Tips on Toric IOLs

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Financial Disclosures

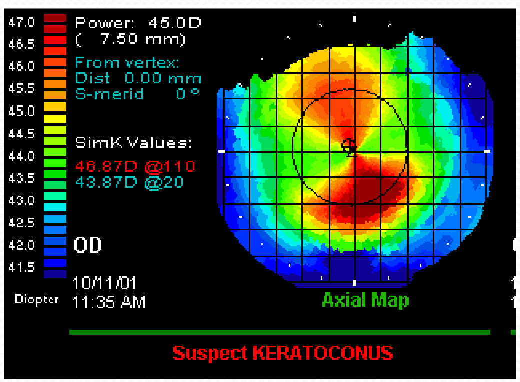
- Consulting Fee: Abbott Medical Optics; AcuFocus; Bausch + Lomb; TearLab Corporation

Tips on Toric IOL Implantation

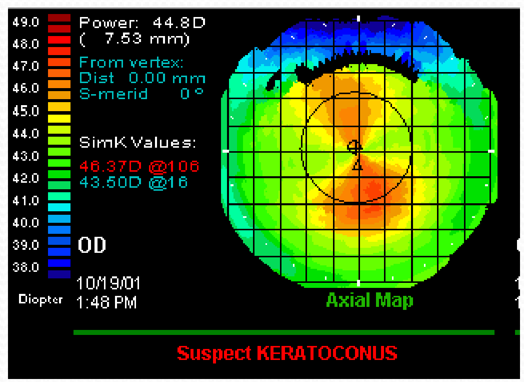
- Contact Lens Warpage

Need to Keep Patients Out of Contact Lenses Until Stabilization

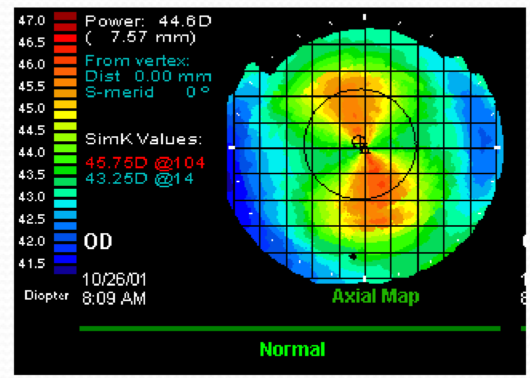
1st week



2nd week



3rd week

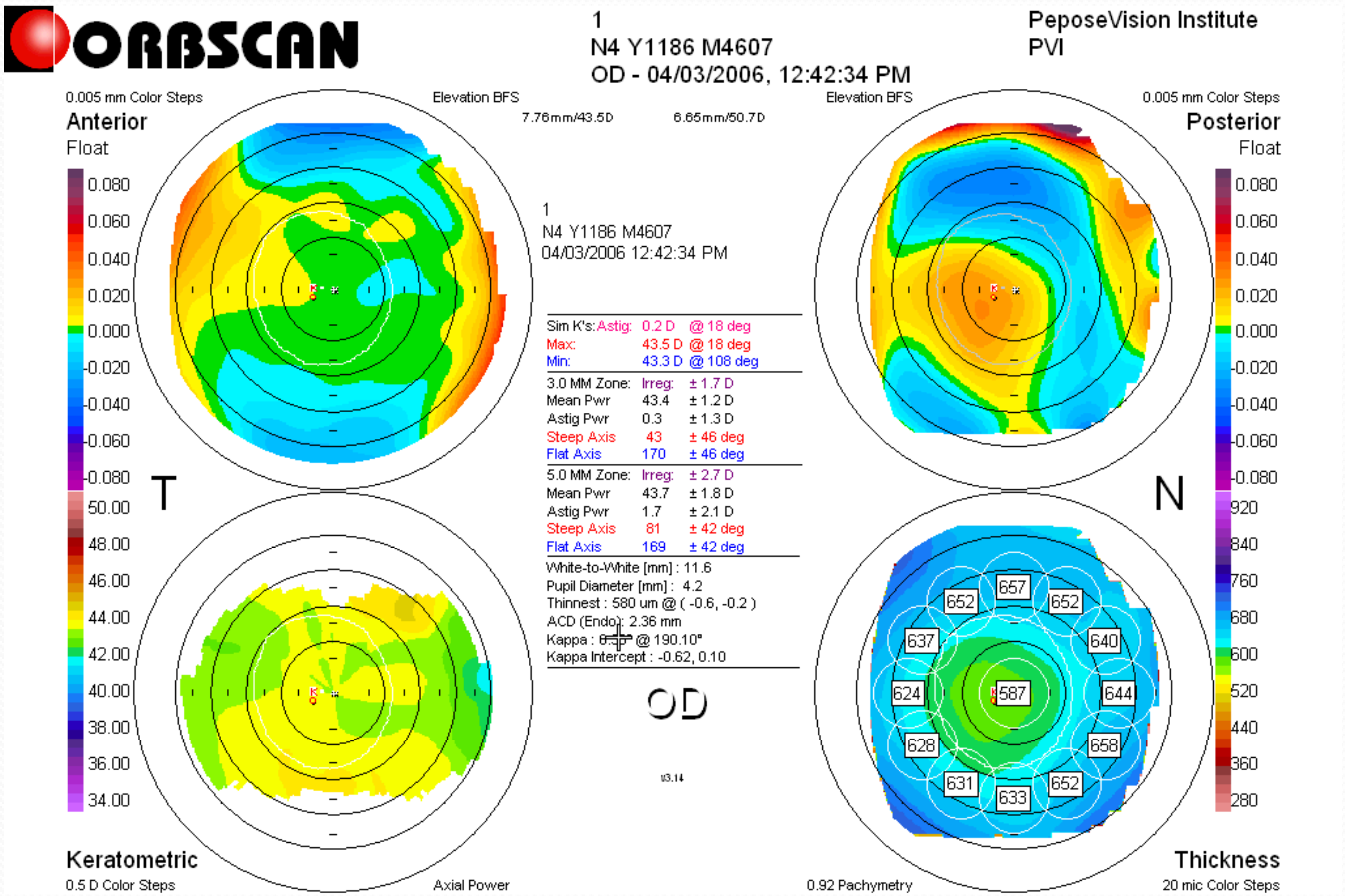


Biometry was performed following stabilization of serial MRx, keratometry, and topographic pattern

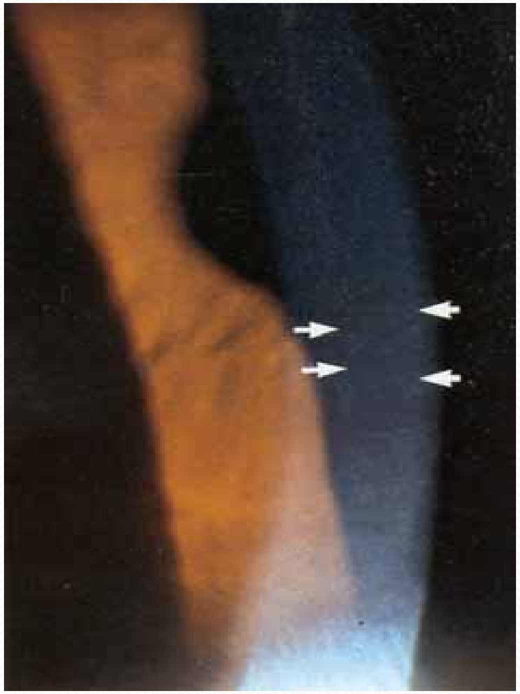
Tips on Toric IOL Implantation

- Look for irregular astigmatism
- Considerations for torics in patients with ABMD or keratoconus

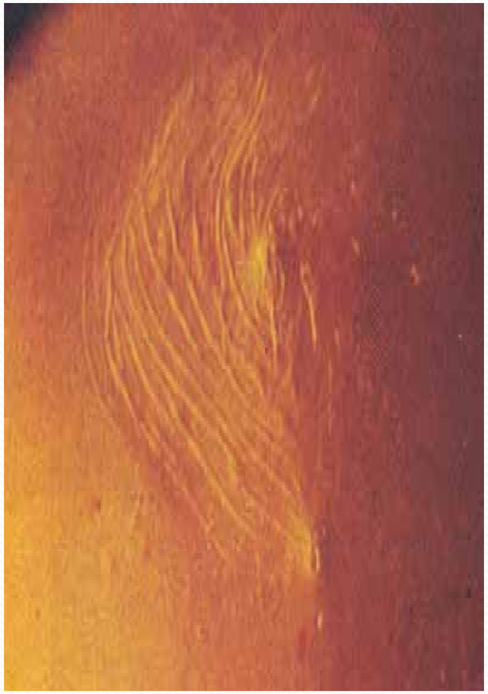
Irregular Topography



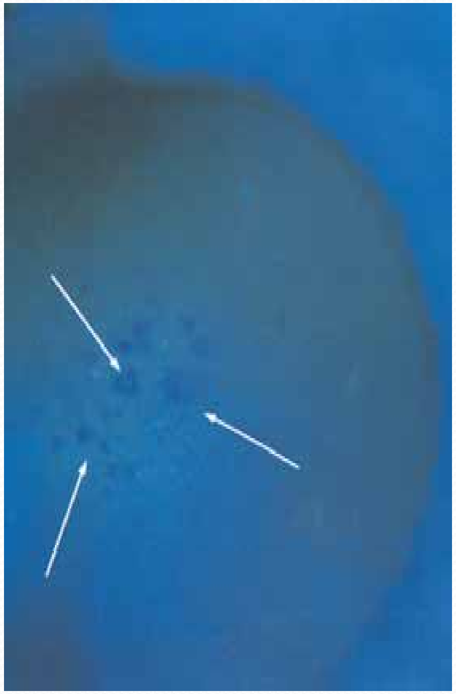
Screening patients for ABMD



Direct Illumination



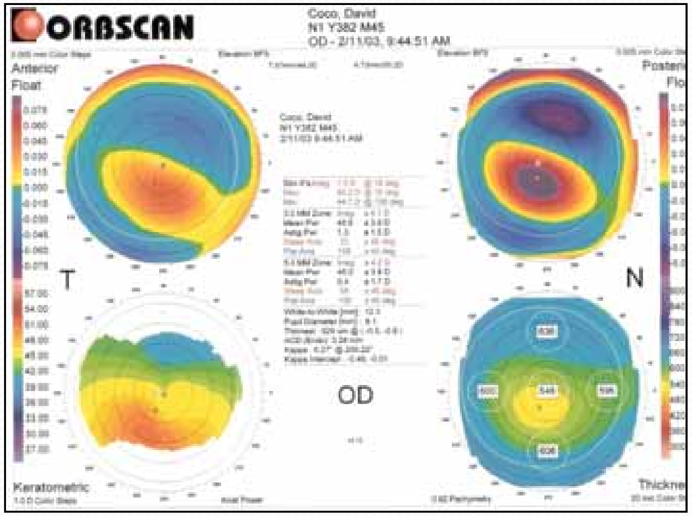
Retro-illumination



Negative Staining

Case Report

- **40 y/o male with h/o forme fruste keratoconus**
- **UCDVA: 20/50, UCNVA: 20/50**
- **BSCVA: 20/40; 1-2+ NS**
- **Postop MRx: -0.25 – 2.50 x 160**
- **Postop Ks: 47.2, 44.7 x 164**



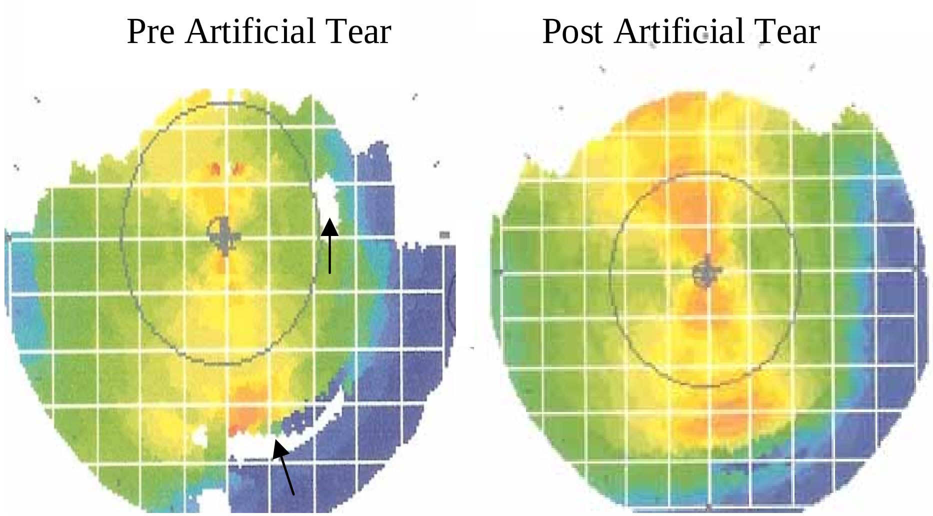
Only consider toric IOL in these cases if manifest and keratometric astigmatism align, astigmatism may be asymmetric but fairly regular and axis not markedly skewed, and the ectasia has shown stability. Otherwise, implanting toric could be problematic, since RGP will unmask IOL toricity.

Tips on Toric IOL Implantation

- Identifying and Pre-Treating Dry Eye

Effect of DES on Biometry

- **Variable serial subjective refraction**
- **Missing areas on topographic maps**
- **Increased wavefront higher order aberrations**



Areas of placido disk distortion (arrows) due to focal corneal drying (left), in an axial topographic map, become more regular following application of an artificial tear drop (right).

Preoperative Risk Factors for Chronic DES

Eyelid & Meibomian Gland Disease:

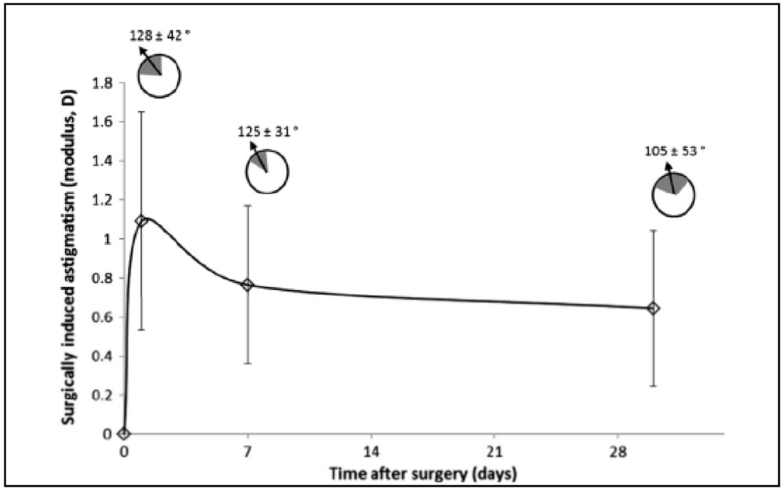
Blepharitis & Acne Rosacea

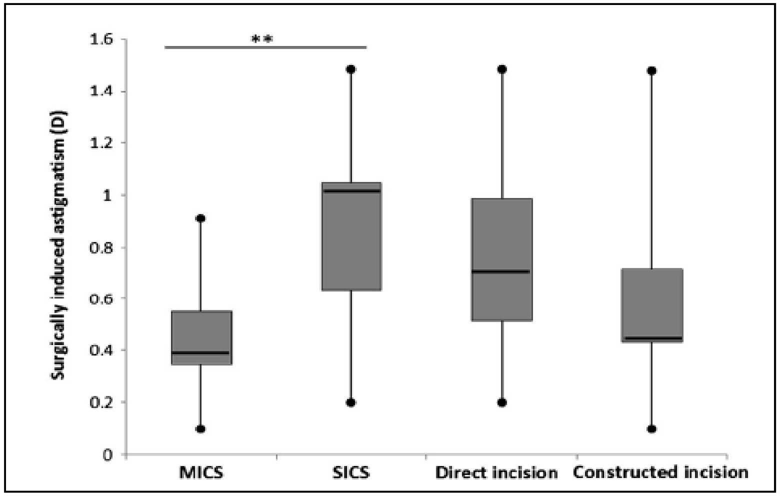
Tips on Toric IOL Implantation

- Determining SIA (vectoral flattening effect of corneal incision)
- Optimizing Incision Location

Factors That Impact SIA

- SIA is generally higher with superior and nasal corneal incisions versus temporal or superotemporal.[1,2]
- Recent studies indicated that 32% of the variation in SIA can be accounted for by corneal biomechanical metrics, such as corneal hysteresis. It is also impacted by wound length and other factors.[3] SIA (D)=2.08+0.24(IL)-0.19CH

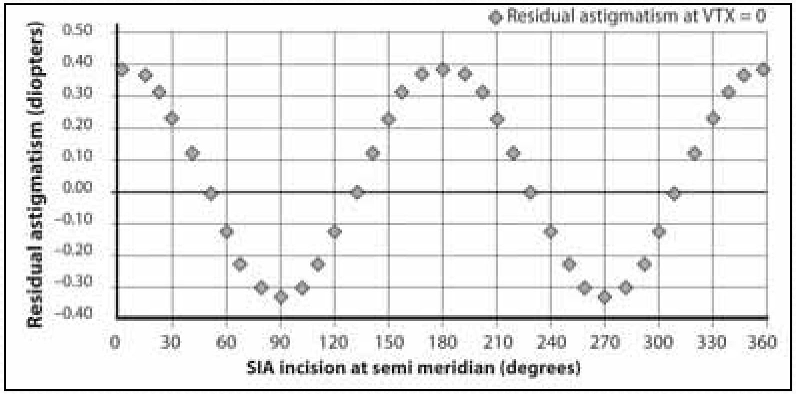


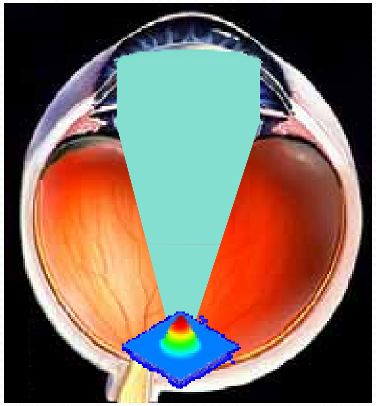


1. Rho CR, Joo CK. L Cataract Refract Surg 2012; 38:666-671.
2. Kohnen S, Neuber R, Kohnen T. J Cataract Refarct Surg 2002; 28:821-825.
3. Denoyer A, et al. J Cataract Refract Surg 2013; 39: 1204-10.

Tips on Toric IOL Implantation

- Optimizing Incision Location for lowest residual manifest cylinder
- These minima are available in the Holladay IOL consultant and are based upon averaging SIA at specific semi-meridians.
- Always target to minimize residual cylinder, regardless of axis. This optimizes retinal PSF.





Tips on Toric IOL Implantation

Measuring Corneal Astigmatism

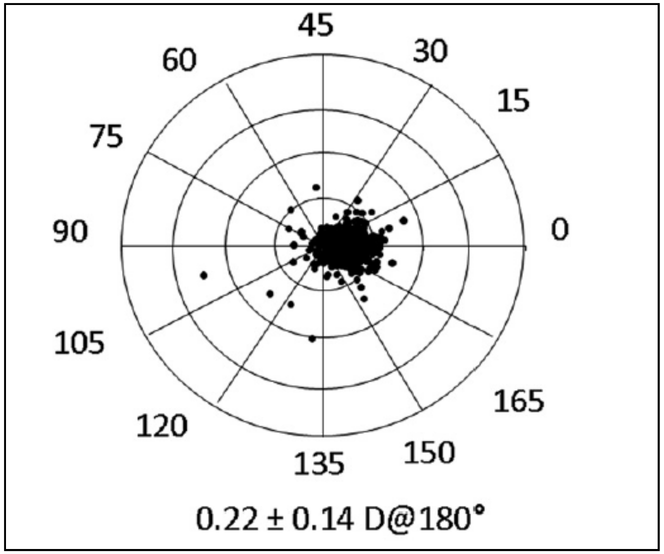
- Keratometers measure 4 points at 3.2 mm optical zone; IOL master 2.5 mm zone; Lenstar rings at 1.7 and 2.2 mm
- Topography (including new systems with no central scotoma) and tomography measure thousands of points over a 3 to 4.5 mm zone and derive zonal power and zonal astigmatism.
- Scheimpflug systems may or may not use Snell's law to account for refraction of rays by the anterior corneal surface in calculating TCP and TCA.

Tips on Toric IOL Implantation

- Impact of Posterior Corneal Astigmatism

Errors in Assessing Corneal Toricity

- Anterior corneal measurements underestimate total corneal astigmatism by a mean of 0.2D @ 180 and >0.5D in 5% of eyes (range -0.01 to -1.1D). This can lead to magnitude of astigmatism estimation error of >0.5D in 2.1% of eyes and >10 degrees in 17.2% of eyes.[1]
- The impact of unmeasured posterior corneal astigmatism can lead to overcorrection in eyes with with-the-rule and undercorrection in eyes with against-the rule astigmatism.

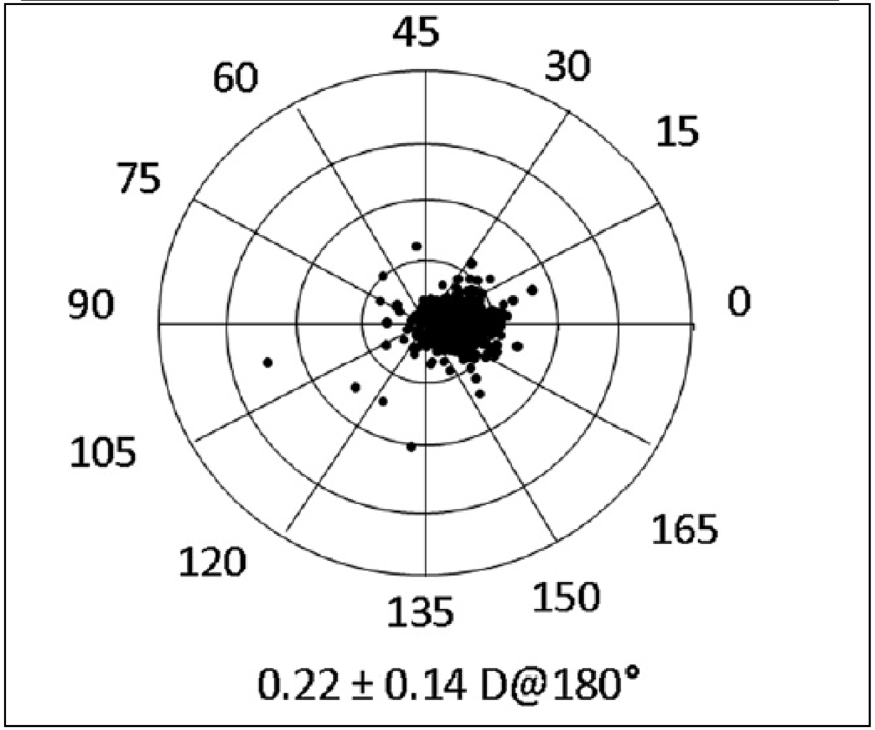


Difference between Total Corneal Power and Simulated K

1. Koch DD, et al.; J Cataract Refract Surg2012;38:2080–2087

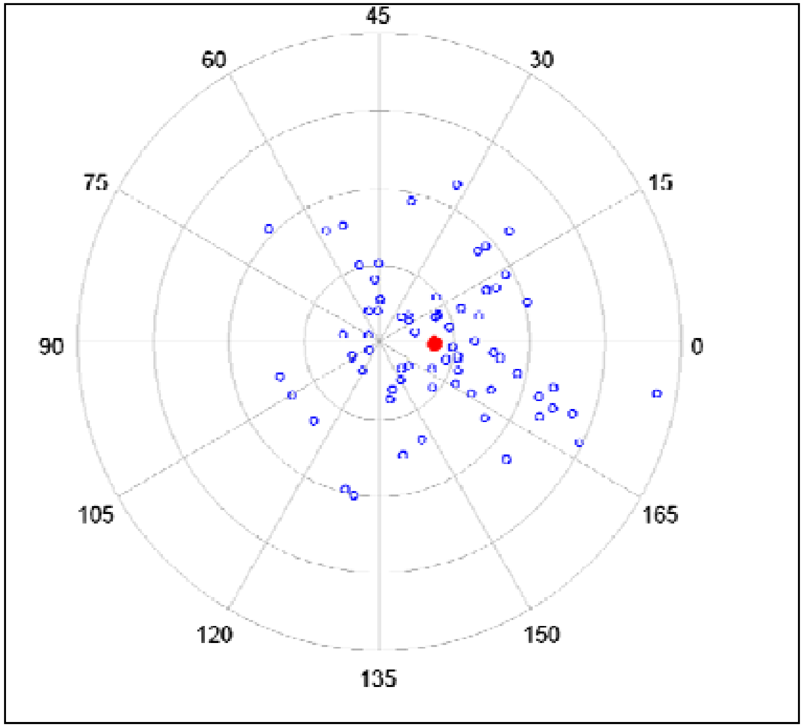
Can we improve our Effectiveness Outcomes?

Difference between Total Corneal Power and Simulated K



Centroid: 0.22 D @ 180°

MR Cylinder – Corneal Cylinder



Centroid: 0.37 D @ 179°

Tips on Toric IOL Implantation

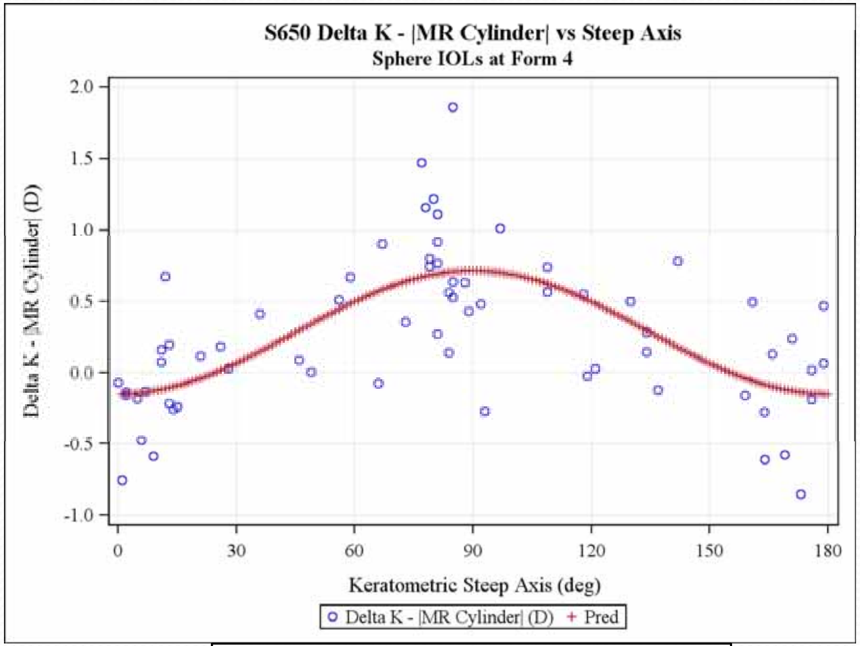
- **Baylor Nomogram** developed as a means to minimize the *average* impact of unmeasured posterior corneal astigmatism.
- However, clinically important variability exists in the magnitude of posterior corneal astigmatism, requiring direct measurement with dual Scheimpflug analyzer or indirectly using intraoperative aberrometry.
- *Red flag cases* may be those with considerable refractive astigmatism, but less keratometric astigmatism. In the past, this might have been completely attributed to lenticular astigmatism.

Baylor Nomogram

Table 3. Baylor toric IOL nomogram (target range up to 0.40 D WTR). Values in the table are the vector sum of the anterior corneal and surgically induced astigmatism. Examples: (1) If the cornea has 3.70 D WTR and surgically induced astigmatism is 0.20 D WTR, use the value of 3.9 D to select IOL toricity. (2) If the cornea has 1.90 D ATR and surgically induced astigmatism is 0.20 D WTR, use the value of 1.70 D to select IOL toricity.

Effective IOL Cylinder Power at Corneal Plane (D)	WTR (D)	ATR (D)
0.00	≤1.69 (PCRI if >1.00)	<0.39
1.00	1.70–2.19	0.40*–0.79
1.50	2.20–2.69	0.80–1.29
2.00	2.70–3.19	1.30–1.79
2.50	3.20–3.79	1.80–2.29
3.00	3.80–4.39	2.30–2.79
3.50	4.40–4.99	2.80–3.29
4.00	5.00–	3.30–3.79

ATR = against the rule; IOL = intraocular lens; PCRI = peripheral corneal relaxing incision; WTR = with the rule
*Especially if spectacles have more ATR



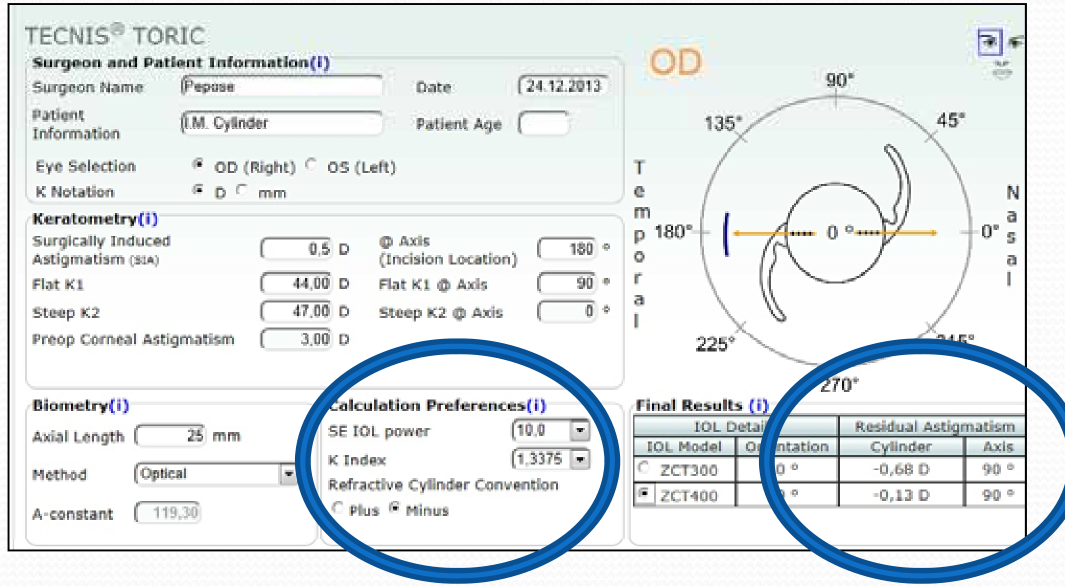
vs.Baylor Nomogram:

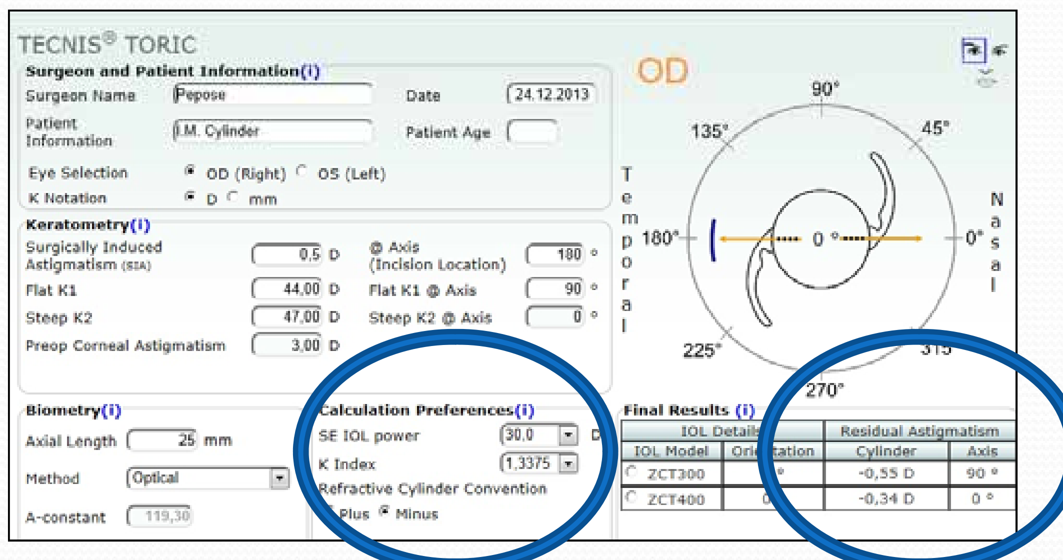
- Add 0.7D ATR
- Subtract 0.7D WTR

Koch DD. J Cataract Refract Surg 2013; In Press.

Tips on Toric IOL Implantation

- Optimized Toric Calculator
- Some toric calculators use a fixed (and even wrong) ratio between the IOL plane and corneal plane powers. This ratio varies considerably with spherical IOL power and vertex distance of the IOL.
- Quick way to check is to make a dramatic change in the IOL power and see if there is a concomitant change in the refractive outcome or the toric power called for by the calculator .



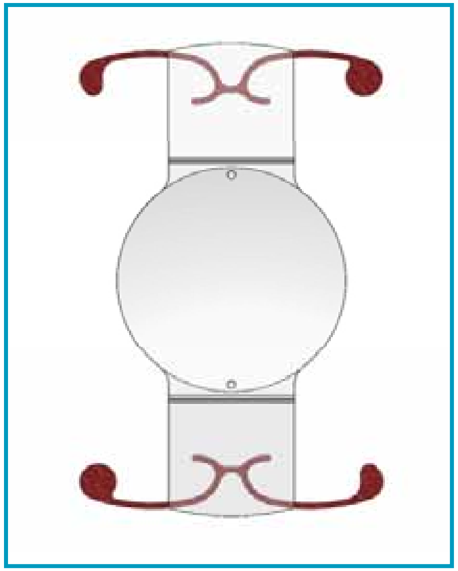


Tips on Toric IOL Implantation

- Minimizing Toric IOL Alignment Errors

Key to Performance of Toric IOLs is Accurate Alignment and Rotational Stability

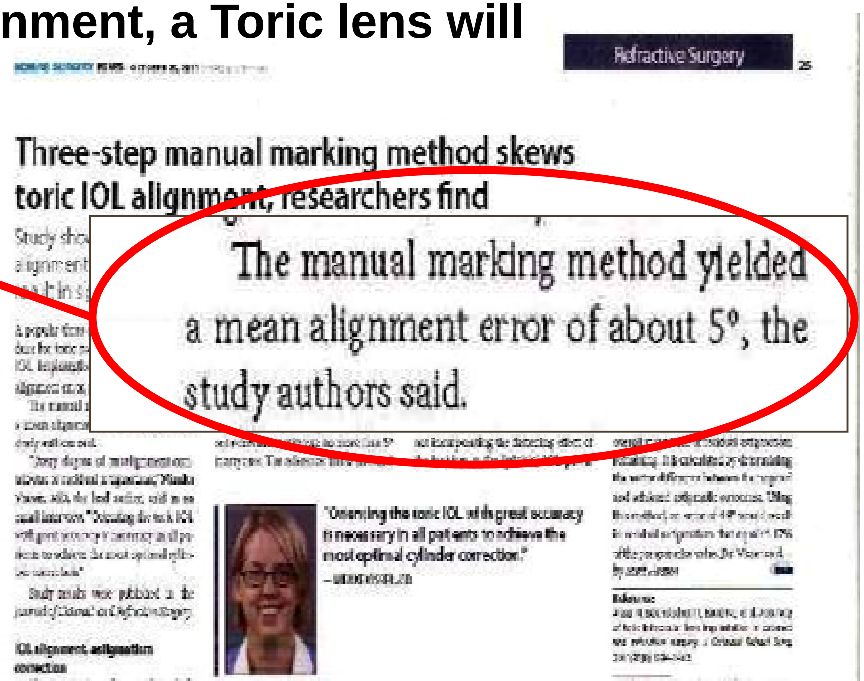
- Every 1° of misalignment of a toric IOL results in 3.3% reduction in offset of astigmatism
- A 10° misalignment means that the toric effect is reduced by a third
  - Remove viscoelastic to ensure better stability
  - Lens design features may enhance rotational stability



Trulign Toric IOL

The Need for Accurate Toric Alignment

- **For every one degree of misalignment, a Toric lens will lose 3% of its corrective effect.**


Refractive Surgery

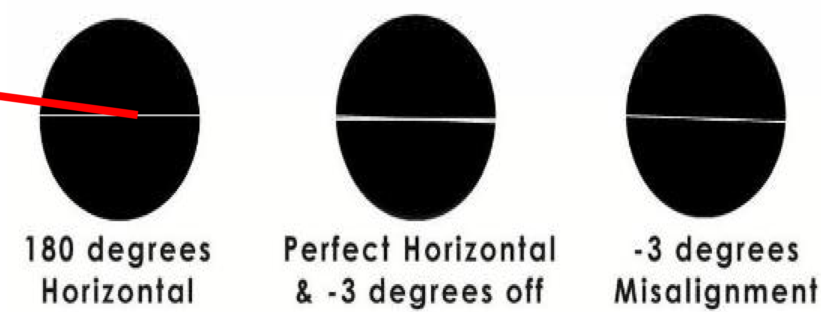
Three-step manual marking method skews toric IOL alignment, researchers find

The manual marking method yielded a mean alignment error of about 5°, the study authors said.

"Orienting the toric IOL with great accuracy is necessary in all patients to achieve the most optimal cylinder correction."

- **Studies have shown that on average, a Toric lens is misaligned by about 5 degrees, that's a 15% loss in corrective effect!**

  - **Looking at a misalignment on an eye, it is nearly impossible for a human to mark with great accurately.**



Electronic Toric Marker vs. Bubble Marker

RESULTS

The electronic marker was over three times more accurate. There was also no difference between the left and right eye (consistency). The bubble marker, in addition to being three times less accurate, had positive and negative angles of deviation between the right and left eyes.

Electronic Toric One Step Marker, AE-2930, ASICO

Pre-op Toric Reference Marker, AE-2791BL, ASICO

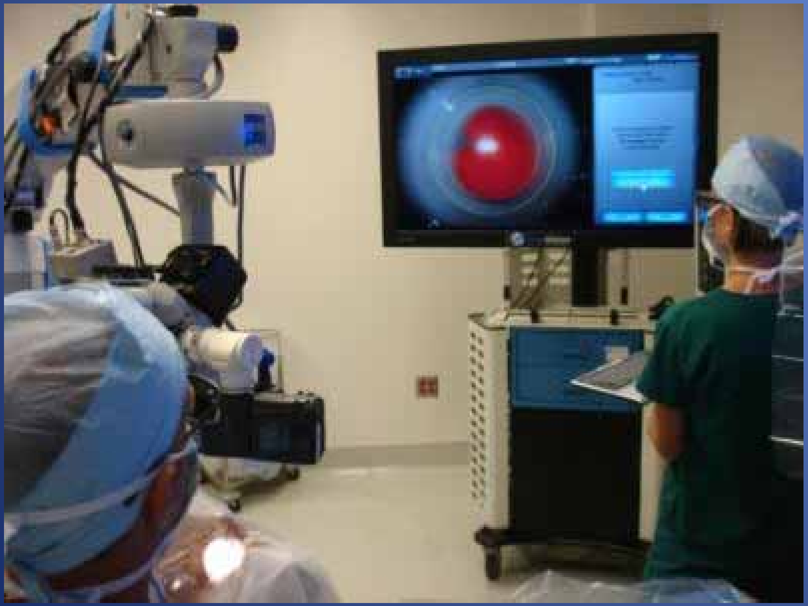
Instrument	Degrees of Deviation from Intended Axis	% of Patients 0°- 2° from intended axis	% of Patients Perfectly on Axis (0° Deviation)	% of Patients 5° and over from the intended axis
Electronic Toric Marker	1.25°	86%	29%	0%
Bubble Marker	4.10°	21%	0%	43%

Tips on Toric IOL Implantation

- "Smart" Microscope Technology

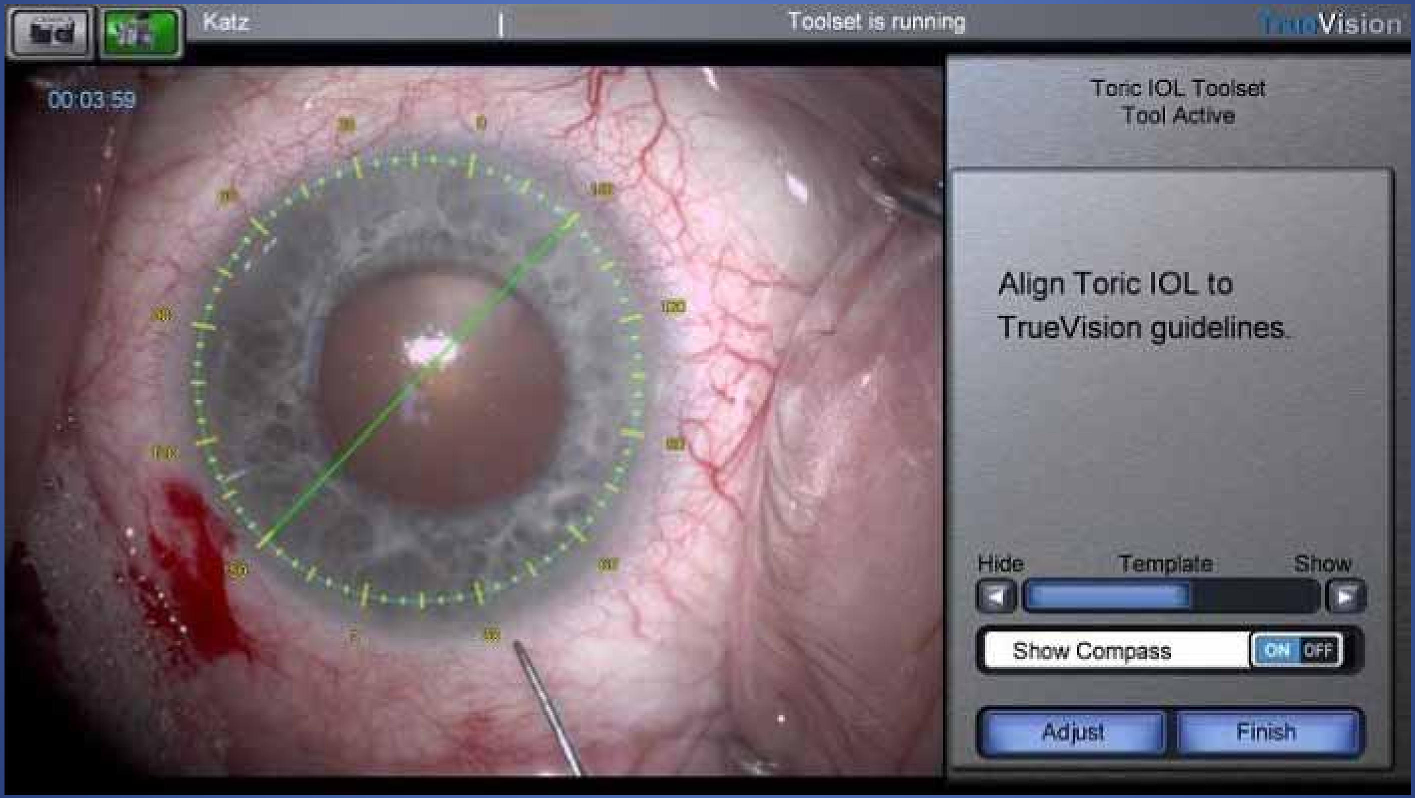
TrueGuide™ with Cassini®

- TrueGuide™ provides digital guidance during cataract and cornea surgery using state-of-the-art diagnostics and intelligent software applications.
- Preoperative patient data and images are processed by TrueGuide™ software, which compensates for cyclotorsion and accounts for individual surgeon SIA.
- Dynamic optimization of incision location and LRI or IOL placement.
- Cassini's novel Color LED corneal imaging for topography and astigmatism analysis.
- Obtains keratometry, white-to-white and eye image for auto-registration.
- Instant acquisition and seamless data flow to the TrueVision® surgical system



i-Optics Cassini® corneal diagnostic

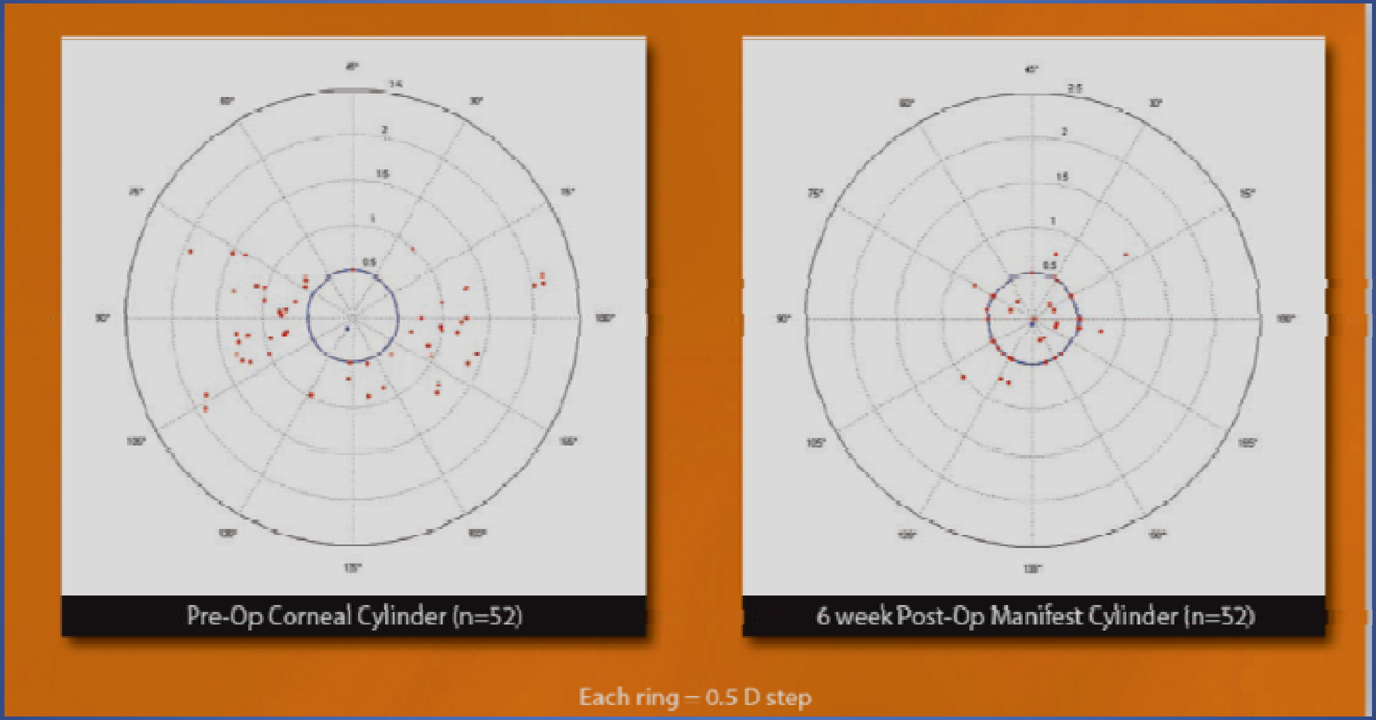
Toric IOL Guidance



The toric lens axis is precisely aligned to the guidance line.

LRI Study Results

4 investigational sites, 52 eyes



87% of eyes were corrected to ≤0.5 D residual cylinder at 6 weeks postop

Abstract: Weinstock, ASCRS 2011

VERION™ Image Guided System

Image. Plan. Guide.

- **Image**

Using a desktop interface, the VERION™ Reference Unit:

- Measures keratometry, pupillometry and other key pre-op parameters
- Captures a high-resolution, diagnostic reference image of the patient's eye
- Auto-detects scleral vessels, limbus, pupil and iris features

VERION™
IMAGE GUIDED SYSTEM

VERION™ Reference Unit

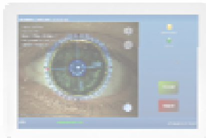
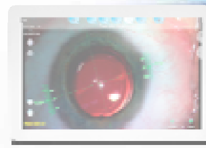


Image.


Plan.


Guide.

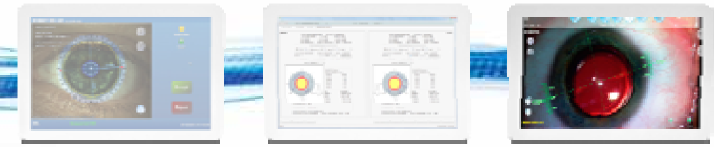
- **Plan**

The VERION™ Reference Unit also enables surgeons to determine an optimized surgical plan:

  - Multiple advanced formula IOL calculations, including lens and power selection
  - Incision and implantation axis planning customized for each patient

VERION
IMAGE GUIDED SYSTEM

Image. Plan. Guide.

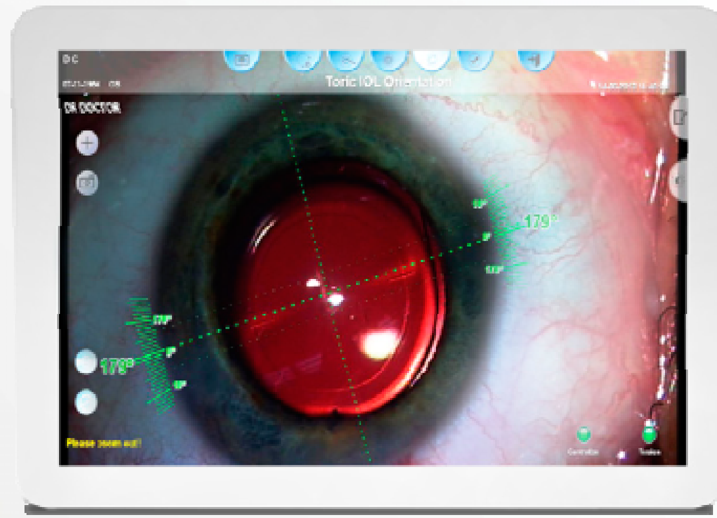


VERION Digital Marker

- **Guide**

To help optimize incision and IOL alignment, the VERION™ Digital Marker displays patient information and images from the VERION™ Reference Unit:

- Features a tracking overlay that enables surgeons to see all incisions and alignment in real time
- Automatically accounts for cyclorotation
- Eliminates the need for manual toric eye markings
- Automatically registers the patient for accurate centering and alignment of multifocal and toric IOLs
- Allows documentation of data to help optimize procedures over time



VERION™ IMAGE GUIDED SYSTEM

Tips on Toric IOL Implantation

- Intraoperative Aberrometry

Comparison of Wavefront Aberrometry

- **Shack-Hartmann: (Commonly used to drive LASIK treatments); generally a static acquisition with extensive processing; lateral resolution several hundred microns; sensitive to ambient lighting**

- **Talbot-Moiré (Wavetec): Based upon interferometry**

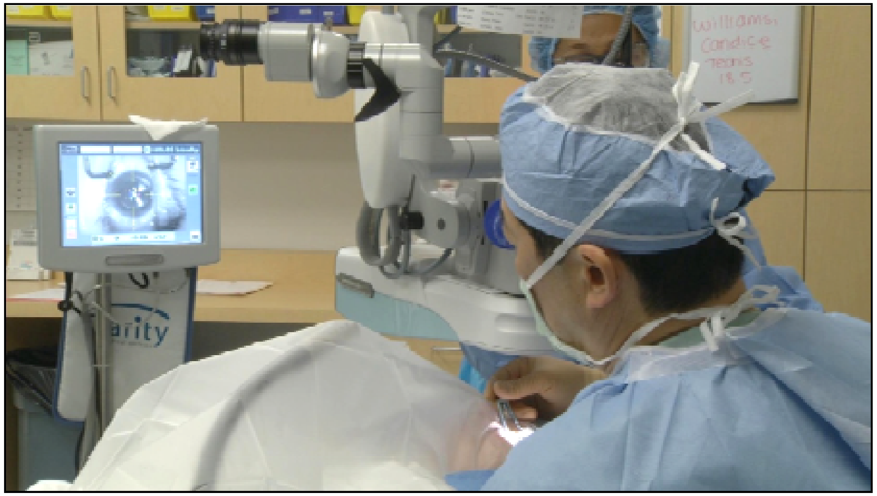
- **HOLOS (Clarity Medical): Dynamic, real time, intraoperative sequential wavefront sensor**

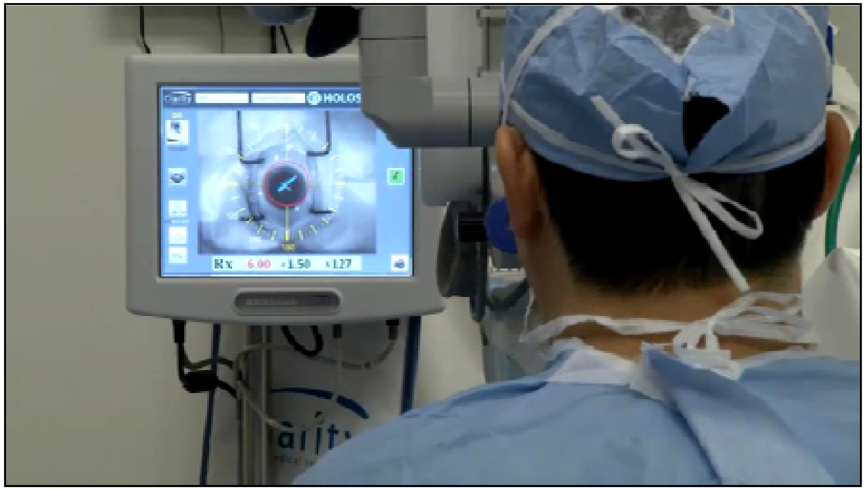
HOLOS IntraOp

	HOLOS IntraOp		Legacy
Technology	Continuous real-time wavefront acquisition and display		Talbot Moiré and Shack-Hartman, snapshots of wavefront then display
	Large dynamic range and ambient light immunity due to lock-in amplification and detection; no grids		Limited dynamic range and ambient light immunity; CCD/CMOS sensor based; grids reduce return wavefront intensity
	Instantaneous wavefront detection and display; minimal algorithm overhead and processing		Multiple frames (samples) and time averaging required for convergence; algorithm and overhead intensive
Working Distance	150mm, 175mm, 200mm		200mm
Diopter Range	-10D to +30D		-5D to +20D
	Dynamic Selectable Region of Interest		Fixed Grid Array
User interaction	Hands free – No user interaction required to acquire refractions		User selects surgical phase (pseudophakic/aphakic) and selects when to accept data/reading; turn down lights, adjust for Z-axis (vertex distance)
Miscellaneous	Record and Playback capability (DVR) of wavefront data synchronized to video of patient's eye		Unknown
Customization	Surgeon configurable for visualization, feedback, confidence levels/indications		Unknown
Calibration	Automatic internal calibration		Unknown

HOLOS Intraoperative Aberrometer

- Ergonomically friendly: slim profile mounts on operating microscope
- Maintains good working distance
- Eliminates need to mark axis
- Real time, continuous data
- Minimal change in surgical throughput





The ORA System®

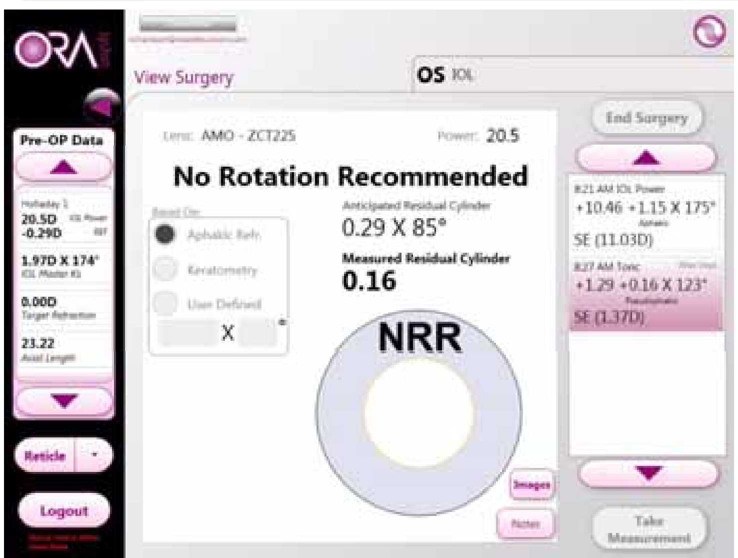
Clinically Studies Show Improved Toric Outcomes

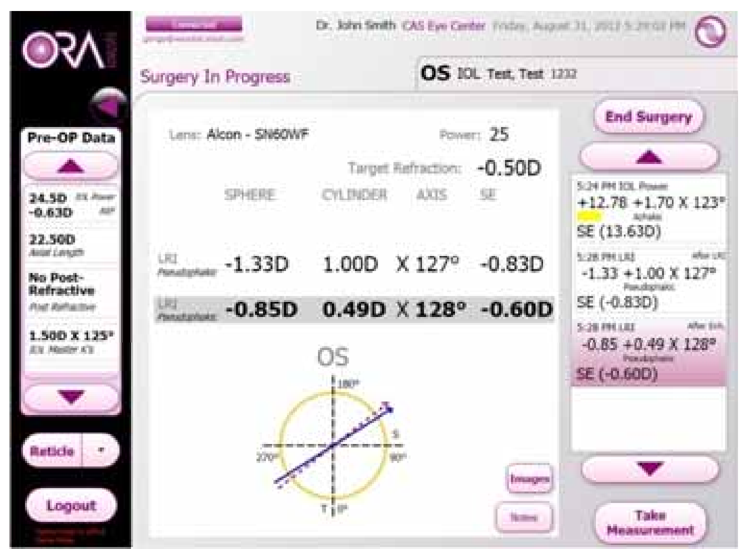
- Provides on demand information which assists in intraoperative decision making
- Utilizes Talbot Moiré interferometry

  Large dynamic range -5 to +20D
- Enables real-time surgical course correction

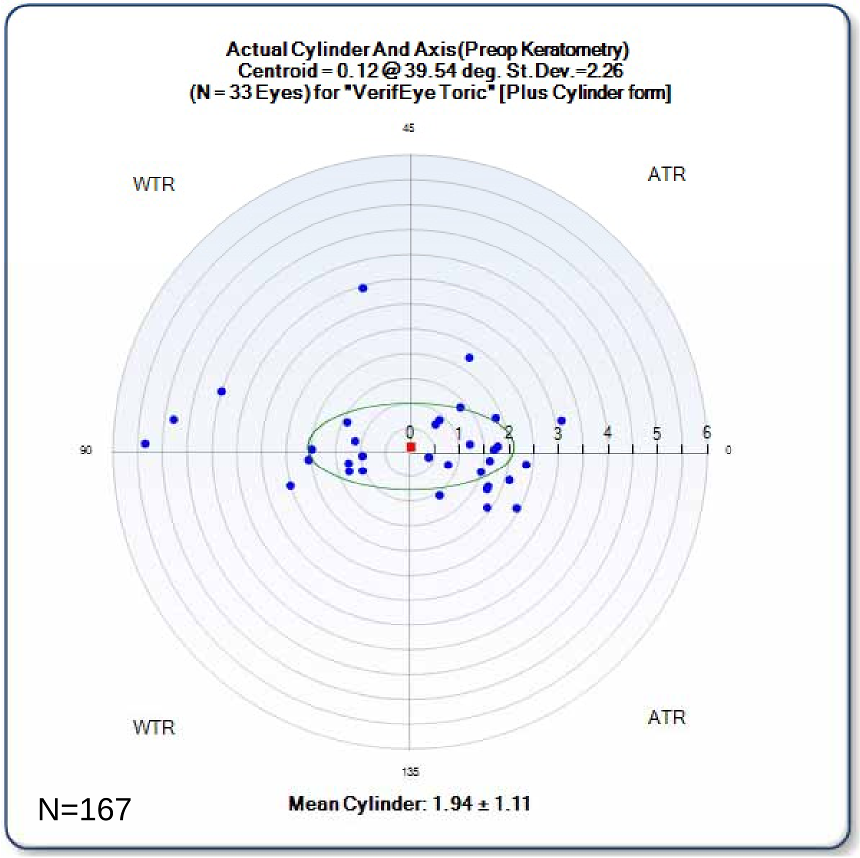
- **Compatible with and attaches directly to existing surgical microscopes**
- **Every system connects live to WaveTec web based servers to capture every procedure and push software upgrades**

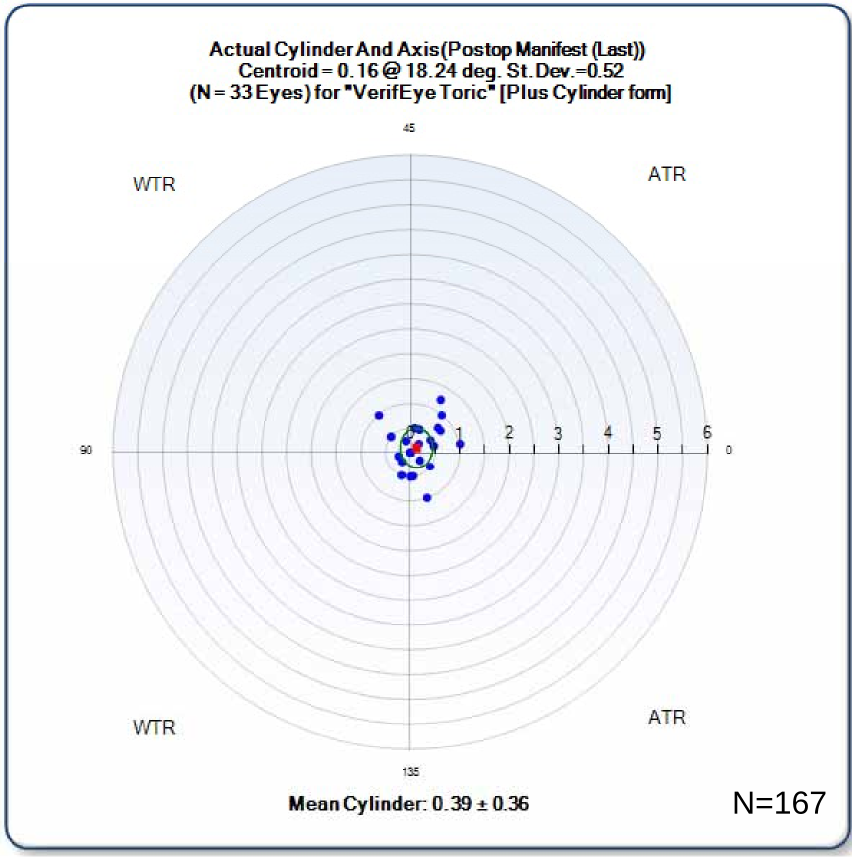
Sample ORA Screen Shots





Toric Outcomes





Mean Pre-op Astigmatism: 1.94 D ± 1.11 D
Mean Post-op Astigmatism 0.39 D ± 0.36 D

Tips on Toric IOL Implantation

- Ray Tracing Formulas

Approaches to Improve Cataract Refractive Outcomes

- **Use of Ray Tracing formulas**[1] (±0.5D in 83%; ±1D in 97%). Full aperture ray tracing is based solely on Snell's law, obviating problems from Gaussian optics (e.g., conversion of effective power in different planes).
- **Measuring a combination of keratometry and anterior and posterior topography/tomography**[1]
- **Use of intraoperative aberrometry**[2-5]

1. Hoffmann PC, et al. *J Refract Surg. 2013; 29:402-408*.
2. Hemmati HD, et al. *Seminars in Ophthalmol. 2012; 27: 100–106.*
3. Canto AP, et al. *J Refract Surg. 2013; 29:484-489.*
4. Packer M. *J Cataract Refract Surg 2010; 36:747–755*.
5. Chen M. *Clinical Ophthalmology 2012; 6:397–401.*

Thank you for your attention!