4. REFRACTIVE CATARACT SURGERY
WHAT IS A SUCCESSFUL REFRACTIVE CATARACT SURGERY?
What is a successful refractive cataract surgery?

- Uncomplicated surgery
- Increased freedom from correction for desired activities
- Patient has realistic expectations
  - Full discussion before surgery of the abilities and limits of chosen lenses
- Patient’s expectations are exceeded
Refactive cataract surgery: optometry’s role

• Put the patient’s best interests first
  • You earn their trust and long-term patronage
• Carefully assess each individual’s candidacy for premium IOLs
  • Ocular health
  • Goals
  • Personality and expectations
• Understand the options offered by constantly evolving technology
• Emphasize ocular health checks rather than vision exams post-op
  • Eye health becomes more critical w/premium IOLs
    • Dry eye
    • PCO
    • Retinal or ONH issues
• Younger cataract patient population
  • Increased likelihood of ocular health changes following cataract extraction
LIFE COULD BE WORSE, CALVIN.

LIFE COULD BE A LOT BETTER, TOO!
Case Report: I Want It All!

- 63 yo female, grocery store clerk
- H/o wearing multifocal SCLs
- Switched to monovision
- Once cataracts developed, her vision in contact lenses was no longer acceptable
- Currently in glasses, vision unacceptable
- Patient’s visual goals: “To be completely free from glasses and/or CLs for all activities - distance, intermediate, and near.”
Case Report: I Want It All!

• Phone conversation with receptionist prior to first appointment:

   “I only have a cataract in one eye, so I would like to have CE in one eye and LASIK in the other so that I have perfect vision in both eyes and don’t need to wear glasses. I have friends older than myself who have had cataract surgery. They have 20/14 vision and no longer require glasses.”
## Case Report: I Want It All!

<table>
<thead>
<tr>
<th></th>
<th>OD</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>scVA</td>
<td>20/40</td>
<td>20/40</td>
</tr>
<tr>
<td>ccVA</td>
<td>20/30</td>
<td>20/30</td>
</tr>
<tr>
<td>Glare</td>
<td>20/60</td>
<td>20/80</td>
</tr>
<tr>
<td>MR</td>
<td>+1.75 -1.25 x 082 20/30</td>
<td>+1.75 -1.00 x 073 20/30</td>
</tr>
<tr>
<td>Ocular health</td>
<td>2+ NS Otherwise unremarkable</td>
<td>2+ NS Otherwise unremarkable</td>
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</table>

**Recommendation?**
Case Report: I Want It All!

- **Initial impression/Plan**
  - Cataracts OU, cleared for CE
  - Planned monovision outcome with monofocal IOLs
However, upon further reflection....
This patient may be an excellent candidate for a mix-and-match situation

- Has worn multifocal SCLs in the past
- Has worn monovision in the past
- HIGHLY motivated
- Pt was called and offered EDOF (Symfony) OD, and MFIOL (Tecnis +3.25) OS
  - Distance vision will be similar
  - EDOF will provide better intermediate vision
  - MFIOL will provide better near vision
  - Pt has already shown success with monovision in the past
  - This lens combination may provide the greatest freedom from glasses
- Pt stated this sounds like what she would like
  - She understands the possible need for IOL exchange if she is unable to tolerate these lenses
Case Report:  I Want It All!

• Uncomplicated CE/IOL OD with Symfony EDOF IOL

• 1-day p-op:
  • scDVA: 20/25-1
  • scNVA: J3
  • IOL well-positioned

• 1-week p-op:
  • Pt disappointed that near vision isn’t better
  • scDVA: 20/25+2
  • scNVA: J4
  • Pt reassurance
Case Report: I Want It All!

- Uncomplicated CE/IOL OS with Tecnis MF IOL +3.25

- 1-day p-op:
  - Pt concerned DVA OS is not as clear as OD was first day
  - scDVA: 20/30-1
  - scNVA: J1
  - Reassurance given

- 1-week p-op:
  - scDVA: 20/25+1
  - scNVA: J1
  - Pt is thrilled with her vision at all distances!!
Case Report: I Want It All!

- 1-month EDOF OD, Tecnis +3.25 MFIOL OS
  - Pt reports that it’s been an adjustment to her new vision. Initially pt reports headaches and nausea. All of those symptoms have resolved. She feels her eyes are working together well. She notes mild halos/starbursting.

- scDVA: OD 20/25-2 OS 20/40 OU 20/25
- scNVA: OD J4 OD OS J1 OU J1

- Pt is able to perform all her daily activities without glasses and is thrilled.
Case Report: I Want It All!

• **Takeaways:**
  • Listen to your patient’s wishes
  • Counsel your patients appropriately
  • Carefully assess ocular health to ensure candidacy
  • We now have the technology to achieve better results than ever
  • We have many more options than 10 years ago
INTRAOCULAR LENSES
A brief history of IOLs

• First IOL implanted by Sir Harold Ridley on November 29th, 1949
• PMMA: polymethylmethacrylate
• He noted that WWII pilots with splinters of acrylic plastic from cockpit canopies lodged in their eyes did not have an inflammatory reaction
• Many challenges
• IOL implantation was almost universally condemned until the early 1980s

“It is dangerous to be right in matters on which the established authorities are wrong.” - Voltaire
Evolution of IOLs

- Anterior chamber lenses
- Iris-fixated lenses
- Second-generation anterior chamber lenses
- Finally posterior chamber lenses

1953: Strampelli
1953: Dannheim
1957: Binkhorst
1978: Worst’s Iris Claw
2nd generation ACIOL
# IOL Materials

<table>
<thead>
<tr>
<th>PMMA IOLs</th>
<th>Silicone IOLs</th>
<th>Acrylic IOLs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages:</strong></td>
<td><strong>Advantages:</strong></td>
<td><strong>Advantages:</strong></td>
</tr>
<tr>
<td>• Excellent optics</td>
<td>• Foldable (=smaller incision)</td>
<td>• Foldable (smaller incision)</td>
</tr>
<tr>
<td>• Does not pit with YAG</td>
<td>• Fewer dysphotopsias</td>
<td>• Holds up well against YAG laser</td>
</tr>
<tr>
<td>• Inexpensive</td>
<td></td>
<td>• High refractive index</td>
</tr>
<tr>
<td><strong>Disadvantages:</strong></td>
<td><strong>Disadvantages:</strong></td>
<td>• Decreased PCO (with truncated edge)</td>
</tr>
<tr>
<td>• Rigid; requires a large incision: 5.5-7.0mm</td>
<td>• Possibly slightly inflammatory</td>
<td>• Positive and negative dysphotopsias</td>
</tr>
<tr>
<td></td>
<td>• Slippery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Incompatible with silicone oil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pocks easily with YAG</td>
<td></td>
</tr>
</tbody>
</table>
Single-focus IOLs
The ideal candidates for single-focus IOLs:

- Patients who desire the sharpest vision possible at one distance
- Do not mind wearing glasses for other distances
- Have less than 1 D of corneal toricity
- Patients who are intolerant of reduced clarity, contrast, or halos
The risks of single-focus IOLs

• Do not provide “perfect” vision
  • ... although it’s often excellent!
• GASH
  • The square posterior edge decreases PCO formation, BUT can cause some reflections
    • Typically a crescent-shaped white line in the peripheral vision
    • Typically goes away after a few days to weeks
• Do not focus at multiple distances
  • Patients will be dependent upon glasses for many tasks
A brief word about spherical aberration...

- A higher-order aberration
  - Can reduce retinal image contrast, and affects visual quality

- The average cornea naturally has +0.27 to +0.30 SA

- Natural crystalline lens induces approx. -0.20 SA
Why is SA important in IOL selection?

- Post-hyperopic LVC can create a cornea with negative SA
- Some popular IOLs also have negative SA
  - If you combine an IOL with –SA and a cornea with –SA, the total negative SA can become large enough that it can decrease contrast sensitivity and even Snellen acuity
- In this situation, we consider a spherical rather than an aspheric IOL
Toric IOLs
Single-focus toric IOL
# Monofocal toric IOLs

<table>
<thead>
<tr>
<th>Model</th>
<th>Toric correction range</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAAR Toric (Staar Surgical)</td>
<td>1.2 – 2.4 D</td>
</tr>
<tr>
<td>AcrySof Toric (Alcon)</td>
<td>1.03 – 4.11 D</td>
</tr>
<tr>
<td>Trulign Toric (B&amp;L) (on Crystalens platform)</td>
<td>0.83 – 1.83 D</td>
</tr>
<tr>
<td>Tecnis Toric (Johnson &amp; Johnson)</td>
<td>1.03 – 4.11 D</td>
</tr>
</tbody>
</table>
Toric candidacy

• **Indicated for corneal curvature, not on refractive astigmatism**
  • That means: look at the AR ΔKs or corneal topography Ks

• **Beneficial for astigmatism >1.00D**

• **Limitation for astigmatism correction:**
  • Irregular corneal distortions (keratoconus, pterygium, etc.)
  • >4.00D astigmatism will result in residual astigmatic Rx
  • Much like glasses, higher astigmatic refractive error is more sensitive to small rotational changes

• **Great for detail-oriented patients**
Your role

• Look at corneal astigmatism
  • Patients with *regular* astigmatism between 1-4D are excellent candidates
  • Patients with >4D are still candidates: a toric IOL will significantly decrease residual astigmatism

• Assess your patient’s desire to have increased freedom from glasses
• Review the potential risks (next slide)
• And additional cost
Risks specific to toric IOLs

- **Incomplete correction of astigmatism**
  - Everybody heals differently. No guarantee of “zero” astigmatism even with toric IOL
  - Important to counsel patients carefully that they still may require a prescription

- **Rotation out of position**
  - Approx. 1-3% of the time, the toric IOL can rotate out of the desired position
  - If it rotates too much, it will cause symptomatic blur
  - This requires a second surgery to reposition the IOL
  - Typically occurs within the first week, and rarely occurs after repositioning

- **Capsular break at time of surgery may make a toric IOL impossible**
  - If surgeon cannot properly position toric lens, will convert to a standard IOL

- **Extra cost**
  - Almost never covered by insurance
Your role: post-op

• 1-day:
  • Uncorrected vision, auto-refraction
  • The refraction can be quite variable at this visit
  • If pupil is still adequately dilated – check IOL markings

• 1-week:
  • Uncorrected vision, auto or manifest refraction
  • Dilate the pupil at this visit to confirm correct IOL position
  • If IOL rotation has occurred, refer back to surgery center ASAP!
  • It is easiest to correct malposition if addressed promptly

• 1-month:
  • Uncorrected vision, manifest refraction
  • No DFE required unless symptoms warrant
Presbyopia correction
Higher demands

• In 2004, the average age at cataract surgery was 74 years old.
• Now, the average age of cataract surgery patient is 67 years old.

• In 2011, only 35% of Americans owned smartphones
• Now, 81% of Americans do
  - 50-64 years old: 79% have smartphones
  - 65+ years old: 53% have smartphones
- Monovision

- Presbyopia-correcting IOLs
  - *Refractive MFIOLs* (ReZoom, Array)
  - *Diffractive MFIOLs*
    - Bifocal (Tecnis, ReSTOR)
    - Trifocal (PanOptix)
  - *Accommodating IOLs* (Crystalens)
  - *Extended depth-of-focus (EDOF) IOL* (Symfony)
Monovision

(not necessarily a premium lens)
Monovision

• Allows good clarity at two different distances
  • Dominant eye is typically set for distance
  • Non-dominant eye is typically set for intermediate or near, depending upon the patient’s visual needs
• Can be achieved with standard, toric, or even EDOF/MF IOLs
• Affordable, if done with standard IOLs
• Ideal in patients with:
  • Natural monovision
  • Successful monovision in CLs prior to cataract development
Your role:

- Assess your patients’ candidacy for permanent monovision
- Discuss this option with your patient prior to referral
- Advise the surgical center if your patient desires monovision
  - Dominant eye
  - Desired refractive outcome for each eye
Risks of monovision

• Decreased depth perception
  • Fall risk

• Inability to adapt
  • Patients must trial monovision prior to surgery!

• May have inadequate intermediate or near vision, depending on the near eye focal point
  • Complete loss of accommodation can lead to some loss of function

• May still need to wear glasses for some tasks
  • Driving, especially in unfamiliar areas, in the dark, in the rain
  • Intermediate tasks, if IOLs not set for this range
  • Extended near tasks, if the reading eye becomes fatigued
Identifying the ideal multifocal candidate
Excellent candidates: personality

• Keenly interested in glasses independence for most distance and near tasks
• Easy-going personality; positive attitude
• Willing to accept a small compromise in distance acuity
• Willing to accept a small compromise in contrast sensitivity
• Willing to understand that it is not a procedure with a guaranteed outcome
Poor candidates: personality

• Do not mind wearing glasses
• Critical patient with unrealistic expectations
• Interested in the sharpest, clearest vision possible
• Heavy dependence on night vision, or specific night-time job requirements
  • Commercial pilots
  • Truck drivers
  • Military and security
The OCEAN personality traits

- One way of classifying personalities
- Patients with conscientiousness and agreeableness as dominant personality traits demonstrated the highest satisfaction with MF IOLs
- Patients with neuroticism as the dominant personality trait were least happy with MF IOLs
- It is not necessary to conduct a formal personality test!

Excellent candidates: refractive

- High hyperopes
- High myopes
- Successful use of multifocal CLs in the past

- Candidates must have:
  - Bilateral cataracts, because binocular summation is important
  - Pristine ocular health
Potential candidates: refractive

- Low myopes
  - But high risk of being less satisfied with loss of excellent near vision
- S/p laser vision correction
- Monocular cataracts
- Emerging presbyopes

- Educate!
- Educate!
- Educate!
Conversation with your patient

- The most important component of success is pre-operative counselling
- “No lens is perfect.”
  - Personality assessment estimates ability to neuroadapt
    - Compulsive checking
    - Orderliness
    - Competence
    - Dutifulness
  - Assess expectations
- Unrealistic expectations + critical personality = not a good candidate!

- Evaluation of patient’s needs, lifestyle, and personality.
  - Work, hobbies give ideas of types of visual tasks patient performs
- Primary optometrist has an edge over surgery clinic due to established relationship
Multifocals & ocular health issues

Considerations:
• Corneal astigmatism over 0.75 D will need toric IOL or limbal relaxing incisions
• Ocular Surface Disease
  • Restasis or Xiidra 3 treatment improves MFIOL outcomes
• Prior laser vision correction
• Pupil size

Absolute contraindications:
• Irregular corneas
  • ABMD, keratoconus, corneal scars
• Macular or optic nerve pathology
  • ERM, ARMD, diabetic retinopathy, glaucoma
• Amblyopia
Your role:

• Assess your patients’ candidacy for EDOF/MF IOL
  • Including personality!
• Careful examination to r/o potential contraindications
• Communicate your patients’ desires to surgical center
• Don’t exclude these improved technologies as potential options for your patients!
Our role: clinical exam

• Careful and complete exam
• Pentacam
  • Assessing both anterior and posterior astigmatism
  • Looking for sub-clinical pathology
• Higher-order corneal aberrations
• Angle kappa
• Macular OCT
• Accurate biometry
• Appropriate IOL selection

Angle kappa: the difference between the pupillary center and the visual axis
Our role: even more counselling

- The most important component of success is pre-operative counselling
- Underpromise and overdeliver
  - Discuss the potential for unwanted effects while still keeping the benefits in mind
- Discuss individual aspects of each patient’s eyes that may make their outcome less than ideal
- Can he/she accept halos/starbursting around points of light?
  - These improve with time and neuroadaptation, but will be permanent to some degree
- Will the patient accept a mild decrease in sharpness as trade-off for decreased dependence on glasses?
- Can the patient accept a slight decrease in contrast sensitivity?
- Will the patient accept the potential need for glasses for some tasks?
“A patient who has received a perfect surgical result with a multifocal IOL still has the potential to be dissatisfied with the outcome if he or she was not properly selected for temperament and counseled regarding possible optical aberrations, enhancements, and neuroadaption.”

Presbyopia-correcting IOLs:

1. Accommodating
2. Refractive
3. Diffractive
4. Extended depth-of-focus
1. Accommodating IOL

- I.e. the B&L Crystalens
- A monofocal lens with wide, hinged haptics
- Ciliary body contraction purportedly moves the IOL
- In theory should give real accommodation
- Less glare/halos
- But limited near power
- Tends to get even more limited with time
2. Refractive multifocal IOLs

- E.g. AMO ReZoom and Array
- Concentric zones of increasing refractive power on the anterior lens surface, with highest power in the center of the lens
- Highly dependent on pupil size
  - Changes in pupil diameter affect the number of zones in use
  - As pupil decreases in size (e.g. with the near reflex,) the effective power of the lens is increased
3. Diffractive multifocal IOLs

- E.g. Tecnis family, ReSTOR family, and PanOptix
  - Concentric *diffractive* surfaces on the posterior surface of the lens
  - Stray light less than refractive IOLs, though still significant
  - Fun fact: diffraction depends on quantum mechanics for its effect

- Both refractive and diffractive designs create an in-focus image that is overlaid by at least one out-of-focus image. This degrades contrast and creates halos and glare.
Tecnis multifocal IOLs

- Acrylic IOLs
- Anterior aspheric surface
- Posterior diffractive surface
- Add powers: +2.75, +3.25, +4.00
Tecnis multifocal IOLs

- Full diffractive optic
- Splits the light between distance and near foci
Alcon PanOptix

- Acrylic IOL
- Posterior diffractive surface
- Not dependent on pupil size
- Focal points at infinity, 60cm (24”), and 40cm (16”)
- The first and only trifocal IOL available in the U.S.
PanOptix: how it works

- Essentially two bifocal structures (a “quadrifocal”) are combined

- The extended intermediate focal point (120cm) is redistributed to the distance focal point for amplified performance

- The second order waves of each bifocal interfere with each other to give an intermediate focal point
PanOptix defocus curve
PanOptix

- PanOptix showed continuous range of vision from 0 to -3.00 D of range
  - Compared to the Symfony: 0 to -1.75D
- PanOptix has 88% utilization of light energy (instead of 82% with older diffractive bifocals) and low dependence on pupil size
- In studies comparing the PanOptix to the Symfony:
  - Similar rates of 20/20 or better for distance and intermediate
  - As expected, the Symfony was inferior for UNVA
  - There may be even less halos and glare with PanOptix than Symfony, though the Symfony IOL may still be better at preserving contrast sensitivity
PanOptix toric

• All the same properties as PanOptix IOL, on a toric platform

• Maximum toric correction: 2.60 D
PanOptix concerns

- Glare
- Contrast sensitivity
- Glistenings
- Chromatic aberration
4. Extended depth-of-focus IOL

• I.e. the Symfony
• An extended continuous focal point (instead of two or three peaks of focus with bifocal or trifocal IOLs)
• Reduces overlap of near and far images
• EDOF IOL has similar photopic contrast sensitivity to monofocal IOL, and much better than the diffractive-refractive multifocal lenses
• Near visual acuity with EDOF IOL is worse than with diffractive IOLs, but intermediate visual acuity is equal or superior
**J&J Tecnis Symfony IOL**

- Aspheric acrylic IOL
- Anterior aspheric surface
- Posterior achromatic diffractive surface
  - Reduces chromatic aberration
  - “Echelettes” designed to extend the range of vision
Symfony

- Two complementary technologies
  - Diffractive achromatic technology
    - Reduces overall chromatic aberration
    - Enhances contrast sensitivity
    - Improves retinal image quality
  - Echelette design
    - This produces light refraction that elongates the focus in the eye
    - Increased depth of field
    - Patients receive a full range of continuous vision while maintaining high image contrast
- The lens uses all of the incoming light to produce a continuous range of vision, rather than dividing it into two or three foci
Symfony defocus curve

![Defocus Curve: 3-Month Adjusted Data Bilaterally Implanted Subjects](image)
What to expect with Symfony

- **scDVA**: 20/20 – 20/30
- **scNVA**: J2-J3
  - Often better with binocular summation
  - Consider a -0.50 target on non-dominant eye
- **Patients will often notice mild blur distance and near after first surgery**
- **This is often significantly improved after second surgery**
- **Difficulty with very near tasks/very fine print**
  - Patients will often need +1.25 readers for these activities – this is normal and expected!
  - Targeting the non-dominant eye for -0.50 myopia may help improve near vision without significantly sacrificing distance
- **Halos/starbursts at night**
Symfony Toric

- All the same properties as Symfony IOL, on a toric platform
- Maximum toric correction: 2.60 D (like the PanOptix)
Post-op care
Your role: post-op

- Check vision at both distance and near at all visits
- Any concerns re: refractive error: perform a careful manifest
  - Push the plus!
- Assess for good centration of optics within the pupil
- Pt reassurance
  - Glare, halos, reflections, blur...all improve with time and neuroadaptation
  - Consider a brimonidine trial for its miotic effect
  - If no resolution at 6 months, consider IOL exchange
- Contact the surgery center with questions or concerns
Tips for success

• **Day 1:** vision can vary widely, even up to 20/80
  • Reassurance and encouragement
• **After the first surgery:** my vision is still blurry (distance, near, or both)
  • It will get better once the second surgery is done
  • And as the eye heals
• **Before the second surgery:**
  • If vision at one distance is good, but less acceptable at the other distance, the second IOL power can be adjusted to give a broader range of focus
• **Ask your patient:** “Tell me what visual tasks you’ve been doing. Have you needed your glasses?”
  • This will often highlight that the patient is more “glasses-independent” than they were prior to surgery
Best way to avoid post-operative issues with premium lenses?

• Careful patient selection prior to surgery
Residual refractive error

• May be addressed with Laser Vision Correction
  • Allow for topography to stabilize post-operatively
• In cases where residual astigmatism is caused by a rotation of toric MFIOl from the desired axis, IOL rotation may be done
  • Best to do this within the first few weeks
• Lens exchange if patient is not a good candidate for LVC
Reduced contrast sensitivity

• The only approach is pre-operative counselling, and ruling out any conditions that reduce contrast prior to surgery
PCO

- Want to make sure a lens exchange will not be needed prior to considering YAG capsulotomy
- Open posterior capsule makes exchange more difficult
Nighttime dysphotopsia

- One of the most common concerns reported by patients with MF IOLs
- Dysphotopsia is a visual disturbance that includes subjective light phenomena in vision, such as halos, starbursts, etc.
- It even occurs with monofocal intraocular lens implantation, but is more prevalent with premium lens designs.
- Due to the fact that MF IOLs divide incident light into multiple focal points, patient’s brain must adjust to be able to process several images simultaneously. The process is called neuroadaptation and it can take time and cause frustration. It is important patients understand that adaptation continues long after the eye heals.
Neuroplasticity is the ability of the brain to reorganize its function and structure in response to environmental changes.

Functional magnetic resonance imaging (fMRI) shows:
- increased activity of cortical areas dedicated to visual attention, effortful action, cognitive control and goal-oriented behavior soon after MF IOL implantation
- a correlation between level of dysphotopsia symptoms and level of activity in the top-down attentional network in the parietal and frontal lobes
- that when fMRI is repeated 6 months after MF IOL implantation, the regions of the brain associated with attentional network and effort are less activated, correlating with improved dysphotopsia symptoms
- No measurable difference in the optical parameters over the same time period; neuroadaptation is the only explanation for such changes.
Neuroadaptation plays an important role in MFIOL outcomes, especially positive dysphotopsia.

- 4-12% of cases in which bothersome glare, halos, starbursts are present lead to IOL explantation.

When bothersome dysphotopsia are present after surgery

- Offer reassurance and encouragement and allow for neuroadaptation to occur
- If still bothersome 3-4 months after surgery, and quality of life is affected, lens exchange for a monofocal implant should be considered.
- Exchanging the intraocular lens involves additional risks to the patient. It is best to do the lens exchange within the first 6 months.

Better understanding of neuroadaptive mechanisms in the future may help manage dysphotopsia and improve MFIOL outcomes, resulting in a lower rate of IOL explantations.
Light Adjustable Lenses
Light-adjustable lens

- RxSight (formerly Calhoun Vision)
- Available in Europe & Mexico since 2008
- FDA approved: Nov 2017
- Photo-reactive silicone
- Proprietary “Light Delivery Device”
  - 2 steps: (1) adjusts and then (2) “locks in” the preferred Rx
- Goal: LASIK-like results
LAL difficulties

• **Difficulties:**
  • Small pupil size; need to be able to visualize full 6mm diameter for proper treatment; requires 6.5-7.00mm pupil
  • Potential “dilation fatigue” with each process
  • Erythropsia and other color vision abnormalities
  • Faulty lenses and UV filter devices

• **Not yet available**
The parts

- Proprietary “Light Delivery Device” (LDD)- 365nm-382nm
- Approved for:
  - ±2D of sphere
  - 0.75-2D of astigmatism
Background

• N=390 eyes
  • Control: 195 eyes had monofocal lenses
• RxLAL group aimed for hyperopia (+0.50D to +0.75D)
• First adjustment @3 week post-op
  • On average, 1.65 adjustments were needed
  • Following adjustments:
    • 97% achieved 20/40 or better
    • 91.6% achieved 20/25 or better
  • Following toric adjustments:
    • 82% had <0.50D residual cyl
    • 98.5% had <1.00D residual cyl
    • Zero lens rotations
• After 1 year:
  • One RxLAL eye and four control eyes had decreased BCVA by ≥2 lines
The adjustment: 3 weeks post-op

• 1-2 minutes post-op treatment, using slit lamp delivery
• Uses a contact lens to focus treatment
  • Followed by 3 days of settling
• Macromers are attracted to the light and form polymers in targeted areas
• Hyperopic surprise: concentrate treatment centrally to thicken central lens
• Myopic surprise: concentrate UV light on periphery to flatten the central lens
• Lock-in the lens by shining the diffuse UV light over the entire lens
• UV protection need up until lock-in is complete
• Additional adjustments can be done every 4-5 days if needed
Adding power to the LAL

- Adjustment Beam
- Photopolymerization
- Diffusion and Power Change
- Lock-In Beam
- Final Result

Light from the RxSight LDD is directed by the surgeon to the RxLAL.
Macromers in the path of the light are photopolymerized.
Unpolymerized macromers move into the exposed area, causing precise shape and power change.
The entire lens is exposed to light to polymerize all the remaining macromers.
The outcome is a precise change in the RxLAL power to match the patient's individual prescription.
Adding power to the LAL
Subtracting power from the LAL
Potential road blocks

- **Pupil size limitations for light adjustments**
  - Whole 6mm should be seen to properly treat polymers
  - Previous study had 2 mandatory “lock-ins” for these cases
- **Dilation Fatigue: tendency for pupils to dilate less with each adjustment**
  - More dilation drops needed
  - Macular burn
  - Result of changing the UV filter supplier for the LDD
  - Acute vision loss to 20/150, but recovered to 20/22
- **Erythropsia (red-tinted vision) and other color vision disruptions**
  - 49% following adjustment
  - 17% following lock-in
  - 0.5% following 6 month f/u
  - 1.8% developed tritan (blue-green) anomaly, prior to establishing UV filter safety specs
  - Five resolved after adjustments, two persisted (one was due to filter issue)
LAL complications

• 1.7% need for secondary surgical intervention
  • Explantation due to faulty filter
  • Explantation due to LAL optic blemish/scratch
  • Explantation due to pt requesting exchange prior to first light adjustment
  • Two incidences of lysing of iris adhesions to treat synechiae limiting pupil dilation
  • Single Descemet’s stripping endothelial keratoplasty due to corneal edema caused by implantation problems
  • Barrier laser tx for PVD heme or horseshoe retinal tear
Advantages of LAL

- Post-op trialing of optimized monovision
- Minimize refractive surprise for s/p LVC pts (off-label use)
- First step toward femtosecond laser adjustable lenses, AKA Refractive Index Shaping (RIS).
LASER-ASSISTED CATARACT SURGERY
PCLI LACS experience

- FDA approved in late 2015
- Lasik flaps, intrastromal pockets, FLACS and corneal transplants
- Acquired shortly after FDA approval
- Performed approximately 60 FLACS cases
- Do believe this technology has something to offer
Initial PCLI LACS experience

- 8 patients, 15 eyes in 2014
- 14 eyes with uneventful surgery and results
- More corneal edema post op day 1
- Wounds more leaky
- Phaco times longer due to concern about capsule edge
- 1 patient with incomplete rhexis and incisions
- Resulted in radialization and posterior capsule tear
- We were not convinced of increased safety and quality for patients
LACS: how does it work?

- Approved in USA for cataract surgery in 2010.
- Femtosecond laser energy is absorbed by tissue and this results in plasma formation.
- The expansion of the plasma creates cavitation bubbles which separate clear ocular tissues.
- Currently used for LASIK, corneal inlays, SMILE, PK, lamellar keratoplasty, and cataract surgery.
LACS: what does it do?

1. Main and port incisions
2. Limbal relaxing incisions
3. Capsulorhexis
4. Nuclear pre-fragmentation
What does LACS deliver?

- Harmer to account for differences in corneal pachymetry
- OCT guided to exact depth
- Titrate effect by opening incision later

Manual LRI vs Femto LRI
LACS: how does it work?

Thousands of laser pulses are connected together in a raster pattern to define a resection plane.

A resection plane is created.
GOOD SURGEON → BETTER
EXCELLENT SURGEON → SLOWER
Low pulse energy, high repetition rate with overlapping pulses
Femtosecond laser comparison

<table>
<thead>
<tr>
<th>Victus</th>
<th>LenSx</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENSAR</td>
<td>Z8</td>
</tr>
<tr>
<td>Catalys</td>
<td></td>
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</tbody>
</table>

Relative floor sizes

Moving the Z8
## Femtosecond laser comparison

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Z8</th>
<th>Catalys</th>
<th>LenSx</th>
<th>LENSAR</th>
<th>Victus</th>
<th>VisuMax</th>
<th>IntraLase</th>
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<td>×</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>×</td>
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<tr>
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<td>×</td>
<td>×</td>
<td>×</td>
<td>✓</td>
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<tr>
<td>Pockets</td>
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<td>×</td>
<td>×</td>
<td>×</td>
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<tr>
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<td>×</td>
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<td>×</td>
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<tr>
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<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
Z8 advantages

- Lower pulse energy and higher frequency allows laser application overlap for a smooth and more precise cut
- Lower energy causes less miosis
- The articulating laser head allows the patient to remain in the same room for all steps of the procedure
Does LACS Pass the MOM TEST?
Potential cases that could benefit from LACS

- Patients with endothelial compromise (Fuchs’, corneal transplants)
- Low astigmatism patients
- Posterior polar cataracts
- Premium IOL patients
- Weak zonules
- Hyperopic patients with shallow anterior chambers
- Hypermature or intumescent cataracts?
Capsulorhexis comparison
Capsulotomies comparison

Manual

Z8  Catalys  Victus  LenSx
Capsulorhexis circularity
Zepto Precision Pulse
LRI comparison

Limbal Relaxing Incision
Nuclear disassembly

Cube Pattern

Pie Segment Pattern
Reasons *not* to adopt LACS

- We are doing just fine with conventional cataract surgery.
- It slows the OR down.
- Most patients are not asking for it.
- Most patients are not willing to pay for it.
- Very few referring doctors are asking us to do it.
- It is costly.
Is LACS better?

• 14,567 Eyes
• Evaluated phaco time, post-op corneal thickness, endothelial cell reduction, and capsulotomy circularity
• Authors concluded that there is no significant difference between LACS and manual cataract surgery in terms of visual outcomes and overall complications.
• The incidence of posterior capsule tears are higher with LACS

Reasons *to* adopt LACS

- Some patients and referring doctors prefer LACS
- LACS is commonly marketed as “bladeless cataract surgery” and this appeals to some patients
- Able to produce very precise incisions, perfectly round and centered capsulorhexis and manage low degrees of cylinder (under 1.5D)
- Due to the predictability of the capsulorhexis the effective lens position and centration may be improved
“Full adoption of new technologies takes decades.”
During the early stages many doctors “move in and out of the technology until it is refined and its benefits are fully appreciated.”
“A period of irrational exuberance for a new technology is often followed by a period of equally irrational disillusionment that evolves into either abandonment or rational adoption of the technology.”
“I do not see FLACS being abandoned.”
“The next stage to me will be rational adoption.”
LACS insurance issues

- LACS is a non-covered service
- Medicare allows patient to pay out of pocket for LACS if it is being performed for refractive purposes (astigmatism management) and (advanced imaging)
- Most commercial insurers follow Medicare guidelines
Is LACS gentler on the eye?

• 4903 eyes (2,861 LACS versus 2,072 Manual)
• Significant differences in mean absolute refractive error, EPT, phacoemulsification power and circularity of the rhesis
• Authors conclude that LACS is a safer and more effective method for reducing endothelial cell loss and post-op central corneal thickening as well as achieving better and faster visual recovery and refractive outcomes

Is LACS better on dense cataracts?

<table>
<thead>
<tr>
<th>Examination</th>
<th>Mean Endothelial Cell Loss (% ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Femtosecond Group</td>
</tr>
<tr>
<td>1 day</td>
<td>17.18 ± 16.28</td>
</tr>
<tr>
<td>1 week</td>
<td>13.10 ± 13.13</td>
</tr>
<tr>
<td>1 month</td>
<td>11.42 ± 12.10</td>
</tr>
<tr>
<td>3 months</td>
<td>7.85 ± 8.59</td>
</tr>
</tbody>
</table>

Does LACS position IOLs more precisely?

Is LACS better for MF IOLs?

- 23 eyes with LACS versus 22 eyes with conventional phaco
- LACS group received arcuate keratotomies for corneal astigmatism greater than 0.75 diopters
- Ocular aberrometry measured and patients completed a satisfaction survey at 1 month post-op
- Less HOAs (0.41 v. 0.76) and tilt (0.44 v. 0.77) with LACS
- Only a small and retrospective study

LACS conclusions

• Laser-Assisted Cataract Surgery can be particularly helpful in...
  • Low astigmatism patients
  • Patients with specialty IOLs
  • Patients with compromised endothelium
  • Dense cataracts
  • Posterior polar cataracts
  • Weak zonules
  • Possibly in hypermature/intumescent cataracts

• Femtosecond laser applications in ophthalmic surgery will likely expand
Refractive cataract surgery conclusions

• Patients have higher visual demands and higher expectations than ever before
• Lens technology has improved dramatically over the last decade
• We are exquisitely positioned to help guide our patients towards an optimal visual outcome
• Discussing ALL lens options with your patients strengthens your relationship with them before and after surgery
• Don’t be afraid to discuss premium lens options to appropriate candidates
IF YOU REMEMBER NOTHING ELSE ...

1. Find out if your patient wants any degree of independence from glasses.

2. Find out if they are willing to make some financial and visual compromises to gain this.

3. Determine if they have any history of monovision.

4. Tell the surgery center as much as you can.