



2015 David W. Parke, Sr., M.D. Lecture

Advances in managing astigmatism: 10 pearls



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Financial disclosure:
Abbott Medical Optics
Alcon
i-Optics
Revision Optics
TrueVision
Ziemer



Who is this guy....

- Superb clinician
- Incredibly dedicated advocate for quality patient care
- Gifted teacher: Yale residents
- Started Low Vision clinic at Yale—and 7 others
- Amazing community involvement

Who is this guy....

- Former CSEP President
- AAO Humanitarian Award recipient
- CSMS Paul K. Maloney, Jr., Distinguished Service Award

Who is this guy....

- Origin of a legacy
- Decent fisherman








Many patients *can* be helped...

Astigmatism	Hoffer ¹	Ferrer-Blasco ²
≤ 0.50	40.2%	58.8%
0.75 – 1.00	26.7%	12.1%
1.25 – 1.50	14.1%	12.6%
1.75 – 2.00	8.1%	7.2%
2.25 – 2.50	3.9%	3.6%
2.75 – 3.00	2.6%	2.3%
3.25 – 3.50	1.6%	1.6%
> 3.50	2.9%	1.7%



40-60% have ≥0.75 D!

¹Hoffer KJ AJO 1980; 90: 360-68
²Ferrer-Blasco T, Montes-Mico R et al. JCRS 2009; 35:70-75

1. Who *should* be helped?

- Desire less dependency on spectacles
- Can afford it (regrettably)
- What is the tipping point???

Threshold for correction--estimated postop:

- **Monofocal IOL*:**
 - 0.50-0.75 (depending on needs)
- **Multifocal IOL**
 - < 0.50

*Villegas EL, Alcón E, Artal P. Minimum amount of astigmatism that should be corrected. J Cataract Refract Surg 2014; 40:13-19

Effect of astigmatism with Restor +3 add

Astigmatism:
 0 D = 20/20
 0.5 D = 20/30

Hayashi et al. Effect of astigmatism on visual acuity in eyes with a diffractive multifocal intraocular lens. JCRS 2010; 36:1323-9

2. Figure out your own results

1. **Optimize your lens constants**
 - Patients will not see the benefit if the sphere is off
2. **Calculate your surgically induced astigmatism**
 - (But don't fully trust it.....)
 - Likely minimal with 2.2-2.4-mm incision

My SIA:

Each ring = 0.25 D

- **Centroid**
 - 0.13 ± 0.30 D @ 95°
- **Vector magnitude:**
 - 0.39 ± 0.20 D
 - 0.07 - 0.81 D

3. Look at at least 3 data points

- **IOLMaster or Lenstar:** for power
- **Topography:** for alignment
- **Glasses (yes, glasses):**
 - Looking for less WTR or more ATR

If discrepancies in first two, remeasure—or punt!

We aren't as good as we think we are... 2 measurements one week apart*

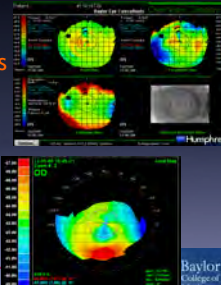
Lenstar: 0.02 ± 0.15 D @ 23°
 IOLMaster: 0.04 ± 0.28 D @ 92°

■ Centroid
 ○ 95% confidence interval

*Courtesy of Adi Abulafia

Role of topography

1. Screening for other conditions
2. Determining topographic stability for CL wearers
3. Screening for possible future corneal refractive surgical procedures

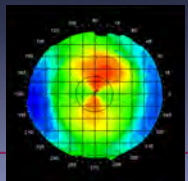


The image shows three topographic maps. The top two are circular maps with color-coded curvature values, and the bottom one is a larger, more detailed map with a color scale on the left. The maps illustrate different corneal shapes and curvatures.

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Role of topography

- 4) Assisting in routine and complex IOL calculations
- 5) Determining IOL asphericity
- 6) Planning astigmatic corrections



The image shows a single topographic map with a color-coded curvature scale, illustrating the role of topography in IOL calculations and astigmatic corrections.

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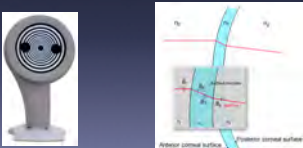
4. Factor in posterior corneal astigmatism

- Contributes ATR refractive astigmatism

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Galilei

Combined Placido-disk and dual-Scheimpflug corneal analyzer



The image shows the Galilei corneal analyzer device on the left and a diagram on the right illustrating the combined Placido-disk and dual-Scheimpflug corneal analyzer. The diagram shows the light paths and the resulting corneal maps.

*Koch DD et al. *J Cataract Refract Surg.* 2012;38:2080-7.

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What is the curvature of the anterior and posterior cornea?

- Anterior: 51% are steep vertically
- Posterior: 87% steep vertically!

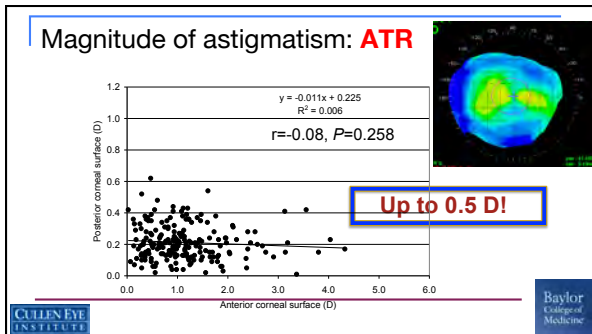
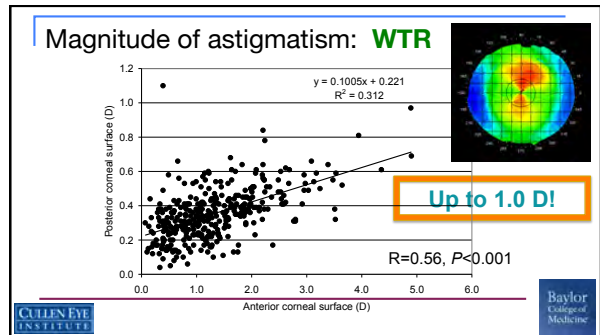
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What is the effect of the posterior cornea being steep vertically?

- Creates net plus power along the *horizontal* meridian
- Therefore creates ATR ocular astigmatism

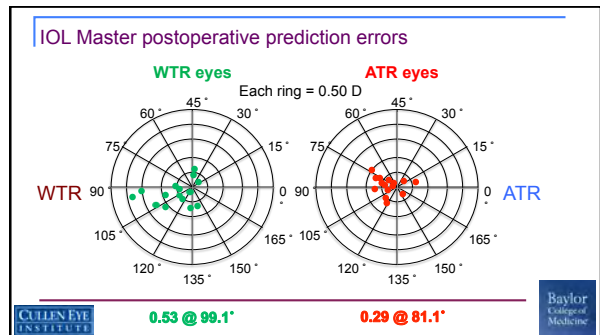
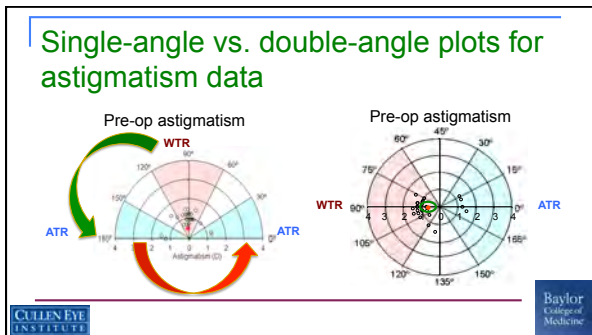
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How much ATR astigmatism does the posterior cornea induce?



So can we prove this clinically?

We studied outcomes in 42 eyes implanted with IOLs....



Clinical study

- If you calculate corneal astigmatism from measurements on anterior corneal surface only
 - WTR group: frequent over-correction of **0.5 D**
 - ATR group: frequent under-correction of **0.3 D**

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Koch DD et al. JCRS December 2013

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5. Another factor: drift with age

- Target: small amount of WTR astigmatism to account for the ATR shift with age
 - Averages 3/8 D over 10 years
 - But clearly variable

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*Hayashi et al. AJO 2011;151:858-65

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6. Yet another factor....

- IOL power and ACD determine effective toricity
 - Deeper AC and lower IOL power: less toric effect
 - Shallower ACD and higher IOL power: more
- At extremes: Up to 0.5 D in each direction!

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7. Picking procedures

- Relaxing incision for up to 1.00-1.25 D
- Toric up to 4 D
 - >4 D: I do toric first and defer relaxing incisions
 - ◆ May not be needed
 - ◆ Likely at a slightly different meridian
- If a quandary, DO nothing

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8. So how do I decide which toric IOL?

- Company nomograms
 - Don't take into account:
 - ◆ Posterior cornea
 - ◆ ACD/IOL power
 - ◆ Always aim to undercorrect
 - Will leave many with residual ATR

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8. So how do I decide which toric IOL?

- Other formulas:
 - Holladay Consultant
 - ◆ Ignores posterior cornea
 - Barrett Toric Calculator: www.ascrs.org
 - ◆ Looks promising but does not leave patients WTR
 - Baylor nomogram
 - ◆ Ignores ACD/IOL power but no added data entry

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Baylor Toric Nomogram

Effective IOL cyl power@corneal plane	WTR (D)	ATR (D)
≤ 1.30 (PCRI if >1.00)	-	-
1	1.70 - 2.19	0.40 - 1.79
1.5	2.20 - 2.69	0.80 - 1.29
2	2.70 - 3.19	1.30 - 1.79
2.5	3.20 - 3.69	1.80 - 2.29
3	3.70 - 4.19	2.30 - 2.79
3.5	4.20 - 4.69	2.80 - 3.29
4	4.70 - 5.19	3.30 - 3.79

0.7 D ↑ (left side), ↓ (right side)

*Especially if specs have more ATR

Example 1

- Cornea: 3.80 D WTR
- SIA: 0.10 D WTR
- Use: 3.90 D for IOL toricity

Toric IOL	WTR (D)	ATR (D)
T6 (2.57)	3.20 - 3.79	1.80 - 2.29
T7 (3.08)	3.80 - 4.39	2.30 - 2.79
T8 (3.60)	4.40 - 4.99	2.80 - 3.29

Not a T8!!

Example 2

- Cornea: 1.90 D ATR
- SIA: 0.20 D WTR
- Use: 1.70 D for IOL toricity

Toric IOL	WTR (D)	ATR (D)
ZCT225 (1.55)	2.20 - 2.69	0.80 - 1.29
ZCT300 (2.06)	2.70 - 3.34	1.30 - 1.79
ZCT400 (2.74)	3.35 - 4.00	1.80 - 2.50

Not a ZCT225!!




Key issue after ablative surgery:

This relationship is lost!

- So we need to be able to measure both the front and the back
- Adds to the existing complexity of interpreting the amount of anterior corneal astigmatism
 - More difficult in post-refractive surgery corneas

Baylor nomogram


- Just a placeholder awaiting more accurate posterior corneal measurements

Gallei iOptics Cassini

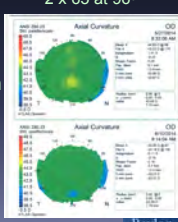
PCRIs

- Diamond



PCRIs

- **Femto**
 - Penetrating: | Nomogram by 1/3?
 - Intrastromal: femtoemulsification.com
 - Adjust for posterior corneal astigmatism



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Femto AK with intraoperative wavefront aberrometer

- **Donnenfeld *et al.* used LenSx (Alcon) to perform AK on 31 patients***
 - Paired, 85% depth, 9 mm diameter
 - ORA intra-op aberrometer (WaveTec) used to selectively open laser incisions to refine astigmatism magnitude

* Donnenfeld *et al.* Presented at ASCRS 2013

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Femto AK with intraoperative wavefront aberrometer

- **Cyl decreased 35% with AK prior to opening**
 - Pre-op mean cyl: 1.07 ± 0.38 D
 - Post-op (before opening) mean cyl: 0.76 ± 0.36 D
 - 1st incision opened, mean cyl: 0.38 ± 0.19 D
 - 2nd incision opened (n=22), mean cyl: 0.23 ± 0.14 D

* Donnenfeld *et al.* Presented at ASCRS 2013

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Non-penetrating astigmatic keratotomy

- **Compared to penetrating AK:**
 - No wound gape
 - No infection
 - No epithelial ingrowth

*Al-Mohtaseb and Culbertson. CRS Today 2014 Mar.
*Viewanathan and Kumar. JCRS 2013; 39(12):1916-1920.

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Non-penetrating astigmatic keratotomy

- **Also expect:**
 - Less inflammation
 - Quicker visual recovery
 - Enhanced patient comfort

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Our data with AMO Catalys: Femtosecond laser intrastromal incisions

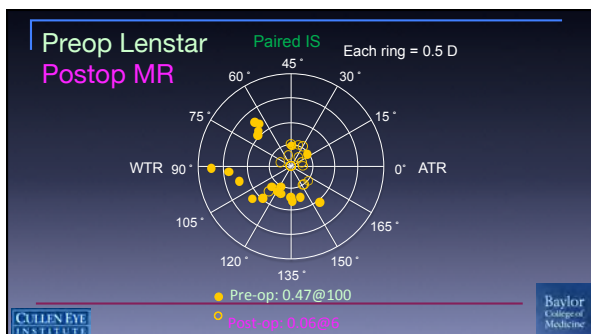
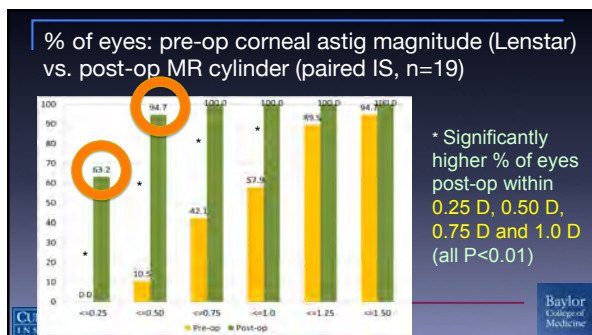
- **24 eyes of 21 patients included**
 - Inclusion criterion:
 - Post-op follow-up 3 weeks or longer
 - Post-op BCVA 20/25 or better
- **Single or paired intrastromal (IS) incisions: 8-mm zone**
 - Paired 30° to 60° (n=19)
 - Single 35° to 60° (n=5)

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Femtosecond laser intrastromal relaxing incisions

- Nomogram by Julian Stevens (Moorfields)
 - Femtoemulsification.com
 - Modified to account for posterior corneal astigmatism
- Goal: Reduce refractive astigmatism
 - Postop anterior corneal astigmatism ignores effect of posterior corneal astigmatism

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Case 1: Reduce astigmatism

- Pre-op Lenstar: 1.17D @ 99°
- Add SIA of 0.3D@125°: 1.38D @ 104°
- Intrastromal incisions: 2 x 45°@104°
- Post-op Lenstar: 0.51D @ 83°
- Post-op MR: +0.25 D sph

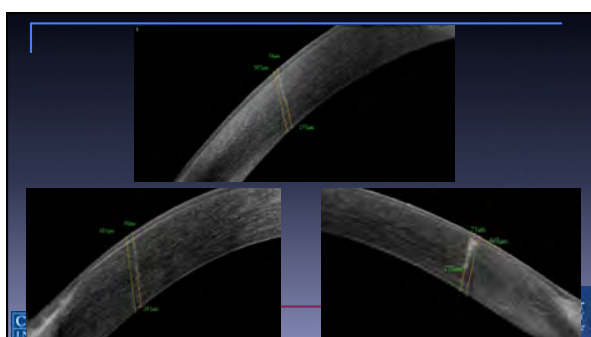
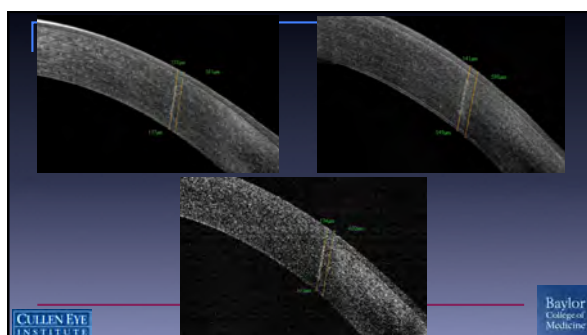
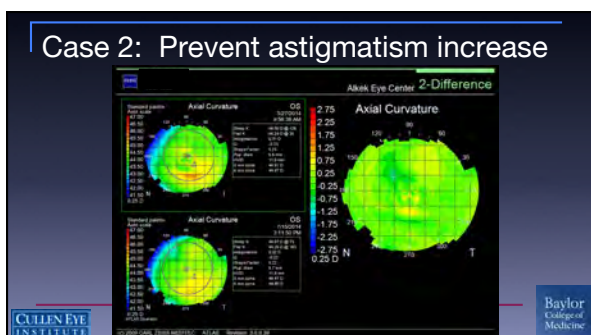
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Case 2: Prevent astigmatism increase

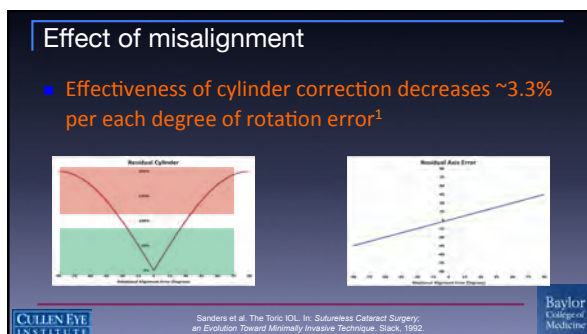
- Pre-op Lenstar: 0.73D@143°
- Add SIA of 0.3D@125°: 0.99D@138°
- Intrastromal incisions: 2 x 35°@128°
- Post-op Lenstar: 0.20D@118°
- Post-op MR: plano

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- ### Complications
- No eyes were overcorrected
 - There were no complications
 - Some large undercorrections....

- ### 9. Align, align, align
- 10 degrees = 34% error
 - 30 degrees = 100% error
 - AND creates astigmatism at a new meridian



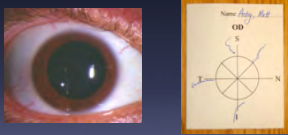
Eyes rotate.....

- **Sitting to lying down:**
 - Mean rotation = 4.1 +/- 3.7 degrees
 - 8% rotate more than 10 degrees

Swami AU, Steinert RF, Osborne WE, White AA.
Am J Ophthalmol. 2002 Apr;133(4):561-2.2

So how should we mark eyes?

- Landmarks
- Freehand
- Special marker
- High tech option



So how should we mark eyes?

- Landmarks
- Freehand*
- Special marker
- High tech option


Mean error ~ 4 degrees +/- 1.5 degrees

Popp N, Hirschall N, Maedel S, Findl O, J Cataract Refract Surg. 2012 Dec;38(12):2094-9



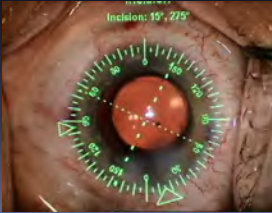
So how should we mark eyes?

- Landmarks
- Freehand
- Special marker
- High tech option




High-tech options

- Alcon Verion
- Zeiss Callisto
- TrueVision 3D



Should we pay for the high-tech option?

- Likely to prove optimal
- Minimizes a key variable...but high cost also



Intraoperative measurement

- Wavetec ORA system
- Clarity HoloS



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10. How to manage residual postop astigmatism: IOL aligned?

- Undercorrected by up to 1.25 D
 - PCRI
- Overcorrected by up to 1.25 D
 - PCRI
- Under- or overcorrected by > 1.25 D
 - Excimer laser or exchange

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Toric IOL overcorrection

- 72 year old female first eye CE/IOL OS
 - Pre-op:
 - UCVA = 20/60, MR: $-1.0 + 0.5 \times 180 = 20/30$
 - Pre-op corneal astig:
 - Tomey: 1.25 D @ 167°
 - Lenstar: 1.39 D @ 177°
 - IOLMaster: 1.73 D @ 009°
 - Galliei TCP: 2.17 D @ 012°
- 23.0 D ZCT300
@180° for I/N

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Toric IOL overcorrection

- POW #3
 - MR: $-2.0 + 1.0 \times 90 = 20/20$
- POM #2
 - MR: $-1.75 + 1.25 \times 87^\circ = 20/20$
- POM #3
 - MR: $-2.25 + 1.00 \times 75^\circ = 20/20$

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Toric IOL overcorrection

- POM #3
 - PCRIs: 40° superior and 30° inferior
- 1 week after PCRI
 - UCVA = 20/200, MR: $-2.0 \text{ sph} = 20/20$
- 1 month after PCRI
 - UCVA = 20/150, MR: $-2.25 \text{ sph} = 20/25+$

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10. How to manage residual astigmatism: IOL misaligned?

- Up to 1.00-1.25 D
 - PCRI
- Off by over 1.25 D
 - Rotate or exchange
 - Berdahl-Harden calculator: astigmatismfix.com

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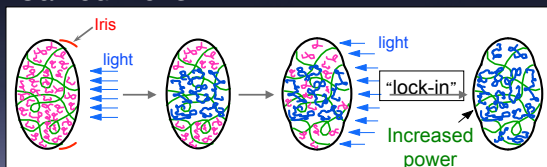
Case: Rotated toric IOL

- 77 year old female second eye CE/IOL OS
- Pre-op corneal astig:
 - ◆ Cassini: 1.43 D @158°
 - ◆ Lenstar: 1.40 D @163°
 - ◆ Galilei: 1.26 D @152°
- 6/4/2014: 19.0 D ZCT300@163° implanted
 - Noted to be aligned at 005° at 3 weeks postop

Rotated toric IOL

- POM #5
 - MR stabilizes: $-1.00 + 1.50 \times 120^\circ$
- Paired PCRI: 45 degrees at 120
- One month postop: UCVA = 20/20-2

Postoperative adjustment: Calhoun lens



Conclusion

- Astigmatism correction is:
 - Integral to cataract surgery
 - Getting increasingly accurate (and expensive)
 - Often the key to patient satisfaction
 - Needs more work!!

Thank you for
your attention

