What’s new in IOL technology?

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Financial Disclosure

I have a financial interest with the following companies:

- Abbott Medical Optics
- Alcon
- Calhoun Vision
- Carl Zeiss Meditec
- NuLens
- Optomedica
- Ziemer

Shockingly little

Why????

Many reasons

- Excellent results with current technology
- FDA and costs of introducing new technology (> $10 million)
- Few if any breakthroughs in the key area: Accommodative IOLS

Current IOLs are great...But do we have the ideal IOL?

- Not even close...

- Problems include:
  - Unwanted visual symptoms
  - Inability to adjust power
  - No decent accommodating IOLs
  - PCO
  - Etc.!
So what do we have now?

- Monofocal
- Multifocal
- Accommodating
- Toric monofocal

Monofocal: Silicone 3-piece IOLs

- Advantages:
  - No cosmetic reflection
  - Little if any dysphotopsia
- Disadvantages:
  - A bit harder to insert
  - Require ≥ 2.8 mm incision
  - Occasional early fibrotic PCO
  - ? Not as accurate for IOL power

Monofocal: Hydrophilic acrylic IOLs

- Advantages:
  - No cosmetic reflection
  - Little if any dysphotopsia
  - Fairly easy to insert
- Disadvantages:
  - Increased PCO
  - Can become tilted with XS capsular forces
  - Reports of surface opacification (calcium)

Monofocal: Hydrophobic acrylic IOLs

- Advantages (one-piece):
  - Easy to insert
  - Excellent biocompatibility
  - Tight accuracy for IOL calcs
- Disadvantages:
  - Negative dysphotopsia
  - Cosmetic: reflection with higher refractive index
Anything new?

- Incisions smaller with better cartridges and injectors
- Preloaded injectors
- But no new materials or designs

Multifocal IOLs

- Refractive: Rezoom
  - Issues: Poor near and severe halos

Multifocal IOLs: How much better can they get?

Categories

- Diffractive
- Refractive

Diffractive designs

- Multiple designs

New refractive model: Lentis Mplus (Oculentis, Netherlands)

- Hydrophobic acrylic
- Aspheric
- 3.0 and 1.5 D add models
Potential advantages

- Distance: Upper ½ and small center
- Light in transition zones refracted away from fovea

Accommodating IOLs: Will complete success require a huge technology leap?

How do we harness this movement in the pseudophakic eye?

- Change in optic:
  - Position
  - Curvature
  - Power
- Or combinations of these
Where do we harness this movement?
- Capsular bag
- Ciliary sulcus

Do we even try to harness this movement?
- Use other accommodative changes:
  - Pupillary constriction
  - Convergence

Accommodative
- Crystalens: Hmm. . .not really
  - Increased depth of focus maybe.

Crystalens vs. SN60WF

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Crystalens HD (n=9)</th>
<th>SN60WF (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCDVA</td>
<td>20/20 (LogMAR 0.00 ± 0.08) (4.12 to 5.85)</td>
<td>20/20 (LogMAR 0.02 ± 0.07) (4.12 to 5.78)</td>
</tr>
<tr>
<td>DCNVA (@40cm)</td>
<td>25 – 36 (LogMAR 0.24 ± 0.25 (0.27 to 0.82))</td>
<td>36 (LogMAR 0.25 ± 0.27) (5.10 to 5.85)</td>
</tr>
<tr>
<td>AA (in D)</td>
<td>1.76 ± 0.82 (1.0 ± 1.34 D)</td>
<td>*1.58 ± 0.80 (1.03 ± 1.93 D)</td>
</tr>
<tr>
<td>Pupil (mm)</td>
<td>2.97 ± 0.52 (2.10 ± 1.02)</td>
<td>*2.75 ± 0.61 (2.25 ± 1.02 mm)</td>
</tr>
</tbody>
</table>

*In SN60WF eyes, AA negatively correlated with pupil size (r= -0.84, p<0.05); Smaller pupil size strongly correlated with increased AA.

Single optic: Crystalens & Tetraflex
How do they work?
- **Mechanism**
  - Optic moves?
  - Optic changes shape?
  - “Accommodative arching”

Anything new?
- Several designs in clinical trials
  - Bag fixated
  - Sulcus fixated
  - IOL flexes
  - IOL moves
  - Electro-optical design
- Will they reach USA in next 5 years???
Dual-optic design: Synchrony
- Two optics connected by haptics with a spring function
- Anterior optic: +32 D
- Posterior optic: minus power individualized

Objective Testing
- All 5 eyes showed dynamic UBM movement and iTrace refraction change

- Mechanism
  - Optic moves
  - Optic changes shape?

NuLens – Neuroadaptive model
- Mechanism
  - Optic moves
  - Optic changes shape

Implantation of Synchrony

Dual-optic: AkkoLens
- Sulcus implantation
- Cl
- Optic changes power
- Mechanism
  - Optic moves
  - Optic changes power

Optic designs: Dynamic optic FluidVision Design (PowerVision)
- Mechanism
  - Optic expands
  - Optic changes shape

2.97 D
3.22 D
2.97 D
2.94 D
2.76 D
Subjective Accommodation (Push Down)
**Elenza Lens: Mechanism of Action**

- On-board Photosensors (10-50 μ)

**Mechanism**

- Optic changes power
  - Independent of movement of ciliary body and capsule

**New accommodative IOLs**

- Not easy!!
  - Wide-open field
- Lots of interrelated questions:
  - How
  - Where
  - What material

**Major hurdles**

- Bag: Need to preserve capsular flexibility
- Sulcus: Need to prove long-term biocompatibility
- Electro-optical: Component safety and durability

**Why are multifocal/accommodating volumes flat?**

- Surgeon lack of confidence in outcomes
  - Multifocal:
    - Quality of vision
    - Patient complaints
  - Accommodating
    - Unpredictable accommodative range
Why are multifocal/accommodating volumes flat?
- Lack of toric models
- Growth of monovision
  - Aided by torics

Toric IOLs are growing
- Cannibalized the premium IOL market
- Offer the opportunity to upcharge with a high likelihood of high patient satisfaction
- The toric IOL is less expensive than presbyopia-correcting IOLs

Toric IOLs are growing
- And likely to expand . . . somewhat
  - New surgeons
    - But it is likely that primarily low-volume surgeons are not currently using them
  - New models
    - Especially toric multifocal and accommodative

Toric
- Truly new:
  - Increased range of powers
  - Devices to aid alignment
    - ORA
    - SM1
    - Tracy

Anything else new?
- Puzzling cases . . .

Patient #1
- Pre-op evaluation for cataract surgery in 41 year-old female
- Left eye
  - UCVA: 20/40
  - MR: -0.50 + 2.00 x 180 = 20/40
  - Retinoscopic refraction: -1.50 + 1.50 x 180
OS: Atlas SimK astigmatism: 1.24 D@80°

OS: Corneal astigmatism

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<tr>
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<tbody>
<tr>
<td>Atlas SimK</td>
<td>1.24 D @ 80°</td>
</tr>
<tr>
<td>Galilei SimK</td>
<td>1.35 D @ 88°</td>
</tr>
<tr>
<td>IOLMaster K</td>
<td>1.23 D @ 92°</td>
</tr>
<tr>
<td>Lenstar K</td>
<td>1.13 D @ 93°</td>
</tr>
<tr>
<td>Galilei TCP</td>
<td>1.02 D @ 87°</td>
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OS: Posterior corneal astigmatism

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<tbody>
<tr>
<td>Posterior astig:</td>
<td>-0.46 D @ 90°</td>
</tr>
<tr>
<td>TCP astig:</td>
<td>1.02 D @ 87°</td>
</tr>
</tbody>
</table>

Monofocal IOL implanted Post-op refraction:

-0.50±0.50x100 =20/20

Patient #2: WTR astigmatism

Patient E.H.
77 y.o. male with 3+ NSC OS

Pre-op Biometry:
- IOL Master: Cyl:  2.01 @ 91°
- Lenstar: AST:  1.66 @ 92°
- Atlas: Astig:  1.73 @ 85°
- OPD Scan II:  1.78 @ 91°

MR: -1.25 +1.25 x85

Lens Selected

Alcon SN6AT4 21.5D

-Placed in the bag at 91°
-Typically used to correct 1.50D of anterior corneal astigmatism
-Target intermediate
**Post-op visit**

- **POM #3**
  - Computer vision “fuzzy”
  - MR: -1.50 +0.75 x180
  - BCVA: 20/15

*Patient’s astigmatism is overcorrected by +0.75 D and the axis has been flipped*

**Patient #3: ATR astigmatism**

- **Patient:** 71 y.o. female with 3+ NSC OS
- **Pre-op Biometry:**
  - IOL Master: 1.34 @ 176°
  - Lenstar: 1.64 @ 173°
  - Atlas: 0.95 @ 169°
  - OPD Scan II: 1.31 @ 176°
- **MR: -5.75 +2.50 x176**

**Lens Selected**

- **Alcon SN6AT4 13.5D**
  - Placed in the bag at 175°
  - To correct 1.50D of corneal astigmatism

**Galilei Dual-Scheimpflug analyzer**

- **Combined Placido-disk and dual-Scheimpflug corneal analyzer**
- **Total corneal power (TCP)**
  - Using Snell’s law
  - Ray tracing through the anterior and posterior surfaces
Results: Corneal astigmatism magnitude

<table>
<thead>
<tr>
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<th>Mean ± SD (D)</th>
<th>Range (D)</th>
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<tbody>
<tr>
<td>CA_{TCP}</td>
<td>1.07 ± 0.71</td>
<td>0.03 to 4.26</td>
</tr>
<tr>
<td>CA_{SimK}</td>
<td>1.08 ± 0.71</td>
<td>0.02 to 4.40</td>
</tr>
<tr>
<td>CA_{front}</td>
<td>1.20 ± 0.79</td>
<td>0.02 to 4.90</td>
</tr>
<tr>
<td>CA_{back}</td>
<td>-0.30 ± 0.15</td>
<td>-0.01 to -1.10</td>
</tr>
</tbody>
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Steep meridian on anterior corneal surface

Steep meridian on posterior corneal surface

What is the effect of the posterior cornea being steep vertically?
- Creates net plus power along the horizontal meridian
- Therefore creates ATR ocular astigmatism

Does a clear-corneal incision make a difference?

Net change:
- 0.37 D ATR shift over ten years
- Same for unoperated and surgical corneas

Corneal astigmatism is not stable
- This long-term ATR change with age
  - Despite temporal clear corneal cataract surgery
  - Must be factored in
    - To extend the benefit of astigmatic correction for our patients

*Hayashi et al. AJO 2011;151:858-65*
Recommendation #1:
To account for the ATR shift with age, we need a new target for postop astigmatism*:

0.25 to 0.5 D of WTR astigmatism

(And, no, it won’t create problems if one flips the axis a small amount!)

Recommendation #2:
Account for posterior corneal astigmatism

- 0.5 D in with-the-rule corneas
- 0.3 D in against-the-rule corneas

Recommendation #3

- Use the Holladay II to account for effect of IOL power and ACD
- Factor in your surgically induced astigmatism

Recommendation #4:
When feasible, measure...

- Posterior corneal astigmatism
- Intraoperatively

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**Baylor Toric IOL Nomogram**

**WTR Astigmatism**
(Target range 0.25 - 0.50 D WTR)

<table>
<thead>
<tr>
<th>Astigmatism (D)</th>
<th>Toric IOL</th>
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<tbody>
<tr>
<td>≤ 1.69</td>
<td>0 (PCRI if &gt;1.00)</td>
</tr>
<tr>
<td>1.70 – 2.19</td>
<td>T3</td>
</tr>
<tr>
<td>2.20 – 2.69</td>
<td>T4</td>
</tr>
<tr>
<td>2.70 – 3.19</td>
<td>T5</td>
</tr>
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</table>

0.7 D shift: UP

**Baylor Toric IOL Nomogram**

**ATR Astigmatism**
(Target range 0.25 - 0.50 D WTR)

<table>
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<tr>
<th>Astigmatism (D)</th>
<th>Toric IOL</th>
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<tbody>
<tr>
<td>&lt; 0.39</td>
<td>0</td>
</tr>
<tr>
<td>0.40* – 0.79</td>
<td>T3</td>
</tr>
<tr>
<td>0.80 – 1.29</td>
<td>T4</td>
</tr>
<tr>
<td>1.30 – 1.79</td>
<td>T5</td>
</tr>
</tbody>
</table>

0.7 D shift: DOWN

*Especially if specs have more ATR
Conclusion

- Needs more work
  - Data
  - Accuracy
  - Role of refraction as predictive factor
  - Age
  - It undoubtedly will change!

Thank you

Thank you for your attention