

SLT For Open Angle Glaucoma

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Disclosures

Nothing to disclose

Course Outline

- Trabeculoplasty overview
- Indications
- Contraindications
- Outcomes
 - Predicting SLT Success
- Special considerations
- Preoperative preparation
- Procedure technique
- Postoperative management
- Risks and complications
- Emerging technologies

Trabeculoplasty: An Overview

- Argon (ALT) and Selective (SLT)
- Laser treatment of the trabecular meshwork to enhance aqueous outflow

When is Laser Useful?

- Often secondary line of treatment, but some use as primary
- Max meds and need for more IOP reduction
- Patient has trouble instilling drops
- Patient noncompliant with drops
- Patient doesn't want to use drops every day
- Concern about diurnal control
- Doctor preference

Am J Ophthalmol. 2005 Oct;140(4):598-606.

Persistence and adherence with topical glaucoma therapy.

Nordstrom BL, Friedman DS, Mozaffari E, Quigley HA, Walker AM.


Ingenix Epidemiology, Auburndale, Massachusetts 02466, USA. bnordstrom@epidemiology.com

Abstract

PURPOSE: The present study describes the patterns and predictors of treatment persistence and adherence among patients who are diagnosed with glaucoma or as glaucoma suspects (based on claims codes).

DESIGN: A retrospective cohort study using health insurance claims data.

METHODS: Newly treated individuals with diagnosed glaucoma (n = 3623) and suspect glaucoma (n = 1677) were obtained from healthcare claims data in the Ingenix Research Database. For each of these two diagnostic groups, we calculated the duration of continuous treatment with the initially prescribed medication (persistence) and the prevalence of use of the initial medication at various time points (adherence). Four drug classes were included: beta-blockers, alpha-agonists, carbonic anhydrase inhibitors, and prostaglandin analogs.

RESULTS:  Nearly one half of the individuals who had filled a glaucoma prescription discontinued all topical ocular hypotensive therapy within six months, and just 37% of these individuals recently had refilled their initial medication at three years after the first dispensing. Prostaglandins were associated with better persistence than any other drug class, which was indicated by hazard ratios for discontinuation of prostaglandins compared with beta-blockers of 0.40 (95% confidence interval, 0.35-0.44) for diagnosed patients and 0.44 (95% confidence interval, 0.37-0.52) for patients with suspect glaucoma. Prostaglandins showed a similar advantage in adherence. Furthermore, patients with diagnosed glaucoma were more likely to adhere to therapy than patients with suspect glaucoma (relative risk = 1.11; 95% confidence interval, 1.05-1.18).

CONCLUSION: Persistence and adherence were substantially better with prostaglandins than with other drug classes, and patients with diagnosed open-angle glaucoma were more likely to adhere to treatment than suspected glaucoma.

Over 90% admitted to missing some drops!

History of laser trabeculoplasty

- Modern ALT based on 1979 report by Wise and Witter
- SLT introduced in 1998 by Latina
 - FDA approved in 2001
- Mechanism of action of both remains controversial

Argon Laser Trabeculoplasty (ALT)

- Pigment dependent laser
- Photocoagulative effect
- Exact mechanism of action unknown
 - Laser may photocoagulate TM, leading to scarring and tissue contraction
 - Leads to opening of channels through TM for aqueous outflow
 - Biological activation of macrophages may help “clean up” TM

Selective Laser Trabeculoplasty (SLT)

- Frequency doubled, Q-switched Nd:YAG
- Wavelength output is 532nm green
- Burn time is 3 nanoseconds
 - Why is this important?

SLT proposed mechanism

- Thermal relaxation time
 - Amount of time it takes melanin to convert light energy into heat
 - 1 microsecond
- SLT pulse duration is 3 nanoseconds
- No thermal damage (“cold laser”)
- Targets intracellular melanin
- No effect on adjacent non-melanin containing cells (“selective”)

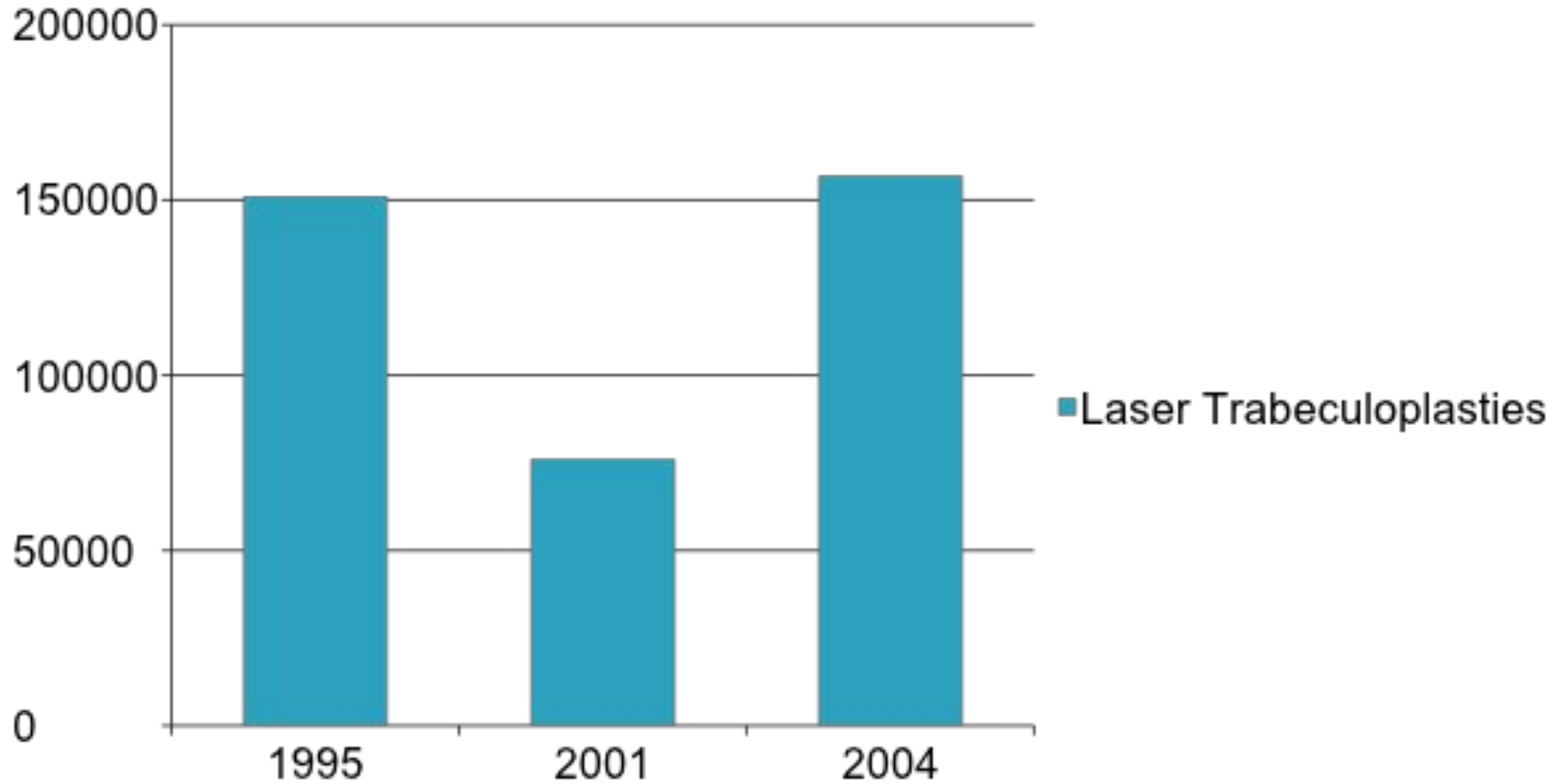
SLT proposed mechanism (cont)

- Target cells activate cytokines, which activate macrophages
- Macrophages clean area, decreasing outflow resistance
- No mechanical damage/scars (unlike ALT)
 - Potentially repeatable
- Recent research: also improves uveoscleral outflow

Trabeculoplasty indications

- POAG
- OHTN
- Normal tension glaucoma
- Pigment dispersion glaucoma
- Pseudoexfoliative glaucoma

Use of Trabeculoplasty in the US



Glaucoma Laser Trial (GLT) (1990)

- ALT (360°) was as effective as medication (timolol monotherapy) for newly diagnosed POAG
- Through 7 years of follow up
 - Equal IOP lowering to timolol
 - Better optic disc/visual field status

SLT/Med Study

- Published 2012
- Prospective randomized clinical trial
- 100 eyes followed for 1 year
- POAG and OHTN
- Randomized to SLT or prostaglandin
- If target IOP not met:
 - Repeated SLT in laser group
 - Added drops in medication group

SLT/Med Study

- Baseline IOP ~24.5 in both groups
- IOP reduction
 - SLT: 6.3mmHg
 - Meds: 7.0mmHg
- Need for additional treatment
 - SLT: 11%
 - Meds: 27%
- Conclusion: SLT is a viable first line treatment for POAG

SLT as first line?

- American Academy of Ophthalmology Preferred Practice Patterns
 - “Laser trabeculoplasty can be considered as initial therapy in selected patients.”

SLT as first line?

- UpToDate
 - “Once the decision has been made to treat a patient with open-angle glaucoma, we recommend pharmacologic or laser therapy as first line treatment.”
 - Grade 1B evidence

SLT as first line?

- 2015 Meta-Analysis (Oi Man Wong et. al)
 - “Robust evidence that SLT may be...offered as a primary treatment to patients with OAG.”

SLT as first line?

Selective laser trabeculoplasty versus eye drops for first-line treatment of ocular hypertension and glaucoma (LiGHT): a multicentre randomised controlled trial

*Gus Gazzard, Evgenia Konstantakopoulou, David Garway-Heath, Anurag Garg, Victoria Vickerstaff, Rachael Hunter, Gareth Ambler, Catey Bunce, Richard Wormald, Neil Nathwani, Keith Barton, Gary Rubin, Marta Buszewicz, on behalf of the LiGHT Trial Study Group**

- RCT with n=718
- Followed for 3 years
- Looked at QoL, efficacy, cost, and safety

Selective laser trabeculoplasty versus eye drops for first-line treatment of ocular hypertension and glaucoma (LiGHT): a multicentre randomised controlled trial

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- “Selective laser trabeculoplasty provides superior intraocular pressure stability to drops, at a lower cost and, importantly, it allows almost three quarters of patients (74%) to be successfully controlled without drops for at least 3 years after starting treatment.”

Trabeculoplasty contraindications

- Angle closure glaucoma and emergency IOP lowering
- Narrow angle glaucoma (if unable to see TM)
- Inflammatory glaucoma
- Neovascular glaucoma
- Hazy media
- Relative contraindications
 - Angle recession
 - Age under 40

Trabeculoplasty efficacy

- Expected IOP reduction: 20-30%
- 80-90% effective at one year
- 30-50% effective at five years

Predicting SLT Success

- SLT is not 100% effective
 - Modest response in some
- What if we could predict nonresponders?

Predicting SLT Success

Development of a Prediction Rule to Estimate the Probability of Acceptable Intraocular Pressure Reduction After Selective Laser Trabeculoplasty in Open-angle Glaucoma and Ocular Hypertension

Alexander J. Mao, MD, OD, MPH, Xiao-jing Pan, MD,† Ian McIlraith, MD,* Maurice Strasfeld, MD,* George Colev, MD,* and Cindy Hutnik, MD**

- Looked at:
 - Pre-treatment IOP, current medications, phakic status, level of pigmentation, steroid use, age, gender

Preoperative intraocular pressure as a predictor of selective laser trabeculoplasty efficacy

Karin R. Pillunat, Eberhard Spoerl, Greta Elfes and Lutz E. Pillunat

Department of Ophthalmology, Medical Faculty Carl Gustav Carus, Technische Universität, Dresden, Germany

Mean diurnal IOP change	Baseline mean diurnal IOP		
	<14 mmHg (<i>n</i> = 56) min. 9.3 mmHg	14–18 mmHg (<i>n</i> = 83)	>18 mmHg (<i>n</i> = 18) max. 24 mmHg
Decrease (<i>n</i> = 15) >20%	1.8% (−3.3 mmHg)	12% (−4.4 mmHg)	22.2% (−5.6 mmHg)
Decrease (<i>n</i> = 55) 10–20%	31.1% (−1.9 mmHg)	36% (−2.2 mmHg)	44.5% (−3.3 mmHg)
Decrease (<i>n</i> = 51) <10%	31.1% (−0.6 mmHg)	35.1% (−0.9 mmHg)	33.3% (−1.1 mmHg)
No change (<i>n</i> = 3)	3.6%	1.2%	0
Increase (<i>n</i> = 33)	32.4% (+1.0 mmHg)	15.7% (+1.5 mmHg)	0

SLT and prostaglandins (PGA)

- SLT may function similarly to PGA
 - Low-grade inflammation
- 2007 study: In patients on drops, SLT had the least impact in eyes already treated with PGA

SLT and prostaglandins (PGA)

- Alvarado et. al
- Two parts to study
 - In vitro
 - PGA and trabeculoplasty have competitive mechanism of action
 - Clinical arm

Alvarado et. al Clinical Arm

- 24 patients
- Withdrew PGA for washout period, then did SLT
- Measured SLT response after 90 days

Alvarado et. al Clinical Arm

- Average IOP reduction
 - PGA: 25%
 - SLT: 30%
- PGA responders tended to be SLT responders (at equivalent levels)

Alvarado et. al Proposed Protocol

- If patient is on no glaucoma meds preoperatively
 - Test response with PGA
 - If successful, proceed with SLT
 - SLT functions like starting PGA
- If patient is already on PGA preoperatively
 - Discontinue PGA for 1 month
 - If IOP increases, expect SLT to work
 - SLT basically replaces PGA

Alvarado et. al Proposed Protocol

- If patient needs further IOP reduction following SLT, consider using non-PGA medication

TM Pigment and Success

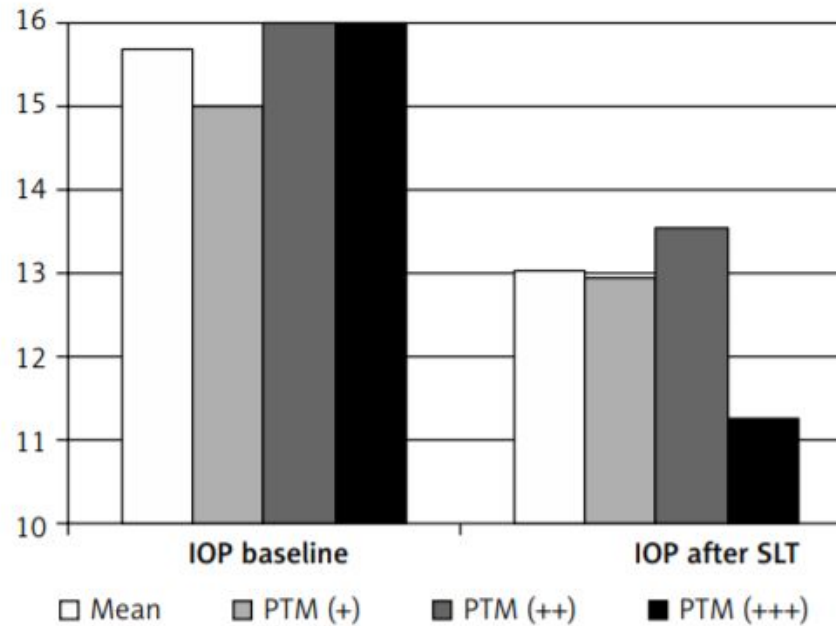


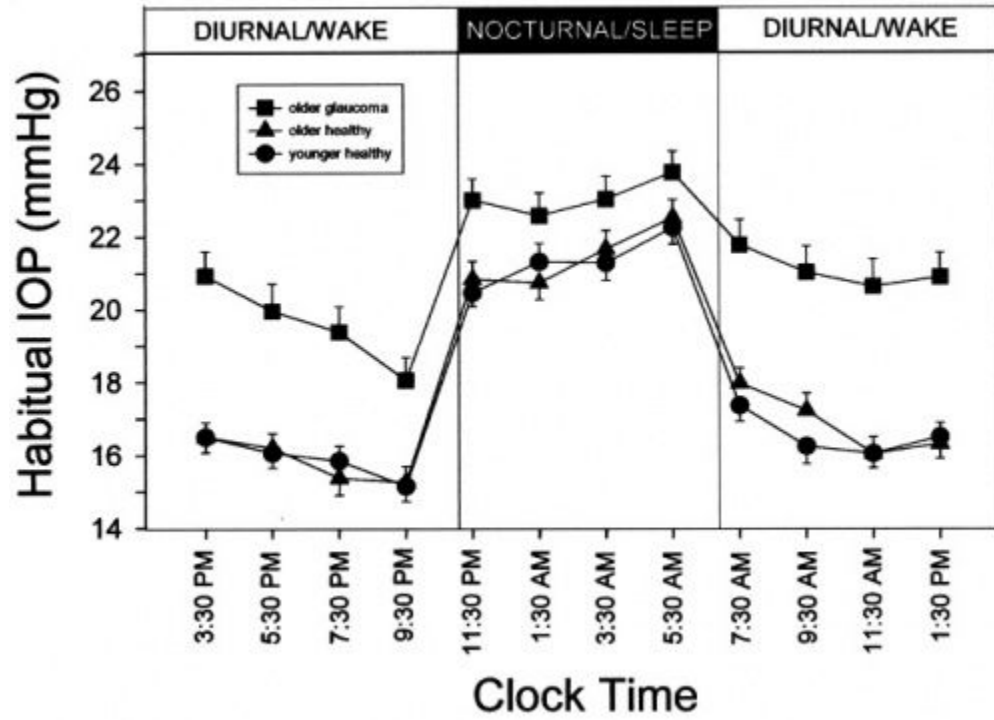
Figure 1. IOP reduction 6 weeks after selective laser trabeculoplasty (in mm Hg) depending on angle pigmentation (PTM)

Table I. Mean IOP reduction in the examined subgroups

PTM +	(n = 17) 13.7%	15.0–12.94 mm Hg
PTM ++	(n = 37) 15.3%	16.0–13.54 mm Hg
PTM +++	(n = 8) 29.6%	16.0–11.25 mm Hg

Trabeculoplasty Diurnal Control

- How effective is SLT at controlling nocturnal IOP spikes?



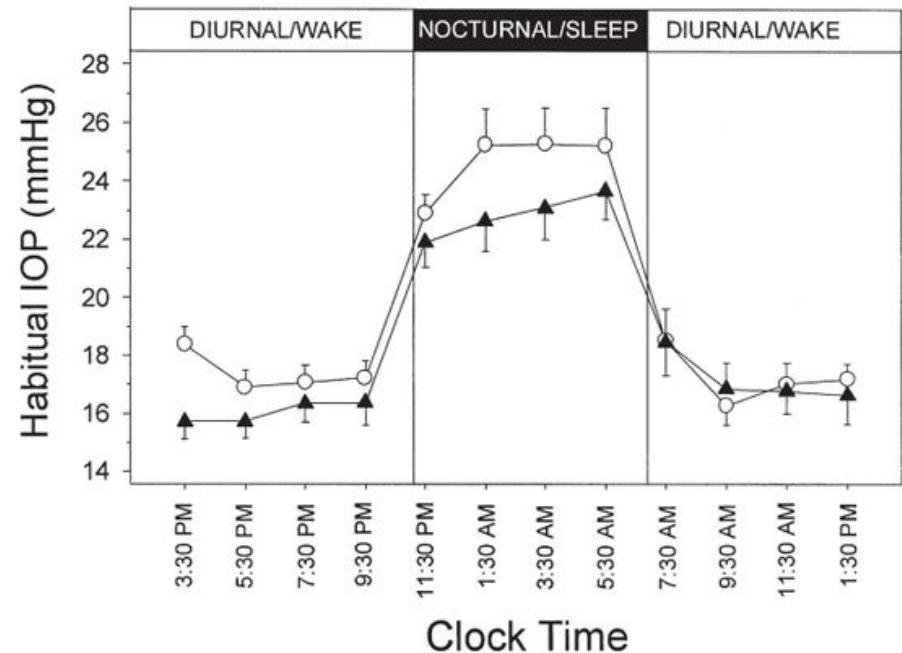
Trabeculoplasty Diurnal Control

- Prospective study: 18 patients on drops undergoing ALT
- Subjects stayed in sleep lab
- Checked IOP during day (sitting) and overnight (supine)
 - Repeated before and after ALT

Enrollment Order	Prostaglandin Analogs*	β -Adrenergic Antagonists [†]	Carbonic Anhydrase Inhibitors [‡]	α_2 -Adrenergic Agonist [§]
1	x			
2		x		
3	x	x	x	x
4		x		
5	x	x	x	
6	x	x	x	x
7	x		x	x
8	x	x		x
9	x	x	x	
10	x	x	x	x
11	x			
12	x	x		x
13	x			
14	x			
15	x	x	x	
16	x	x		
17	x	x	x	x
18	x	x	x	x

Trabeculoplasty Diurnal Control

- Mean nocturnal IOP was 1.8mmHg lower after ALT
 - Some patients showed no improvement during day, but still had blunted nocturnal spike

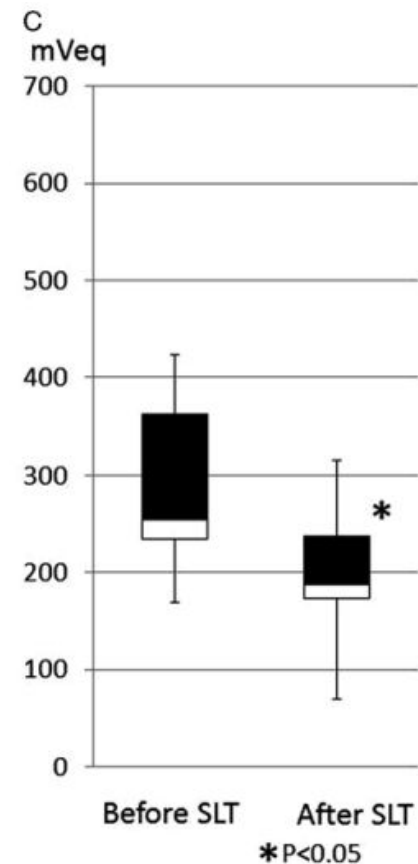


SLT and normal tension glaucoma (NTG)

- How much IOP reduction can we expect?
- Does improved diurnal control still apply?

SLT and normal tension glaucoma (NTG)

- 14-16% IOP reduction
 - 2015 meta-analysis of SLT studies
- Diurnal control benefits
 - 2014 study: SLT decreases nocturnal spikes in NTG patients



SLT and pigment dispersion

- Is it effective?
- Is it safe?

SLT and pigment dispersion

- SLT mechanism of action
- Thermal relaxation time

SLT and pigment dispersion

- SLT tends to be very effective, HOWEVER...
- 2005 paper reported four cases of PDG with severe IOP spike following SLT
 - Required urgent trabeculectomy
- Some doctors avoid SLT in PDG

SLT and pigment dispersion

- Consider “test dose”: 10 shots at 0.3mJ
- If no IOP spike, proceed with treating one quadrant at a time
 - Monitor IOP response after each quadrant
 - May not need to treat all four quadrants

SLT and Pseudoexfoliation

- Heavy pigmentation → Good response
- Wears off more quickly
- Higher risk (similar to PDG)
 - 2016 case series of 5 patients with persistent IOP spikes needing incisional surgery
- Recommended for mild/moderate cases

SLT for Steroid-Induced Glaucoma

- Effective in cases of intravitreal triamcinolone
- Sometimes advocated prophylactically before intravitreal injection, especially if OHTN

Preoperative preparation

- Basic exam components
 - VA, IOP, slit lamp, etc
- Gonioscopy
 - Open angle?
 - Assess pigmentation
 - Rule out angle recession, peripheral anterior synechiae, NVG

Preoperative preparation

- Informed consent
 - Risks, benefits, alternatives
- Blood pressure/pulse
- One drop brimonidine or apraclonidine
- Pilocarpine 1% if needed to open angle and better visualize TM
- Proparacaine OU immediately before laser lens insertion

Laser Lenses

- Latina lens
 - 1x magnification
- Ritch lens
 - 1.4x magnification
 - Reduces spot size by 30% and increases laser power by 2x
 - Must account for this in laser settings!

Laser settings

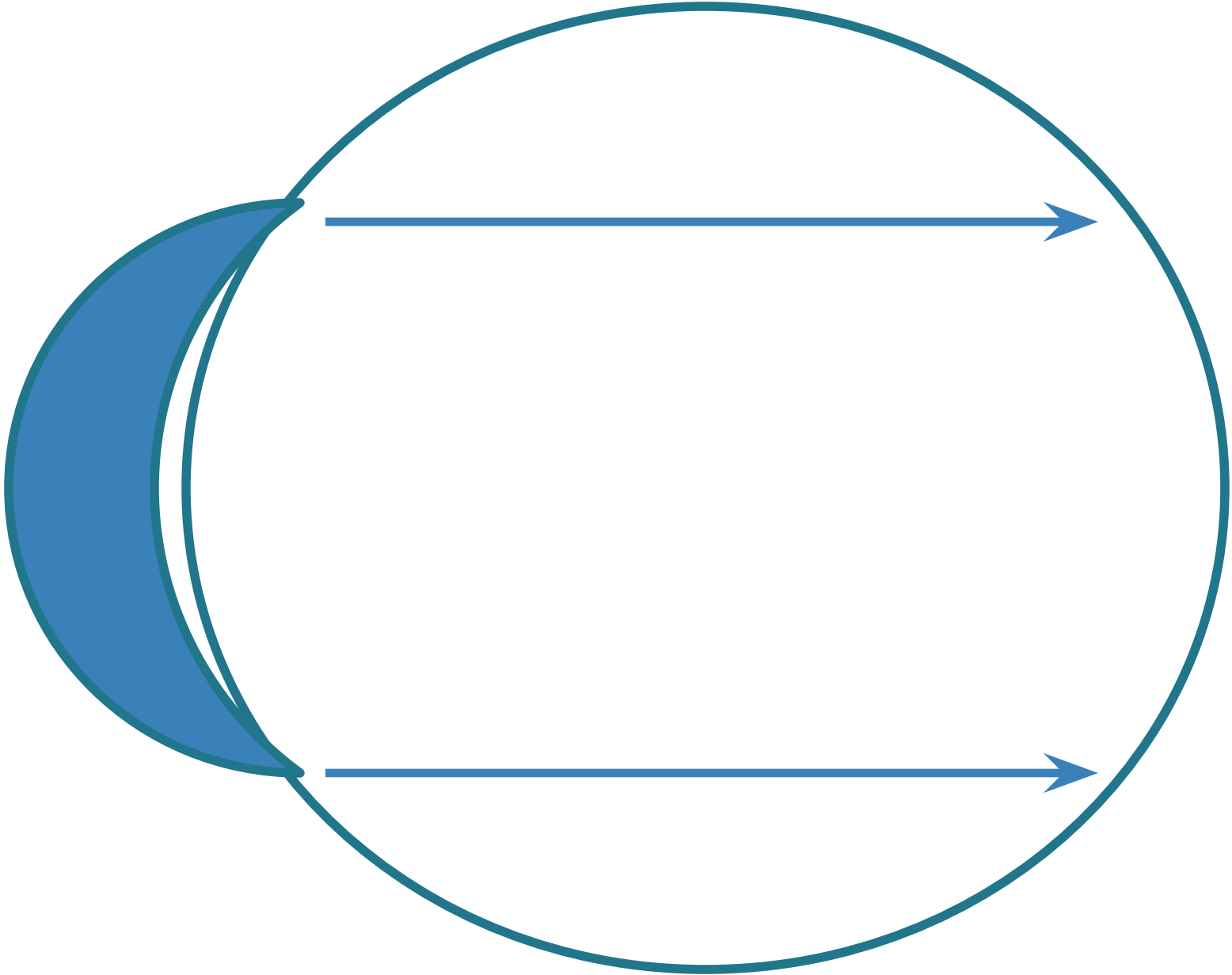
	ALT	SLT
Power	600mW	0.6-1.2mW
Spot size	50 microns	400 microns
Pulse duration	0.1 second	3 nanoseconds

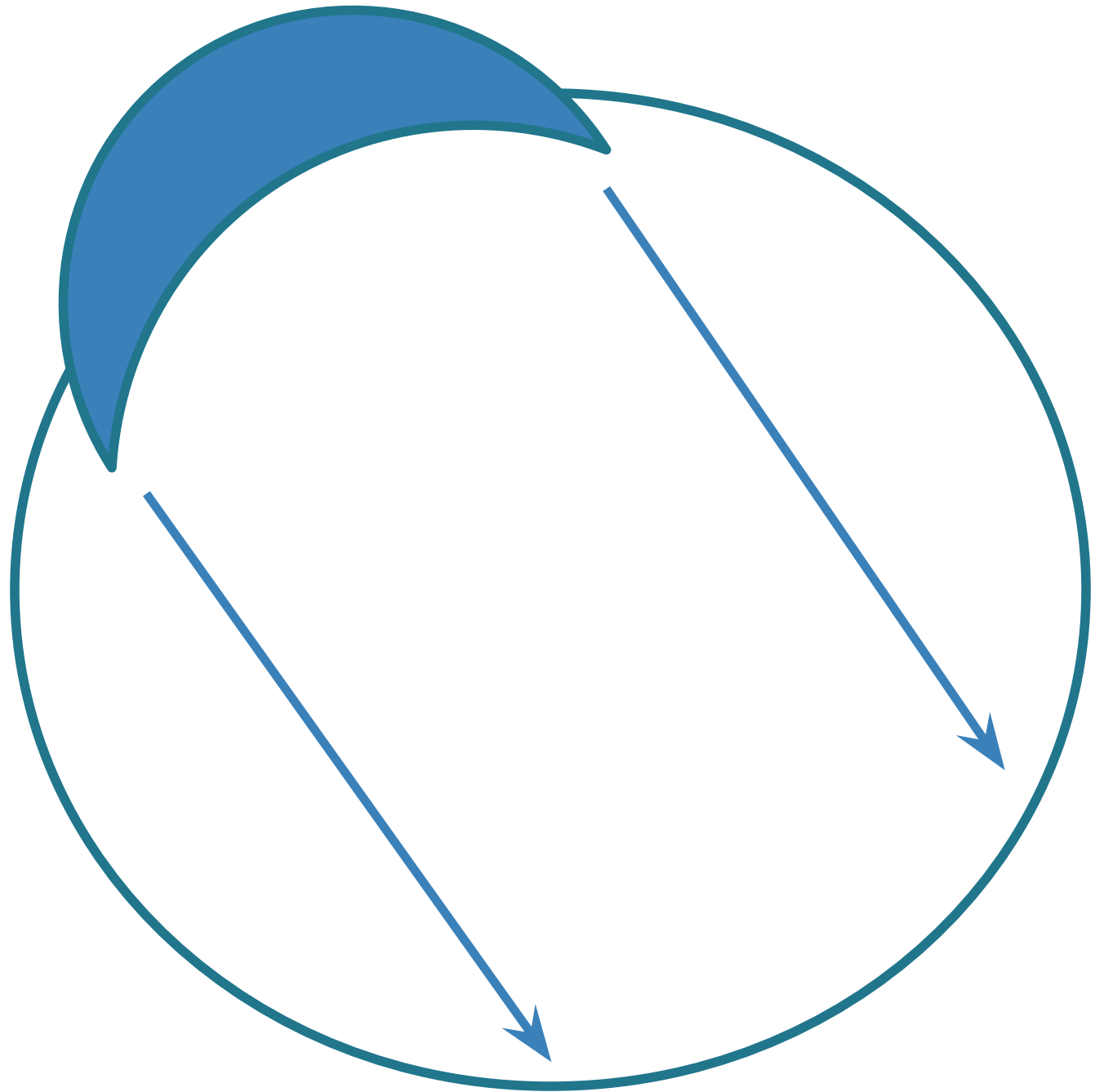
Laser preparation

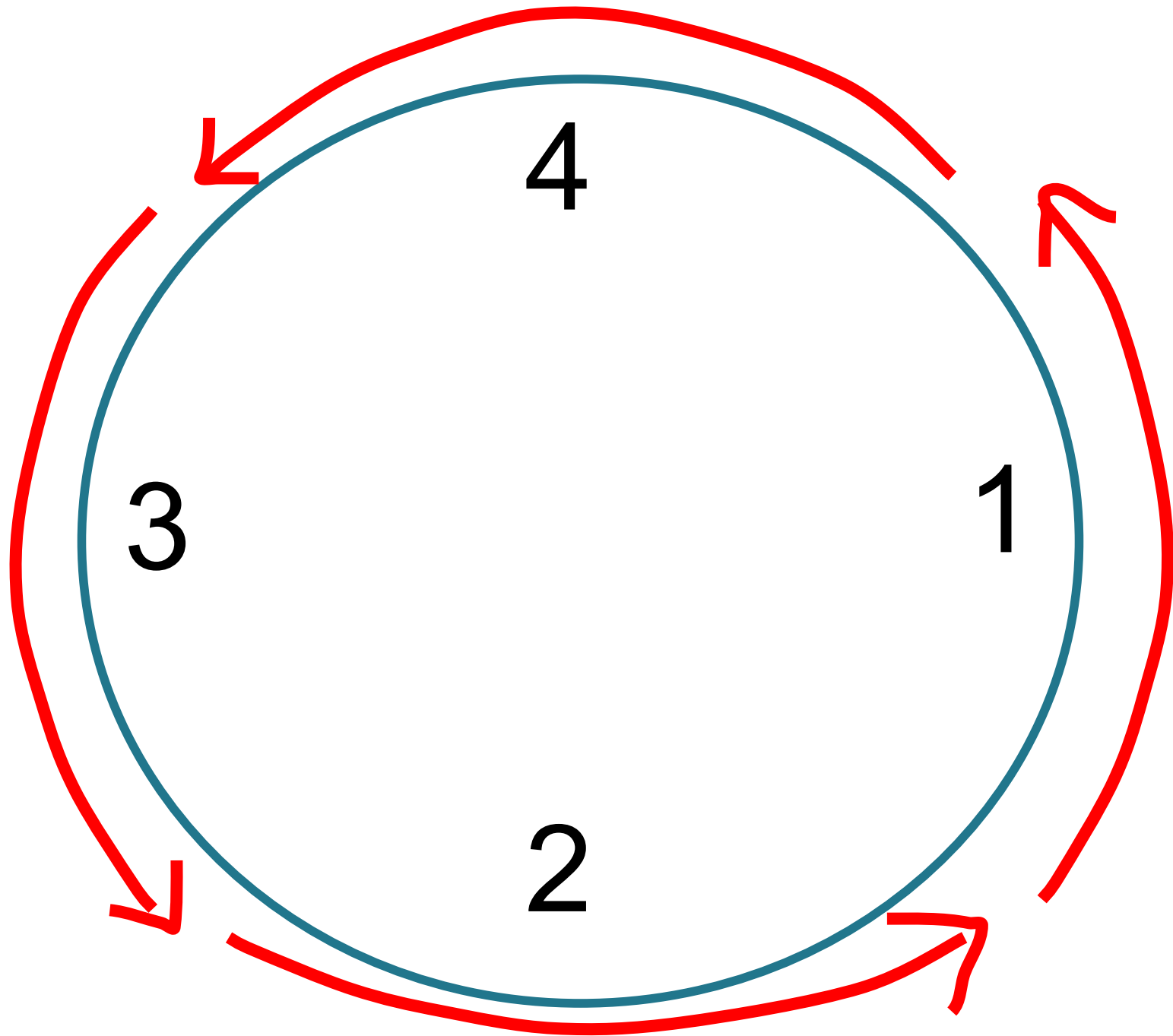
- Adjust patient height for comfort
- Adjust table and laser for your comfort
- Configure elbow rest and oculars

Procedure Technique

- Insert laser lens with cushioning solution
- Visualize angle
- Establish a consistent approach that you follow every time
 - i.e. start at 9:00 and go clockwise
 - Identify a landmark before rotating lens







ALT technique

- Focus on anterior TM
 - Aim is critical
- 50 micron spot size
- Place burns two spot sizes apart
- 50 burns per 180°
- Look for slight pigment blanching and bubble formation
 - Adjust energy as needed

SLT technique

- Treatment spot covers entire TM
 - Easier to aim than ALT
 - 400 micron spot size
- Place spots next to each other
- Initial power 0.8-1.0mJ
 - 0.5mJ for heavy pigment (PDG)
 - Titrate by 0.1mJ increments
 - Want bubbles every 1-3 pulses (none in PDG)
 - No tissue blanching or other visible response
 - May need more energy in superior angle
- 50 spots per 180°

SLT technique

- 360° treatment generally considered standard
 - Literature is fairly inconclusive
 - Strongly consider a “trial run” in PDG eyes
 - 90-180° at a time
 - Excess pigment → extra inflammatory response
 - IOP spike more likely
 - Rule of thumb: More pigment, less energy

SLT technique

- 360° treatment generally considered standard
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ALT vs SLT spot size

- ALT 50 microns
- SLT 400 microns

ALT vs SLT

	ALT	SLT
Laser Used	Argon	Q-switched frequency doubled YAG laser
No of laser shots/180 ⁰	45-60	45-60
Energy	400-600 mW	0.8-1.4 mJ
Fluence (mJ/mm ²)	40,000	6
Spot Size	50 microns	400 microns
Duration of laser shot	0.1 seconds	3 nsec
Mechanism of Action	Mechanical	Biological
IOP Reduction	20-30%	20-30%
Repeatable?	No	Yes

Postoperative management

- Remove lens, rinse eye with saline
- One drop brimonidine or apraclonidine
- Check IOP 30 min-1 hour later
- Continue all glaucoma meds
- Rx postop drops
 - ALT: Prednisolone acetate QID x 1 week
 - SLT: Topical NSAID TID x 3-4 days

Postoperative management

- ALT works by mechanically altering TM structure
 - Prednisolone prevents excessive inflammation
- SLT works by activating macrophages to “clean up” TM
 - Controlled inflammatory response is needed for SLT
 - NSAID prn, may discourage if no ache

One week postoperative visit

- IOP check
 - No expected effect yet
- Check for iritis/inflammation
 - Expect minimal/no reaction
- Gonioscopy for peripheral anterior synechiae
- Discontinue anti-inflammatory drops
- Return 5-7 weeks for 6-8 week postop

Two month postoperative visit

- Evaluate IOP response
- If good response, treat other eye
 - Consider stopping/changing medications
- May see response in fellow eye due to systemic activation of macrophages

Repeat treatments

- Is SLT repeatable?
- Are repeat treatments as effective as the first?

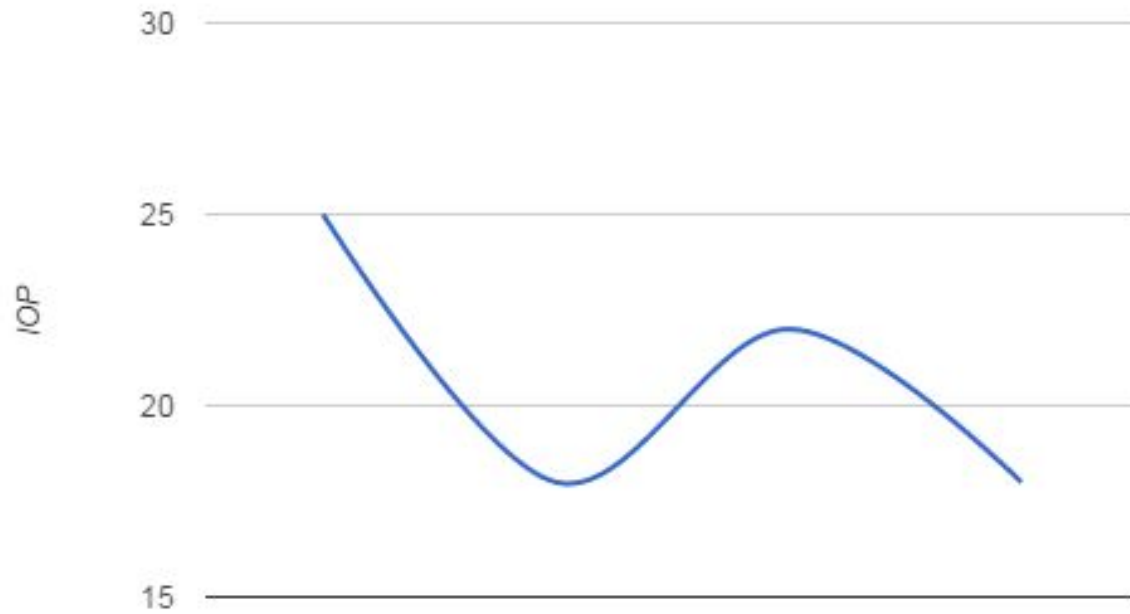
Repeat treatments

- SLT is widely considered to be repeatable
 - No mechanical damage to TM
 - Largely based on anecdotal evidence and small studies
 - Repeat treatments may be less effective and may not last as long
- ALT is not repeatable

Repeat treatments

- 2011 multicenter retrospective study
- 137 eyes
- 6 months to 8 years between first and second SLT
- First SLT
 - 20.3mmHg → 16.3mmHg
- Second SLT
 - 19.4mmHg → 16.3mmHg

Repeat treatments



Repeat treatments

Table 1 Summary of conducted studies regarding SLT repeatability.

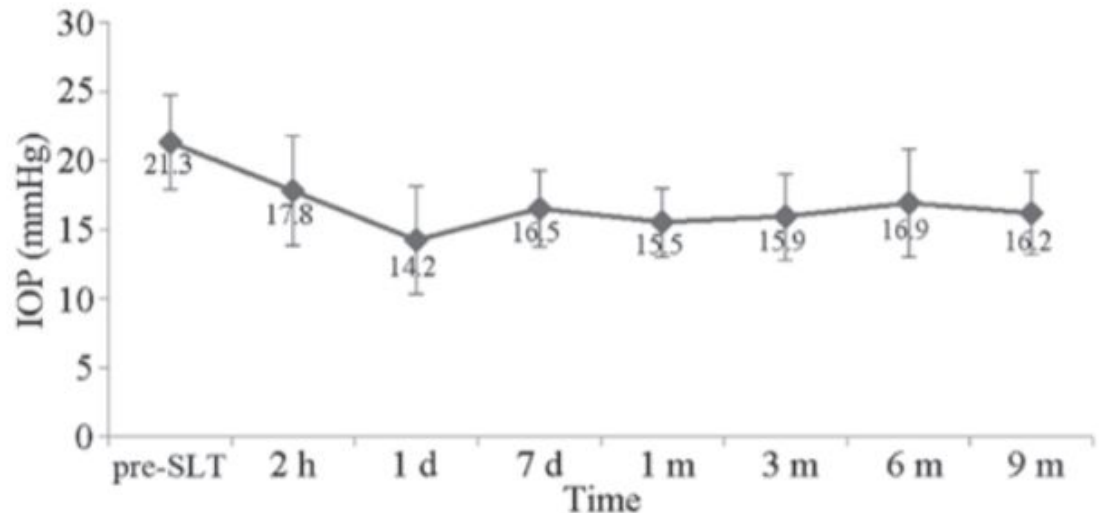
Paper	Year	Diagnosis	Number of eyes (n)	Number of patients (n)	Conclusion
Hong <i>et al.</i> (11)	2009	POAG, PXG and PG	44	35	The repeat 360° SLT performed 6 months after the successful initial 360 SLT may be safe and effective
Avery <i>et al.</i> (12)	2013	POAG	42	42	Similar efficacy was found in primary SLT and repeat SLT in treatment of POAG. Repeat SLT produces a longer effective duration
Khouri <i>et al.</i> (13)	2014	POAG, PXG and PG	51	34	Equal proportion of eyes responds successfully to repeat SLT regardless of the initial SLT effect was successful or modest
Ayala <i>et al.</i> (14)	2014	POAG and PXG	80	80	Repeat SLT on the same trabecular meshwork area has same effect as on two different areas
Khouri <i>et al.</i> (15)	2014	POAG, PXG and PG	45	25	Repeat SLT is effective in controlling IOP up to 2 years
Polat <i>et al.</i> (16)	2016	POAG, PXG and PG	38	38	IOP in open-angle glaucoma can be controlled with repeat SLT which achieves comparable result as successful initial SLT
Francis <i>et al.</i> (17)	2016	POAG, PXG, PG, OHT and JOAG	137	137	Both initial SLT and repeat SLT with 360-degree treatment lowers IOP similarly
Durr <i>et al.</i> (18)	2016	POAG, PXG and NTG	38	38	The second SLT resulted in similar IOP lowering effect as previous 360° SLT with possibly more sustained response

Complications

- IOP spike
 - Generally 24 hours or less
 - 5-25%
- Mild inflammatory response
 - 50% or more
 - Quiet by 1 week
 - Watch laser power setting
- Peripheral anterior synechiae
 - May be more common in ALT (promotes scarring)
 - 2015 meta-analysis: ~3%
- Cystoid macular edema (rare)

SLT following other surgeries

- SLT after failed trabeculectomy
 - AGIS: ~30% success rate
 - Higher risk of hyphema?
 - More recent studies suggest better success



SLT following other surgeries

- SLT after iridotomy
 - Recent studies support SLT if at least 180° open
 - 2018 study: 87% successful at 1 yr (20% reduction)
 - Often only do 180°
 - Heavy pigment in angle
 - PGA may be more effective

SLT and MIGS

- MIGS: Minimally/micro-invasive glaucoma surgery

SLT and MIGS

- SLT is likely safer
 - “I see SLT as something to do before the patient has to go to the operating room. I think SLT is the safest thing I do in glaucoma care...Many patients should have SLT first...If the patient ends up needing to go to the OR, adding a MIGS procedure might be sufficient.”
 - Robert Noecker, MD, Review of Ophthalmology 2014
- MIGS may be stronger
 - SLT enhances trabecular meshwork, MIGS bypass trabecular meshwork completely

SLT and MIGS

- MIGS procedures may be combined with cataract surgery
- 2013 study: SLT following failed Trabectome
 - All 14 SLTs failed

SLT Learning Curve

- Gonioscopy is best practice
- 2014 study compared SLT performed by attending physicians to those performed by first year ophthalmology residents (doing their first SLT)
 - 110 procedures
 - Supervised by an attending surgeon
 - Comparable results between residents' first SLT and attending surgeons
 - IOP reduction and safety profile

SLT Learning Curve

Acta Ophthalmologica

ACTA OPHTHALMOLOGICA 2019

**Evaluation of selective laser trabeculoplasty as an
intraocular pressure lowering option**

SLT Learning Curve

- Residents vs “less experienced specialists” vs “senior specialists”
- Residents = specialists
- Residents & specialists < senior specialists
- Senior specialists: More spots, more energy, more success
 - No mention of complications
- Conclusion: “The data would suggest that experience is not the deciding factor in terms of outcome and IOP reduction.”

SLT Learning Curve

- Conclusion: “The data would suggest that experience is not the deciding factor in terms of outcome and IOP reduction.”

SLT Pearls

- Clearing the view with a hazy cornea
- Accommodating prominent brows
- Patient perception of laser procedures

Micropulse laser trabeculoplasty (MLT)

- Delivers small, repetitive micropulses rather than one continuous pulse
 - Cooling periods between micropulses reduces tissue damage
 - Does not destroy pigmented cells
 - Less pain during and after procedure

Novel SLT approaches

- Annual low-power SLT for OHTN
 - 2014 ARVO paper
 - 0.4mJ; 40-50 spots over 360 degrees
 - Repeated yearly, regardless of IOP level
 - Followed 3-10 years
 - Mean treated IOP similar to traditional SLT
 - Fewer patients needed medications to control IOP vs traditional SLT

Novel SLT approaches

- Trans-scleral approach
 - 2014 ARVO paper
 - SLT applied to sclera overlying TM
 - IOP reduction equivalent to traditional SLT

Novel SLT approaches

- Direct SLT (DSLTL)
 - Automated device being investigated
 - 100 spots simultaneously
 - 1 second treatment time
 - No gonio lens

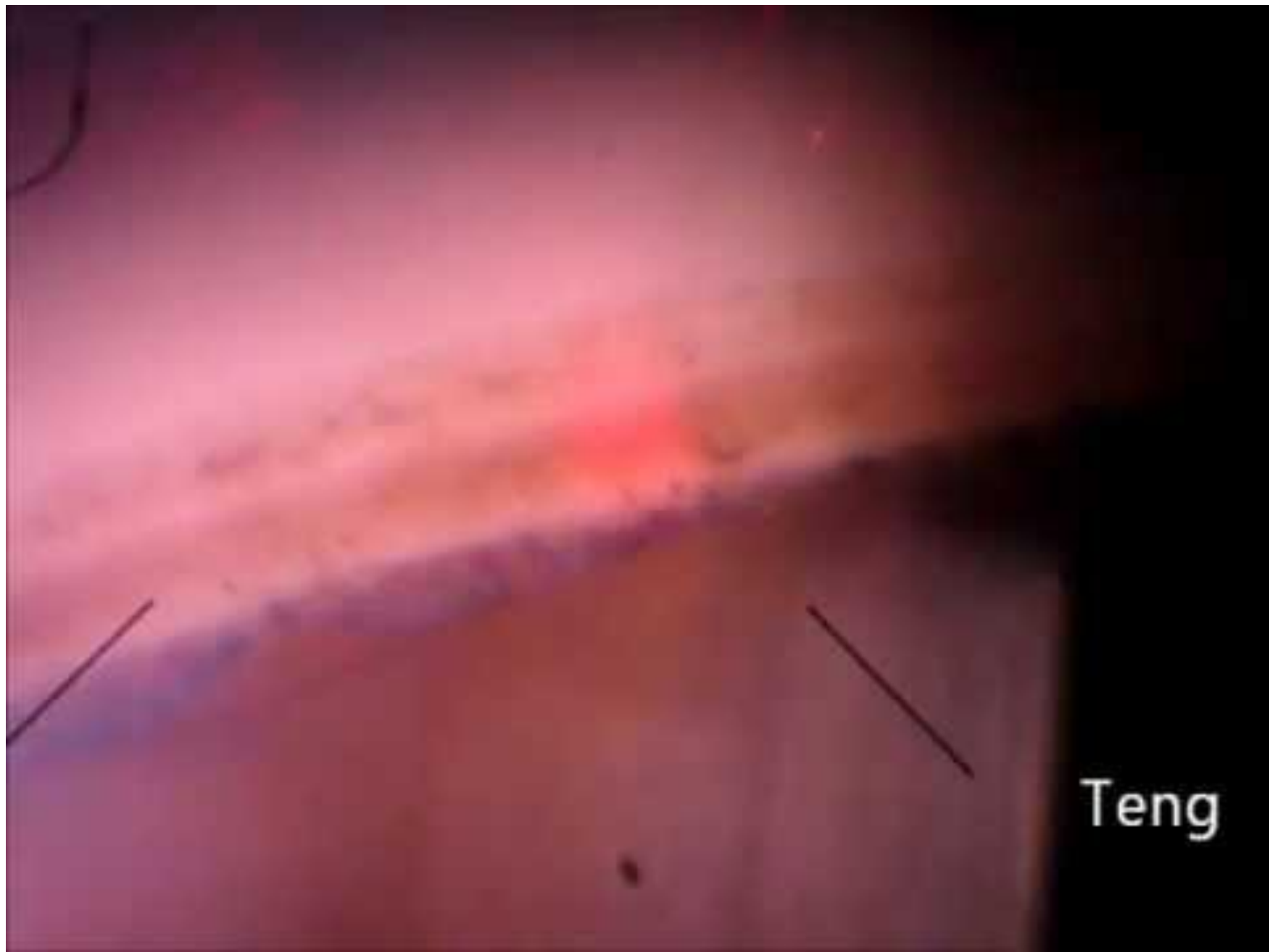
Pattern SLT (PSLT)

- Computer-guided treatment algorithm
- Spots are precisely placed without overlap or gaps
- 100um spot size; 3 rows

Reimbursement

- CPT 65855 (both SLT and ALT)
- \$276/eye in Washington (Medicare)
 - \$242 in facility
- 50% for second eye if same day
- 10 day global period

Video examples



Questions?

Thank you!

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