema – from 35 to 50% of cases
- Synechial formation
- Inflammatory glaucoma
- Others: Monocular diplopia, Peaked pupil, Corneal/lens/retina damage, RD, CME
**PI Laser Selection**

**Nd:YAG**
- Penetration rate 95%
- Photodisruption (non-pigment dependant)
- Initial energy variable – 2.5 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
PI Laser Selection

**Argon (photocoagulation)**
- 80% success (more difficult to penetrate thick irides)
- 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 Techniques

- Direct
- Linear incision
- 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
PI Success

Patent PI at 6 weeks
  - Remember greater success with Yag than with Argon
Deepening of anterior chamber
IOP control
No persistent complications
Angle closure
post laser peripheral iridotomy
Angle Closure due to Relative Pupillary Block

Before laser iridectomy:
- Iris against TM
- Sclera
- Ciliary body
- Lens capsule

After laser iridectomy:
- TM in contact with aqueous
- Convex iris
- Flat iris

NYEEI, Ocular Imaging Center
Common Complications

All laser procedures have risk of severe complications.

Minimize risk:

patient education
  ◦ understand their role in procedure
  ◦ signed informed consent

proper pre-op, surgical and post-op techniques

appropriate follow-up appointments
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
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.
Risk Management

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
Risk Management

Complications increase with increased cumulative amounts of laser energy

inflammatory responses
◦ iritis, cyclitis, iridocyclitis
◦ synechiae, posterior and peripheral anterior
◦ cystoid macular edema

elevated IOP
Risk Management

Cumulative energy totals dependent on
- total laser bursts fired
- number of pulses per burst
- amount of energy per pulse

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

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
General Complications

Elevated IOP

POAG is pre-existing risk factor

existing pressure induced ONH damage

pre- and post-treat with aqueous suppressers
  ◦ apraclonidine
  ◦ beta-blockers
  ◦ carbonic anhydrase inhibitors (consider)
  ◦ new glaucoma meds
General Complications

Inflammation - iritis

- iritis intensity directly associated with total cumulative energy delivered to eye
- increased inflammation increases risk of inflammatory adhesions and permanent structural damage
General Complications

Inflammation - iritis

- peripheral anterior synechiae
  - PAS could negate IOP reduction effect of thermal trabecuoplasty

- posterior synechiae possible
  - pupil distortion
  - impaired pupil function
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
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 that from consent form
- Education on possible emergency complications and follow-up care procedures
Procedure Billing

65855 – SLT/ALT code
- 10 day global period
- Oklahoma allowable is $308.98

66761 – PI code
- 10 day global period
- Oklahoma allowable is $295.50

66821 – YAG Cap code
- 90 day global period
- Oklahoma allowable is $295.53