



## Financial Disclosure

- I have the following financial interests or relationships to disclose:

- Abbott Medical Optics: C;
- AcuFocus, Inc.: C,O;
- Alcon Laboratories, Inc.: C;
- ArcScan: C,O;
- Calhoun Vision: C,O;
- Carl Zeiss Inc: C;
- Elenza: C,O;
- Oculus, Inc.: C;
- Visiometrics: C,O;

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## 4 Questions to Answer

- How do we measure outcomes?
- What are our current outcomes?
- What are our current limits?
- What is our near future hold?

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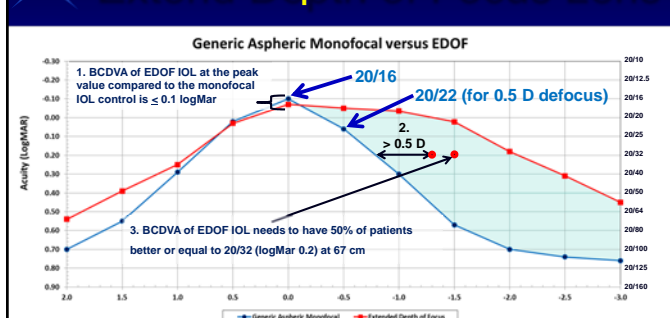
## IOL Optical Comparison

IOL Type	Theoretical BSCVA	Actual BSCVA	Contrast Loss	Halos & Glare	Forward Light Scatter
Aspherical Mono	20/09	20/16	0%	-	0%
Spherical Mono	20/12	20/20	10%	+	0%
EDF 1.50 D (1.00)	20/16	20/17	20%	+	10%
Diffraction Multi 3.00 D (2.00)	20/20	20/22	25%	++	18%
Diffraction Multi 4.00 D (2.75)	20/20	20/22	30%	+++	18%

LA Dodgers 1993-1995: 1.7% from 20/8.9 to 20/9.2

42% ≤ 20/12.5 AJO 1996; Oct 122 (4): 476-85.

## Extend Depth of Focus Lens



## Total BLUR must be < 0.50 D

- $\text{SEQ} + \text{CYL} < 0.50 \text{ D}$
- $0.25 + 0.25 = 0.50 \text{ D}$
- $0.50 + 0.00 = 0.50 \text{ D}$
- $0.00 + 0.50 = 0.50 \text{ D}$

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## Outcomes – Prediction Error

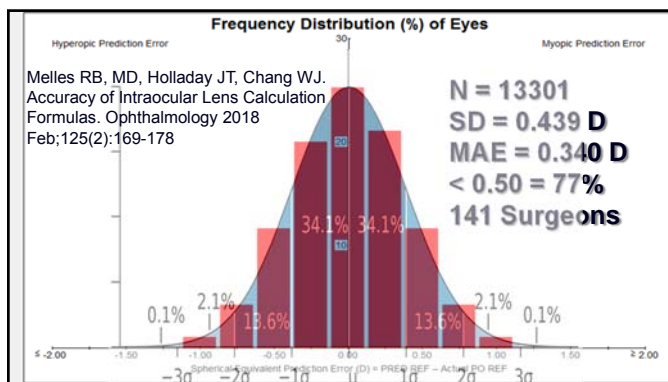
Difference in  
Predicted Ref and the  
Actual Ref

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## Formula Performance Prediction Error (PE)

- Optimized => Mean PE ( $\mu$ ) = 0
- Std Dev ( $\sigma$ ) or MAE
- % within  $\pm 0.50$  D
- “All comers” – cannot exclude outliers, out of boundary, target not emmetropic, small ACDs ...

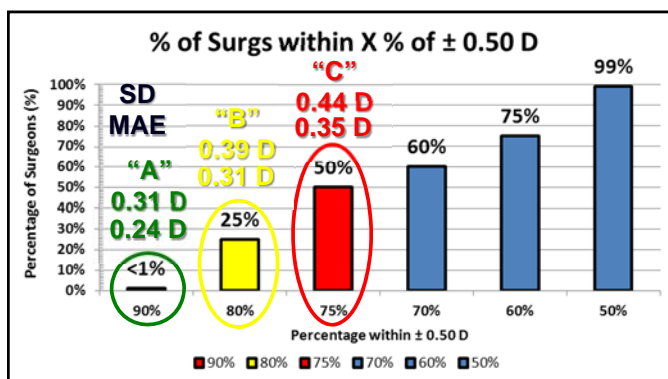
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## PE is always Gaussian (NL)

	“C” Average	“B” Excellent	“A” Best
SD	0.48 D	0.39 D	0.31 D
MAE	0.39 D	0.31 D	0.24 D
$\pm 0.50$	70%	80%	90%

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## Data Screening Identifies Measurement Error - Repeat

- Binocular
  - AL difference > 0.3 mm
  - K difference > 1.0 D
  - IOL power difference > 1.0 D
- Monocular
  - AL Signal/Noise (S/N) Ratio < 2.0
  - K Std Dev ( $\sigma$ ) > 0.20 D

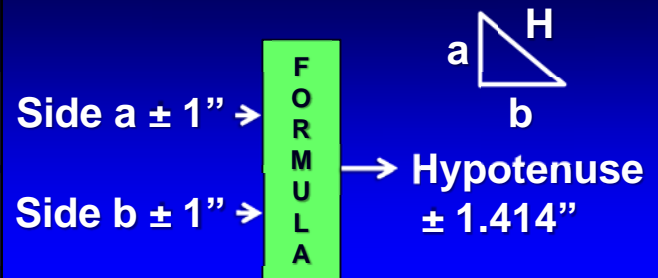
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### Alcon Purchase: Wavetec (ORA)

- Had to show statistical superiority to H2 IOL Calc within  $\pm 0.50$  D
- H2 = 82%      ORA = 92%  
18%      vs      8%

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### Tolerances/Errors



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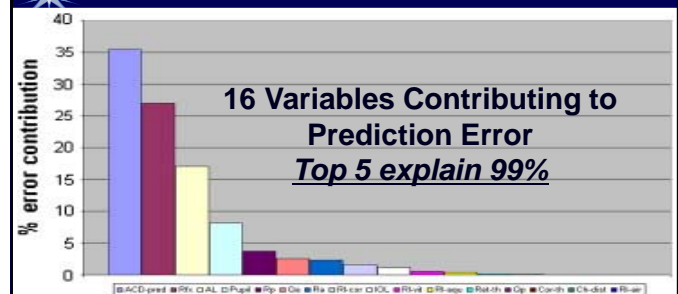
### Sources of error in intraocular lens power calculation

Sverker Norrby, PhD

J Cataract Refract Surg 2008; 34:368–376

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Figure 1



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#### Major Factors (>99%)

Pred ELP = 35%  
PO Spec Ref = 27%  
AL = 17%  
Pupil Size = 8%  
K post rad = 4%  
Ant Corneal Q = 3%  
K ant rad = 3%  
Cornea Ref Indx = 2%  
IOL Power = 2%

#### Minor Factors (< 1%)

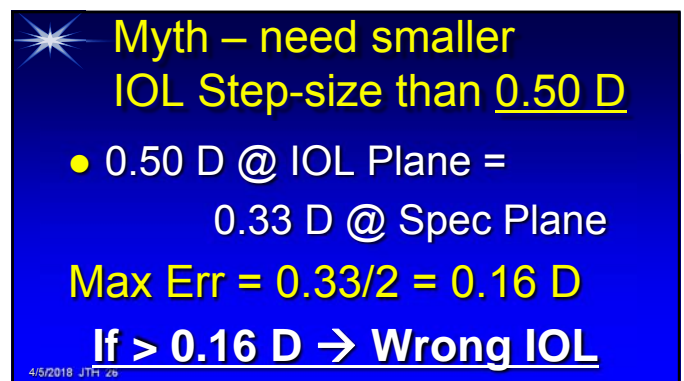
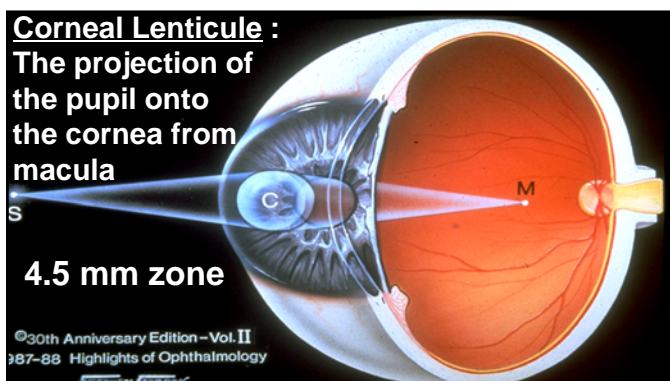
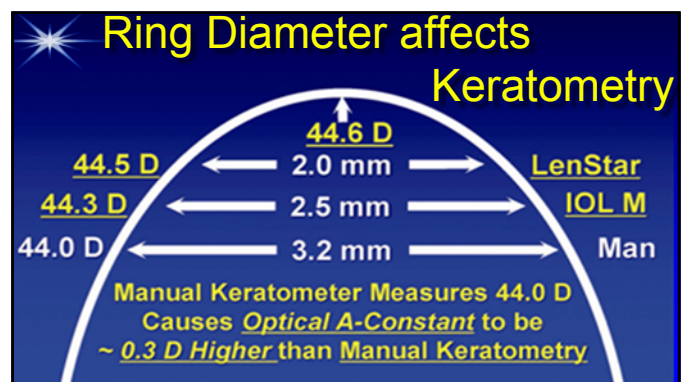
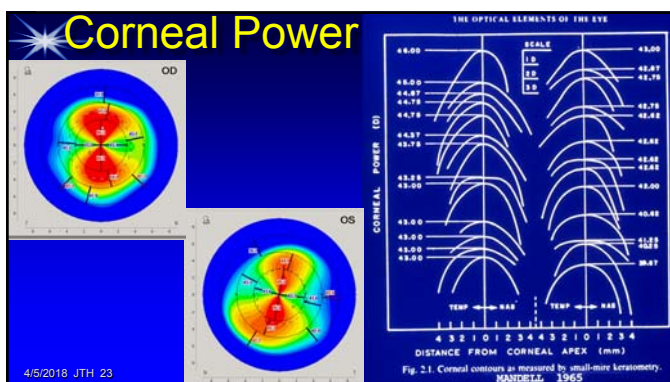
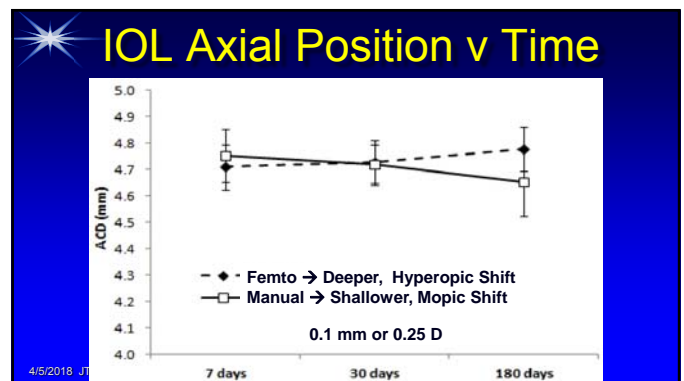
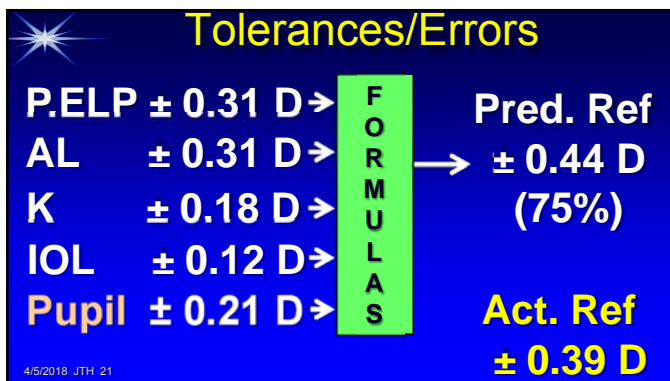
Vitreous Ref Index <1%  
Aqueous Ref Index <1%  
Retinal Thick <1 %  
Post Cornea Q <1 %  
Cornea Thick <1 %  
Chart Dist <1 %  
Air Ref Index <1 %

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### 99% Contribution to PE

Vari.	%	SD (D)	MAE (D)
① ELP	35%	0.31	0.24
② Ref	27%	0.39	0.31
③ AL	17%	0.31	0.24
④ K	10%	0.18	0.14
⑤ Pupil	8%	0.21	0.16

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## Current Accuracy Limitations

- AL, K & Ref **measurement error**
- Corneal Back Surface measurement  
**EVOLVING**
- IOL Radii, asphericity and thickness  
**PROPRIETARY**
- Prediction of **ELP NOT EXACT** and  
**Evolving**

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# IOL Power Selection Methods

- 1 Thin IOL Vergence Formula
  - Binkhorst, Holladay, SRK, ...
- 2 Thick IOL Vergence Formula
  - Holladay 2, Olsen 2, Barrett 2
- 3 Ray Trace
  - Preußner, Findl, Olsen, Hoffman, Wahl
- 4 Neural Network
  - Kaprowski, Clarke, Hill

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# IOL Power Selection Methods

- Thin IOL Vergence Formula:
  - Cannot adjust for variations in IOL Thickness
- Thick IOL Vergence Formula:
  - Cannot adjust for aspheric IOLs
- Ray Trace:
  - Cannot adjust for systematic errors in Biometer
- Neural Network:
  - Is still limited by measurement error and variability in ELP

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## Tolerances/Errors

P.ELP	$\pm 0.31$ D	F O R M U L A S	→	Pred. Ref
AL	$\pm 0.31$ D			$\pm 0.44$ D
K	$\pm 0.18$ D			75%
Pupil	$\pm 0.21$ D			
IOL	$\pm 0.12$ D			Act. Ref
				$\pm 0.39$ D

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# Future Is Now!

## Post Operative Adjustment

- Light Adjustable IOL
  - RxSight (Calhoun) – Ron Kurtz
  - FDA Nov 22, 2017
- Femto Adjustable IOL
  - Perfect Vision – Steven Smathers
  - Clerio - Mike Totterman

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## Light Adjustable Lens Technology

- The first truly custom IOL; designed to be noninvasively **adjusted** after implantation using proprietary UV light
- ~2-3 weeks after cataract surgery, surgeon enters desired refractive change into the Light Delivery Device (LDD)
- Multiple light adjustment treatments can be performed (as needed), and then vision is permanently locked in
- **91.8% of eyes achieved result within 0.50 D** of target MRSE (similar to refractive accuracy seen in recent LASIK studies<sup>1</sup>).



### Conclusion

We are at the beginning of a paradigm shift where every surgeon will achieve  $\geq 92\%$  of cases within  $\pm 0.50$  D by adjusting the IOL postoperatively

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### Conclusion

Our Outcomes will ONLY BE limited by the ACCURACY and STABILITY of our REFRACTION!

Just like REFRACTIVE SURGERY!

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**!Thank You!**

