

Management of Astigmatism in Cataract Surgery

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Financial Disclosure

- Alcon
 - Consultant
- Bausch and Lomb
 - Consultant

Introduction

• The goal of modern cataract surgery is to achieve emmetropia or balance with the fellow eye.

- ◆ 1. Control the spherical component
 - IOL Master or LensStar
 - Water bath ultrasound
 - Keratometry or topography
- ◆ 2. Manage the astigmatic component
 - Size and location of the cataract wound
 - Peripheral Corneal Relaxing Incisions (PCRI)
 - Toric IOLs
 - Post-operative management
 - Astigmatic Keratotomy, Wound Revision or Excimer laser

Introduction

- Goal is to achieve ≤ 0.50 D of post-op cylinder to minimize the need for post-operative spectacles

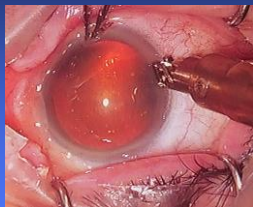
What is the best way to manage astigmatism?

- PCRI
- Toric IOLs



Peripheral Corneal Relaxing Incisions (PCRI)

- Incisions made $\sim 90\%$ depth, in front of the limbus, in the steep meridian of the cornea
- Incisions in the peripheral clear cornea
 - ◆ Heals faster
 - ◆ Refractive effect stabilizes quickly
 - ◆ Less irregular astigmatism, glare and foreign body sensation



Pre-operative Assessment of Astigmatism

Magnitude and Axis

- Manual Keratometry
- IOL master or LENSTAR
- Corneal Topography
- Elevation mapping

Pre-op Assessment of Astigmatism

- Best test for **axis**
 - IOL master - quantitative
 - Topography - qualitative
- Best test for **power**
 - Manual Keratometry
 - IOL master



Intra-operative - Alignment

- Alignment is critical!

- Traditional Method

- Mark the 6 o'clock or 3, 6, and 9 o'clock positions on the patient's limbus with the patient sitting up looking straight ahead with both eyes open



Intra-operative - Alignment

- In the OR, mark the steep corneal axis, using a marked fixation ring, astigmatic ruler or arcuate marker with the 90° mark aligned with the 6 o'clock mark on the cornea

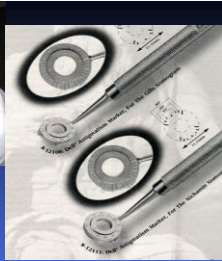


Intra-operative - Alignment

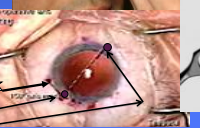
- Many different types of astigmatic markers are available
- Mark in mm or in degrees - depending upon which nomogram used



Reference
Marks



Axis Marks



6 o'clock
Astig. axis

III. Peripheral Corneal Relaxing Incisions - Example

- Example:
- A 75yo pt. With 2.5 D @ 180°:
- Use paired 45° cuts (Koch) at the limbus at the 3 o'clock position or paired 50° cuts (Nichamin) at 180°

Koch Nomogram ATR

Cataract WTR Astigmatism (steep meridian at 090)*			
Pre-op Astig	Age	Number	Length
0.75 - 1.00 D	-65	2 or 1	45° = 4.5mm
			60° = 4.0mm (if asymmetric)
	-65	1	45° = 4.5mm
1.01-1.75 D	-65	2	60° = 4.5mm
	-65	2 or 1	50° = 5.0mm
	-65	2	60° = 4.5mm (if asymmetric)
>1.75 D	-65	2	80° = 6.0mm (if asymmetric)
	-65	2	60° = 4.5mm
	-65	2	60-70° = 6.0-7.0mm

*combined w/ 3.0mm corneal temporal wound (150°-30° OD, 0°-30° OS)

Cataract ATR/Oblique Astigmatism (steep meridian at 180)*			
Pre-op Astig	Age	Number	Length
>0.4-1.24 D†	---	1	35-40° = 3.5-4.0mm
1.26-3.00 D†	---	2	50° = 3.0mm
	---	1	45° = 4.5mm
>2.00 D	---	2	45° = 4.0mm
	---	2	45° = 4.5mm

*combined w/ 3.0mm corneal temporal wound (150°-30° OD, 0°-30° OS)



III. Peripheral Corneal Relaxing Incisions - Example

- Example:
- A 75yo pt. With 2.5 D @ 180°:
- Use one 6mm cut (Koch) at the limbus at the 3 o'clock position or paired 50° cuts (Nichamin) at 180°

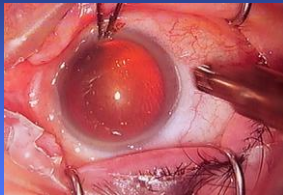
Table II		NOMOGRAM FOR CLEAR CORNEAL PHACO SURGERY					
Lewy D. "Step" Nichamin, M.D., Laurel Eye Clinic, Brookville, PA							
● ASTIGMATIC STATUS = "SPHERICAL" (+0.75 X 90 → +0.50 X 180)							
Incision Design = "Neutral" temporal clear corneal incision (2.5 mm. or less, single plane, just anterior to vascular arcade)							
● ASTIGMATIC STATUS = "BAMNET-THE-RULE" (Steep Axis 0-30°/150-180°) Intraoperative keratometry determines exact incision location							
PRE-OP CYLINDER	30-60 yrs	41-50 yrs	51-60 yrs	61-70 yrs	71-80 yrs	81-90 yrs	> 90
+0.75 → +1.25	steep (vertical axis only)					35°	
	temporal	50°	50°	45°	40°	35°	
+1.50 → +2.00	temporal	50°	45°	40°	35°	30°	
+2.25 → +2.75	temporal	50°	40°	35°	30°	25°	
+3.00 → +3.75	temporal	50°	35°	30°	25°	20°	

*The temporal incision is made by first creating a free-phasic, general-phasic plane (FPG/APL), which is then converted to the appropriate arc length at the conclusion of FPG.



Peripheral Corneal Relaxing Incisions - Technique -

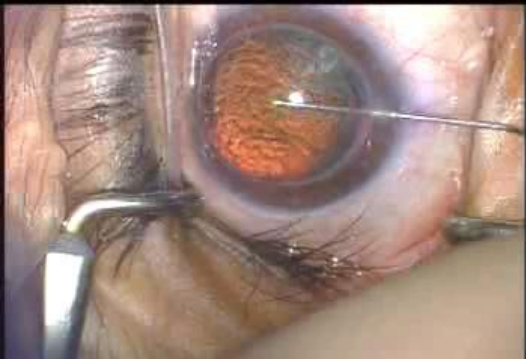
- Make incisions at the beginning of the case
- While the corneal epithelium is still pristine
- While the eye is still closed and IOP is controlled



III. Peripheral Corneal Relaxing Incisions

- After PCRI is made, make your usual temporal cataract incision
- If the PCRI is **against-the-rule**:
 - Limit the PCRI to 3 mm length and make cataract incision within the PCRI
- If the PCRI is **with-the-rule**:
 - Make paracentesis peripherally and PCRI more centrally
- Calculate the IOL in the same way as normal - **no change in spherical equivalent** is produced

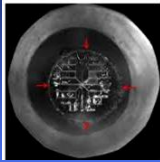
PCRI Video



PCRI w/ ReSTOR



Femto-second LRIs



Femto LRI Video

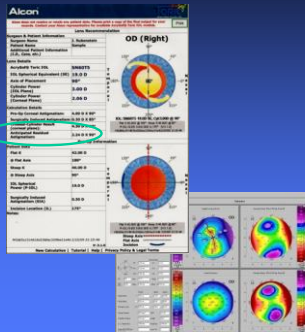


Complications

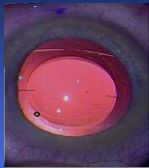
- Under correction
- Over correction - including flipped axis
- Perforation - examine peripheral cornea pre-op to look for peripheral thinning
- Wound leak
 - ◆ Relaxing incision made coincident with cataract wound at 180°
 - ◆ Secondary to tear of the PCRI
- Interference with paracentesis
 - ◆ PCRI made at 90 degrees

Peripheral Corneal Relaxing Incisions Special Indications

- High corneal astigmatism
 - > 5.00 D
 - Combine PCRI with Toric IOLs
- Low corneal astigmatism
 - 0.75 - 1.25 D
- Irregular corneal astigmatism
 - Non-orthogonal axis
 - When exact axis in question
- Inability to implant a planned Toric IOL secondary to capsular break or zonular instability, still can correct cylinder with a PCRI



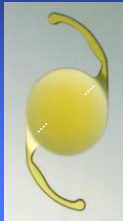
Toric Lenses



STAAR



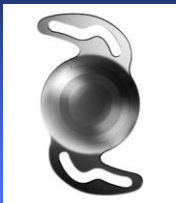
Alcon



Rayner Toric IOLs



C-flex IOL (570C)



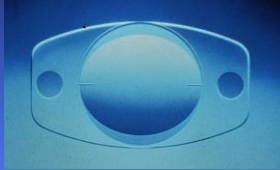
Superflex® IOL (620H)



Sulcoflex® Toric (653T)

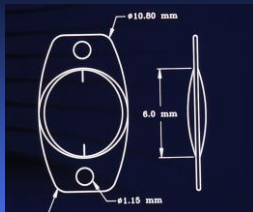
II. Staar Toric IOL

- A. A plate-haptic style foldable silicone IOL
- B. A biconvex 6mm optic IOL with a spherocylinder anterior surface and a spherical posterior surface



II. Staar Toric IOL

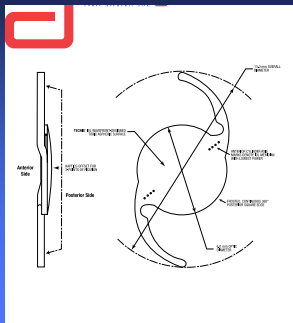
- C. The interhaptic diameter is 10.8 mm with a 1.15 mm round hole
- D. Powers of 2.0 D and 3.5 D that can correct from 1.5 - 3.5 D of preoperative astigmatism



II. Staar Toric IOL

- Complications:
 - ◆ Decentration of IOL - ?? increased in plate IOL's?
 - ◆ Lens rotation or shift
 - ◆ Lose 3.3% of cylinder with each degree off axis
 - ◆ May need manipulation of IOL, at slit lamp or in the OR
 - ◆ Increased posterior capsule opacification??
 - ◆ Increased pitting of silicone with YAG??
 - ◆ Bad IOL for Pt.s at risk for vitrectomy

TECNIS Toric Aspheric IOL



TECNIS Toric Aspheric IOL

Cylinder Power Options

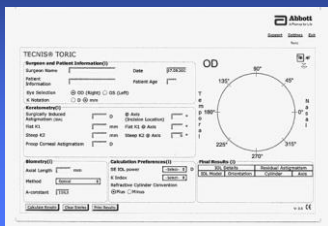
Lens Model	ZCT180	ZCT150	ZCT225	ZCT300	ZCT400
Cylinder Power					
IOL Power	1.00 D	1.50 D	2.25 D	3.00 D	4.00 D
Corneal Plane*	0.89 D	1.03 D	1.54 D	2.06 D	2.74 D
Corneal Anticipation	0.50-0.75 D	0.75-1.50 D	1.50-2.00 D	2.00-2.75 D	>2.75 D
Correction Range					

*Based on average pseudophakic human eye.



TECNIS Toric Aspheric IOL

- On line toric calculator
- www.tecnistoricalc.com



Trulign Toric Accommodating Intraocular Lens

Based upon the Crystalens AO platform



Trulign Toric Accommodating Intraocular Lens

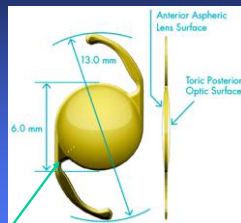
- Astigmatic powers
 - 1.25, 2.00, 2.75 D
 - 0.83, 1.33, 1.83 D at the corneal plane
- Spherical power
 - 17.0 - 25.0 D

Trulign online IOL calculator



AcrySof® TORIC IOL

- Design
 - AcrySof Single-Piece platform
 - Aspheric
 - Posterior toricity
 - Spherical Power +6 to +30 D
 - Astigmatic power 1 - 5 D
- Dimensions
 - Overall length: 13.0 mm
 - Optic diameter: 6.0 mm
 - A-Constant - 119.0 for SN6AT
- Delivery
 - Monarch III Injector
 - B, C or D Cartridge



Steep K alignment marks

Cylinder Powers

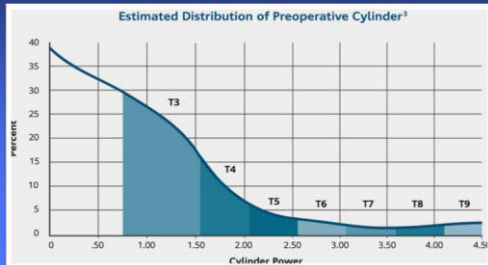
A wide range of cylinder powers means more candidates can benefit from AcrySof® IQ Toric IOL.

ALCON® LENS MODELS		SN6AT3	SN6AT4	SN6AT5	SN6AT6	SN6AT7	SN6AT8	SN6AT9
Cylinder Power (C)	IOL Plane	1.50 D	2.25 D	3.00 D	3.75 D	4.50 D	5.25 D	6.00 D
	Corneal Plane*	1.03 D	1.55 D	2.06 D	2.57 D	3.08 D	3.60 D	4.11 D
Recommended Corneal Astigmatism Correction Range		0.75 D to 1.54 D	1.55 D to 2.05 D	2.06 D to 2.56 D	2.57 D to 3.07 D	3.08 D to 3.59 D	3.60 D to 4.10 D	4.11 D and up

*Based on average pseudophakia from c.c.s.

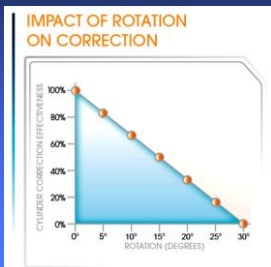
Cylinder Powers

Distribution of Pre-operative Cylinder



Rotational Stability – Important!

IOL rotation can have significant impact on astigmatism correction.



- › Generally, for every 1° of IOL rotation, 3.3% of lens cylinder power is lost².
- › A complete loss of cylinder power can occur with a rotation of >30°².

Toric IOL Procedural Considerations

- Surgeon performs standard cataract procedure from capsulorhexis through phacoemulsification
- Toric IOL implantation requires only minor variation from standard procedure:
 1. IOL calculation
 2. Marking of the eye
 3. IOL alignment (on-axis)

1. IOL Calculation

Step I:

- Determine required spherical power using preferred method

Step II:

- Utilize AcrySof Toric IOL Calculator to determine
 - ◆ The correct Toric model
 - ◆ Optimal axis location of the IOL
 - ◆ www.acrysoftoriccalculator.com

AcrySof® IOL Calculator Home Page

ACR Sof® Toric IOL Web Based Calculators Alcon

Please select the appropriate AcrySof® Toric IOL model for implantation.

Model	Model	Model
SNI071	SNI073	SNI072
SNI074	SNI074	SNI073
SNI075	SNI075	SNI074
SNI076	SNI076	SNI075
SNI077	SNI077	SNI076
SNI078	SNI078	SNI077
SNI079	SNI079	SNI078

Suggested A-Constant: 119.4

Suggested A-Constant: 119.0

Suggested A-Constant: 119.8

AcrySof® Toric IOL AcrySof® IQ Toric IOL AcrySof® IQ ReSTOR® Multifocal Toric IOL

AcrySof Toric IOL Calculator

Precision Calculations:

- Uses vector analysis to determine correct axis
- Compensates for surgically induced astigmatism

Data Input:

- Preoperative manual keratometry
- IOL power
- Incision location
- Estimated surgically induced astigmatism

The screenshot shows the Alcon AcrySof Toric IOL Calculator interface. The top section is titled "Let's Recommendations" and includes fields for Doctor & Patient Information and Lens Details. The "Lens Details" section shows: AcrySof Toric IOL (5.00D), K1 Spherical Equivalent (M) (22.0 D), K1 Cylinder (D) (3.25 D), and Incision Location (225°). The "Refraction Details" section shows: Preop Spherical Equivalent (2.00 x 90°), Surgically Induced Astigmatism (0.85 x 90°), Estimated Spherically Equivalent (2.00 x 90°), and Estimated Cylinder Result (Dx plane) (0.85 x 90°). The "Patient Data" section shows: Preop K1 (42.00 D), Preop K2 (43.00 D), IOL Power (43.00 D), and Incision Location (225°). Two diagrams show the eye's principal meridians with axes marked.



2. Marking of the Eye

I. Reference Marks (pre-op)

- Single mark at 6:00 limbus
- Patient in sitting position (avoid cyclotorsion)

II. Axis Marks (intra-op)

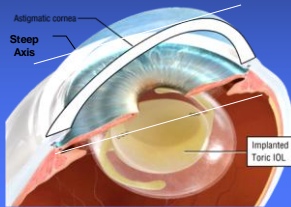
- Axis marks identify the optimal axis of IOL placement
- Axis marks are placed on the eye using 6 o'clock pre-op reference mark for alignment steep axis



3. IOL Alignment

3 Step Procedure:

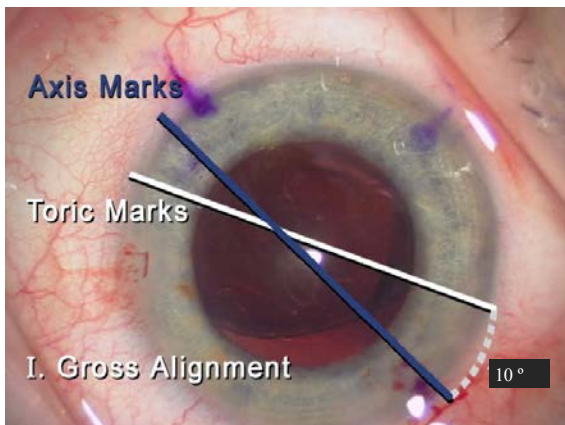
- I. Gross alignment
- II. Removal of OVD
- III. Final alignment



IOL Alignment

I. Gross Alignment

- ◆ Rotate IOL clockwise to approximately 5 - 10 degrees short of desired position or on axis if can be kept stable
- ◆ Complete while the IOL is unfolding in the capsular bag



IOL Alignment

II. Stabilize IOL During OVD Removal

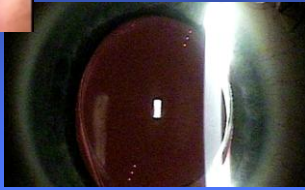
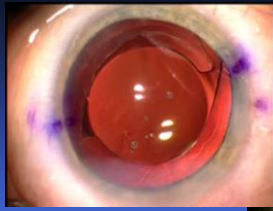
- ◆ Take care to prevent IOL from rotating past intended axis during OVD removal
 - 2nd instrument
 - I/A tip - polyester
 - Bi-manual I/A
- Thoroughly remove all the OVD from behind IOL



IOL Alignment

III. Final Alignment

- ◆ Carefully rotate IOL clockwise precisely onto the intended axis of alignment with infusion running
- ◆ Tap IOL down into capsular bag to seat lens in place



Patient Selection

- 1 to 5 diopters of cylinder
- Intact capsule
- Continuous curvilinear capsulotomy (CCC)
- In the bag lens placement

Alcon Toric



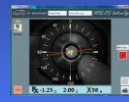
Alcon Toric



New Technology

Refining the Astigmatism axis location

- TrueVision 3D system
- Clarity-Holos
- Verion



New Technology

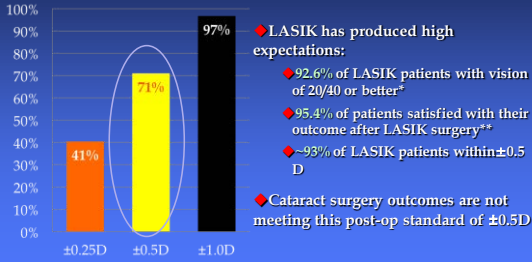
Intra-operative aberrometry

WaveTec
ORA



Need for this new technology High Patient Expectations in Cataract Refractive Surgery

Cataract Outcomes***



- ◆ LASIK has produced high expectations:
 - ◆ 92.6% of LASIK patients with vision of 20/40 or better*
 - ◆ 95.4% of patients satisfied with their outcome after LASIK surgery**
 - ◆ ~93% of LASIK patients within ± 0.5 D
- ◆ Cataract surgery outcomes are not meeting this post-op standard of ± 0.5 D

* U.S. News & World Report "Best Hospital" (2013-2014) based on patient satisfaction scores. ** American Optometric Association (2013) based on patient satisfaction scores. *** Current Data on Cataract Surgery Outcomes: A Review of the Literature. JAMA Ophthalmol. 2013;31(10):1414-1421.

Outcomes Not Meeting Expectations...

% of Eyes within 0.50 D of Intended Target



Sources of Post-op Error



- Biometry
- Transcription
- Astigmatism Planning
- Manual marking
- Cyclorotation
- Incision effects
- Capsulorhexis
- IOL positioning

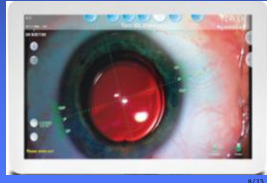
Possible Fix The VERION Image Guided System

Designed to add greater astigmatic accuracy during surgical planning and execution.

VERION™ Reference Unit



VERION™ Digital Marker



8/13

VERION Reference Unit

Image:

- ◆ Captures a high-resolution reference image of the patient's eye
- ◆ Auto-detects scleral vessels, limbus, pupil and iris features
- ◆ Measures keratometry, pupillometry

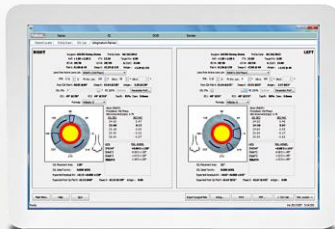


VERION Reference Unit

Plan:

Enables surgeons to determine an optimized surgical plan:

- ◆ Multiple IOL formula calculations, yielding lens power selection
- ◆ Incision and implantation axis planning



Comprehensive Astigmatism Planner

IOL 64%
 RI 36%
 RI1: 22° @101° RI2: 22° @281°

The astigmatism slider bar allows surgeons to select their preferred balance of correction between IOL power and relaxing incisions in a single calculation.

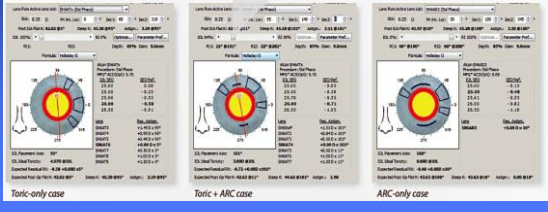


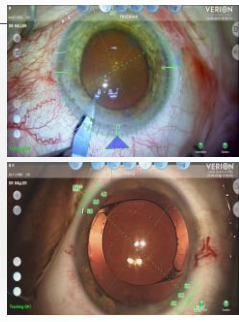
Image and Plan Video



VERION Digital Marker

Guide

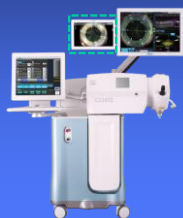
- ◆ Displays patient information and images from the VERION Reference Unit:
 - ◆ A tracking overlay enables surgeons to see all incisions and alignment in real time
 - ◆ Tracking accounts for cyclorotation
 - ◆ Eliminates the need for manual eye markings
 - ◆ Assists in accurate centering and alignment of multifocal and toric IOLs



VERION™ Digital Marker

The VERION Digital Marker can be used with the LenSx Laser as well as most surgical microscopes.

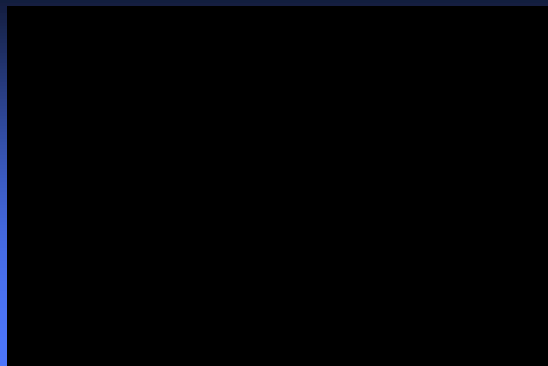
With LenSx Laser:



With OR Microscope:



LenSx Laser Dock



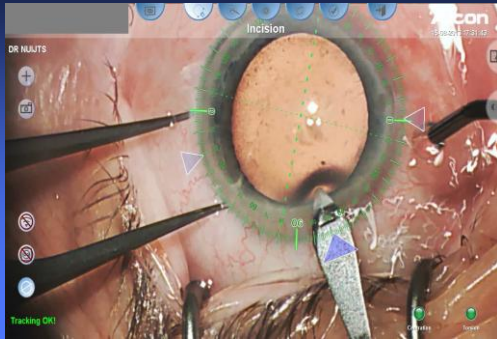
VERION Digital Marker

Registration at the Scope (after LenSx Laser)



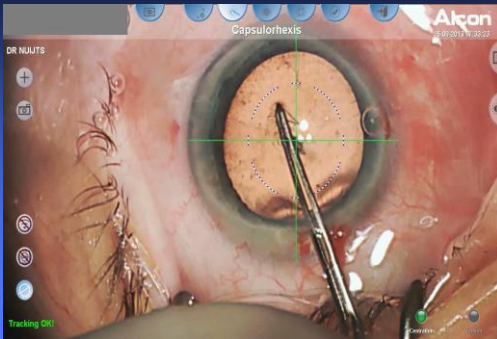
VERION Digital Marker

GUIDE: Std Phaco Incisional Plan



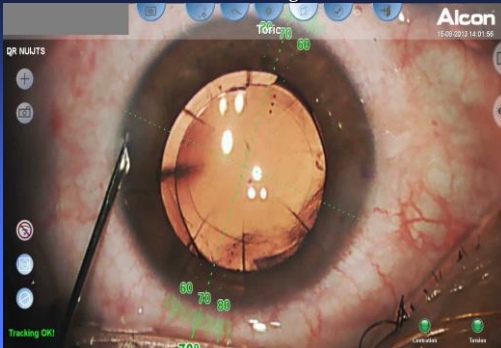
VERION Digital Marker

GUIDE: Std Phaco Capsulorhexis



VERION Digital Marker

GUIDE: Toric Alignment Plan



New Developments

Intra-operative aberrometry

WaveTec
ORA



The ORA System

- Provides on demand information which assists in intraoperative decision making
- Utilizes Talbot Moiré interferometry
- Enables real-time surgical course correction
- Attaches directly to existing surgical microscopes



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ORA System Components

Analyze-OR™
Web Based
Data System



Allows for entry of pre and post-op information into the database from any computer via the web. Entering post-op results facilitates optimizing ORA IOL power calculations

Aberrometer



ORA provides both Aphakic & Pseudophakic refraction for:

- IOL power calculation
- Axis of astigmatism
- Magnitude of astigmatism

Surgical
Cart



The monitor displays:

- 3 camera view of the eye during the measurement process
- On-demand refractive information

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VerifEye



VerifEye is the new monitoring hardware upgrade that provides continuous refractive information

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VerifEye

- ◆ Streaming refractive information
- ◆ Verifies that the eye is stable and ready for measurement
- ◆ IOL power recommendations
- ◆ Astigmatic guidance
- ◆ Shorter measurement time
 - ▶ Faster processor
 - 2 seconds for measurement
 - 3 seconds for processing

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Requirements for Successful Measurement

Four Simple Characteristics

Widely Opened Eye	Well Hydrated Eye	Well Pressurized Eye	Well Aligned Eye
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ORA with LRI



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ORA with Toric IOL



In Summary

- Need to know how and when to use both Toric IOLs and PCRIIs
- PCRIIs - remain a necessary part of your surgical armamentarium
