

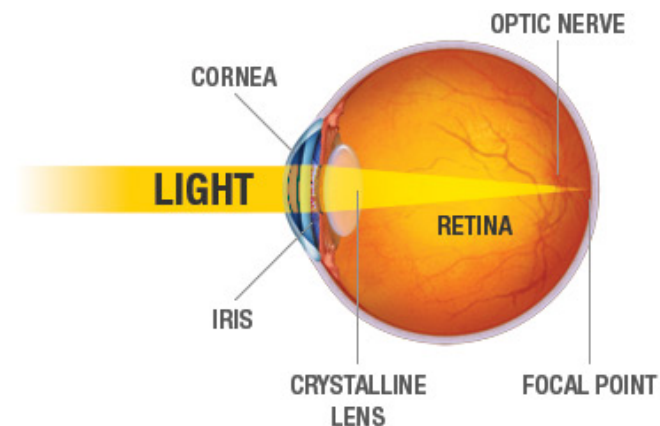
# Recent Advances in Cataract Surgery

Brian Nichols, MD, PhD  
Boulder Eye Surgeons  
303-500-6918



## How Vision Works

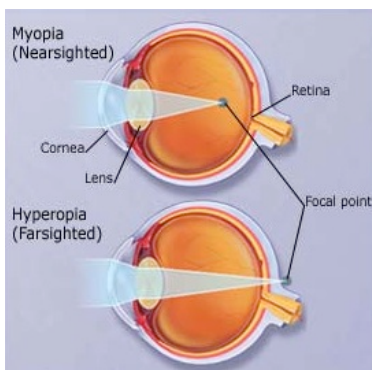
The cornea and the lens work together to focus images in the eye



## Near and Farsightedness

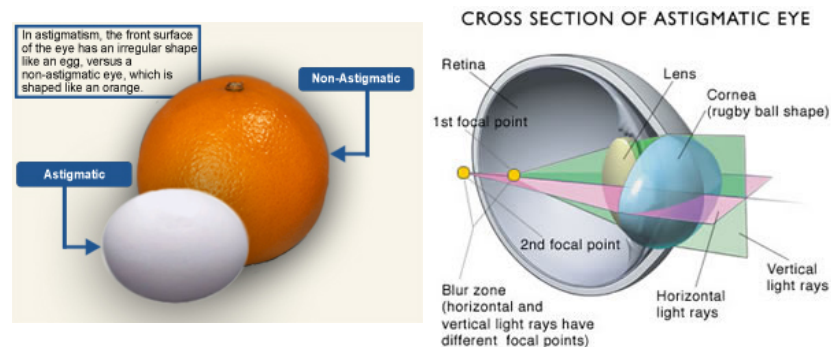
**The Nearsighted Eye** - the cornea is too steep and/or the eye is too long.

**The Farsighted Eye** - the cornea is flat and/or the eye is too short.



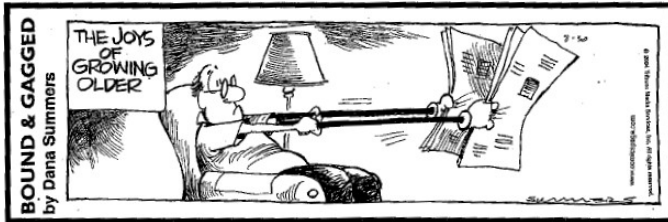
## Astigmatism

- “out of roundness” of the eye
  - Usually from the cornea
  - Blurs vision at both far and near



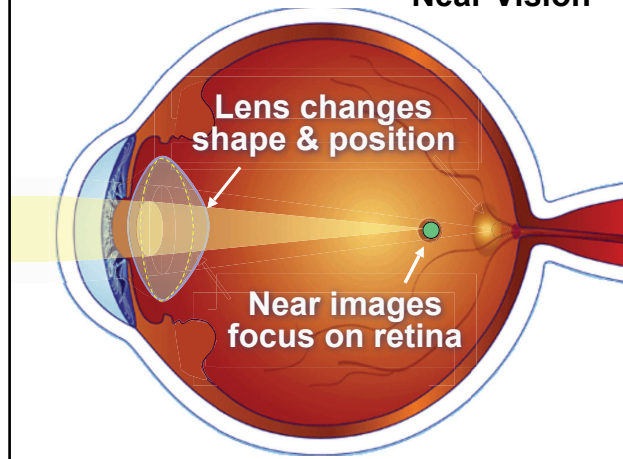
# Accommodation

the automatic adjustment of the eye for seeing at different distances effected chiefly through changes in the position and convexity of the crystalline lens



# Normal Accommodation

Near Vision



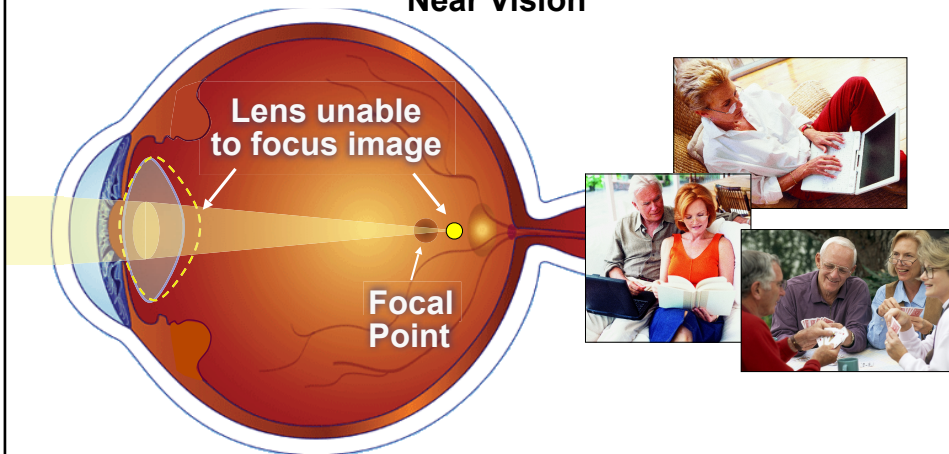
Near vision is clear  
Distance vision out of focus



When looking at near objects, the lens continues to change shape & move forward to focus image

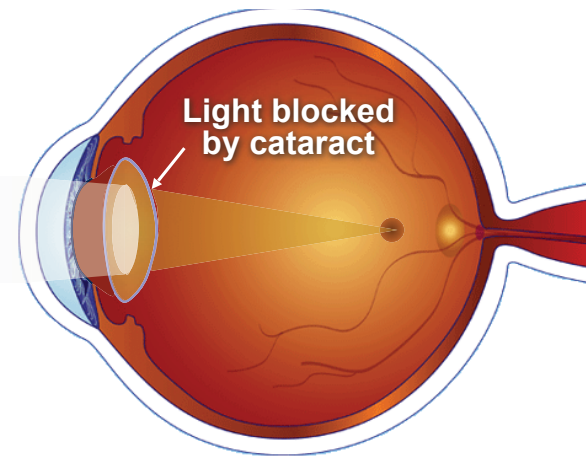
# The Aging Eye

Near Vision

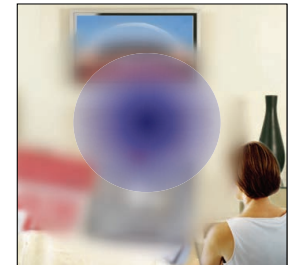


The aging lens loses its ability to change shape  
Reading glasses or bifocals are required  
Loss of Accommodation is called **PRESBYOPIA**

# Cataracts

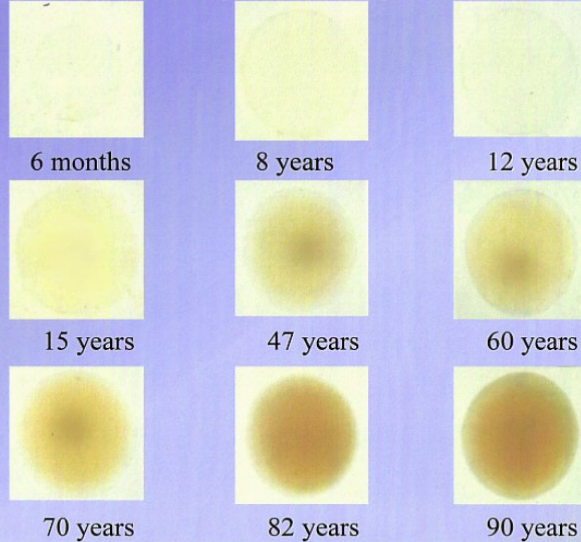


Cataract blocking & distorting central vision



Cataract disrupts transmission of light through lens  
Images may be blurred, dark & distorted

### Changes of a Healthy Human Crystalline Lens with Time

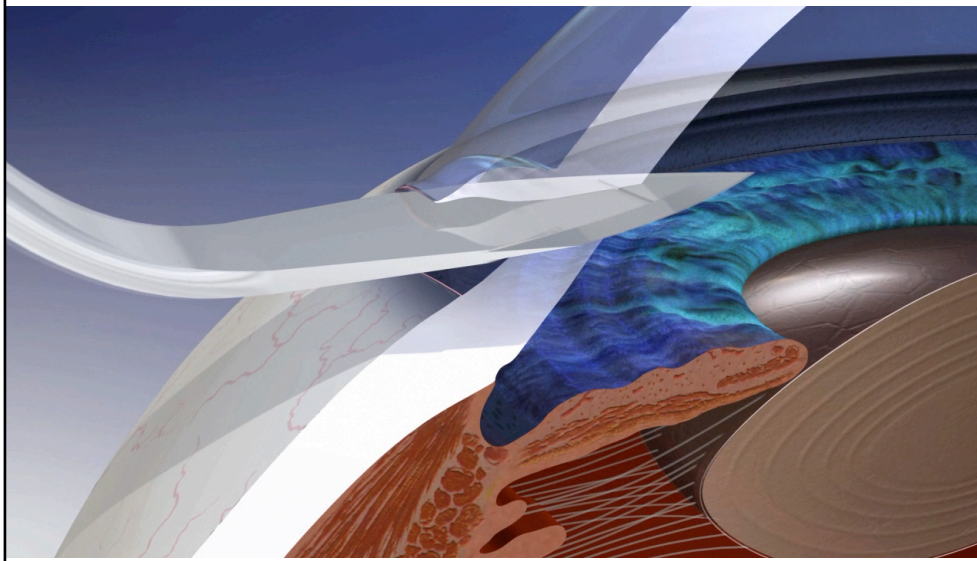


\*photos  
courtesy of  
J. Marshall

## Cataract Surgery

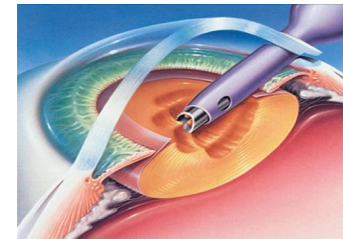
- Most common surgery done in US
- Very successful with greater than 95% enjoying an improvement in vision
- The cataractous lens is removed leaving an empty “bag” of lens capsule
- The human lens is replaced with an artificial lens (intraocular lens)
- Advancements in incision size, irrigation fluid, time, lenses, safety, laser

## Cataract Surgery



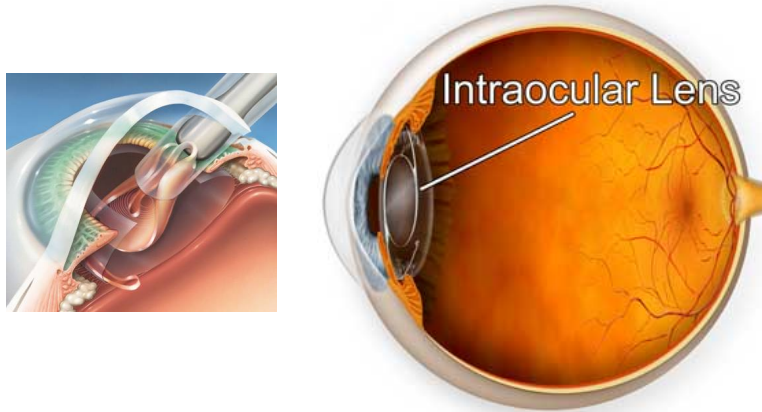
## Cataract Surgery

- Phacoemulsification
  - Surgical procedure to remove a cataract using sound waves to disintegrate the lens which is then removed by suction.
  - 2 mm incision
  - 80% less irrigation



## Intraocular Lens Implantation

- Injectable through small incision



## Recent Advancements

- IMPROVED FRONT TO BACK PROCESS
  - Pre-operative measurements, planning, surgery, and outcomes
- HOW the surgery is performed
  - Femtosecond Laser assisted cataract surgery
- LENS IMPLANT types
  - Astigmatism correction, Multifocal, Accommodating Lens

## Pre-operative measurements

- Biometry
  - Measurements of the length and front curvature of the eye
  - Formulas to calculate PREDICTIVE lens implant power

## Pre-operative measurements

- Ultrasound
  - Gold standard
  - More time consuming
- Laser interferometry
  - LenStar, IOL Master
- Carpenter's adage



## Outcomes data

- Modern cataract surgery has become complicated
  - Planning
  - Intraoperative issues
  - Post-operative outcomes

## Verion Image Guided System

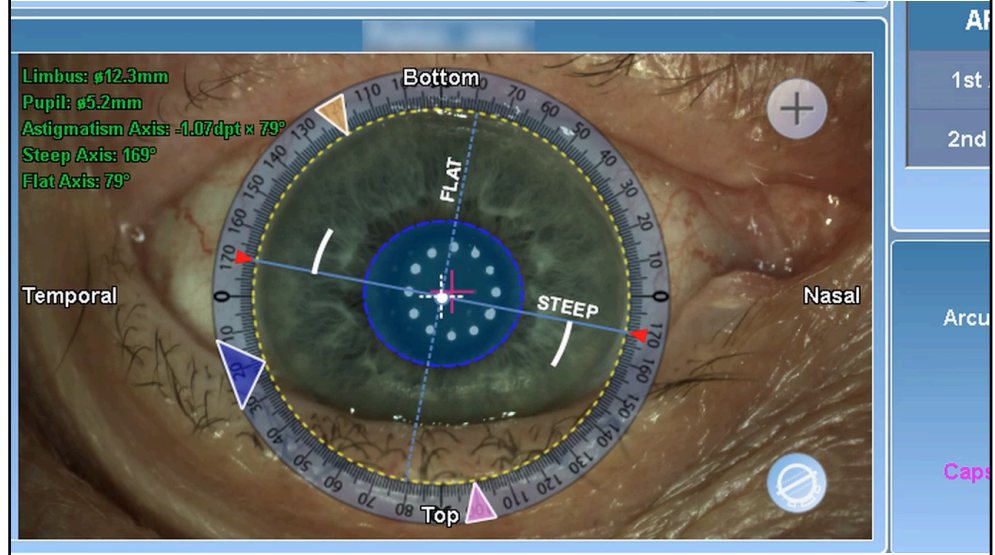
- Pre-operative Reference Unit
  - Astigmatism and rotational management



## Verion Image Guided System



## Verion Image Guided System



## Verion Image Guided System

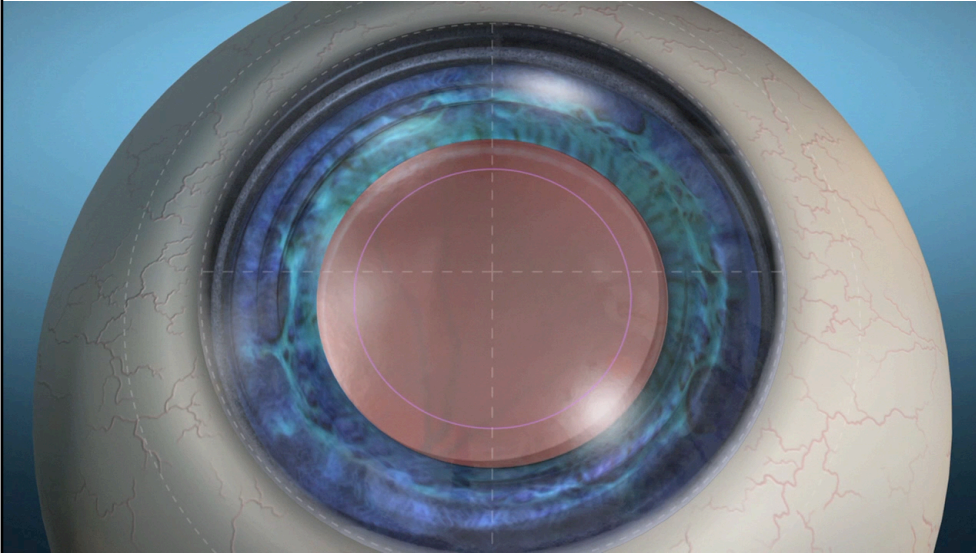
- Outcomes
  - Results collated individually and collectively to improve outcomes
  - Evolving standardization

## Femtosecond Laser for Cataract

- History
  - Developed in 2005
  - First US case in 2010
  - Greater than 100,000 performed worldwide
  - LensX, Catalys, Victus, Ziemer



## Femtosecond Laser for Cataract



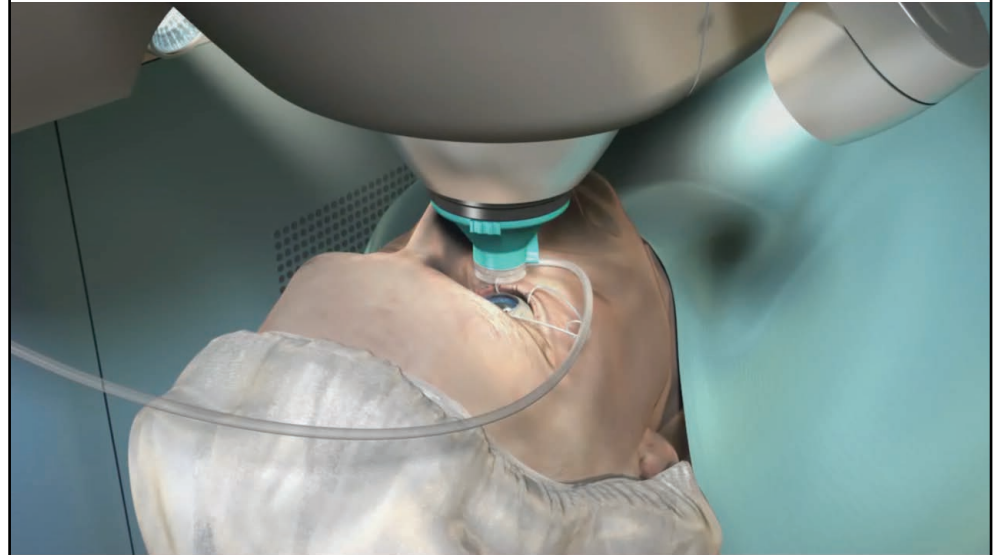
## Femtosecond Laser for Cataract

- Each pulse lasts for about 100 femtoseconds
- Incision is made by photodisruption
  - At the laser focus, Laser Induced Optical Breakdown (LIOB) forms a Plasma Bubble
- Computerized high resolution scanning system directs the laser to the correct spot

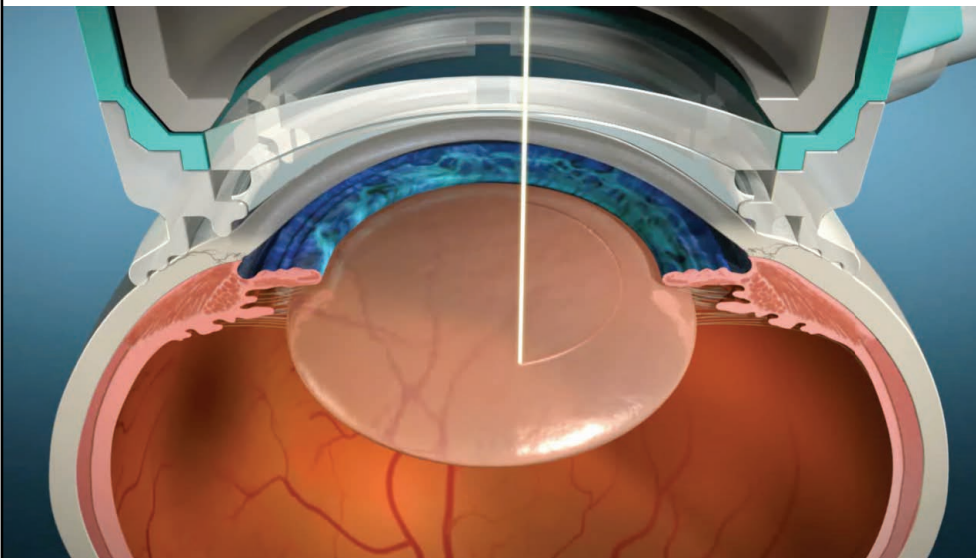
## Femtosecond Laser for Cataract

- Precision, Predictability, and Safety
- Assists cataract surgery
  - Wound construction
  - Capsulorhexis
  - Fragmentation of cataractous lens
  - Astigmatism correction with Arcuate Incisions
    - Adjustability
    - Can be used in conjunction with Toric IOLs

## Femtosecond Laser for Cataract



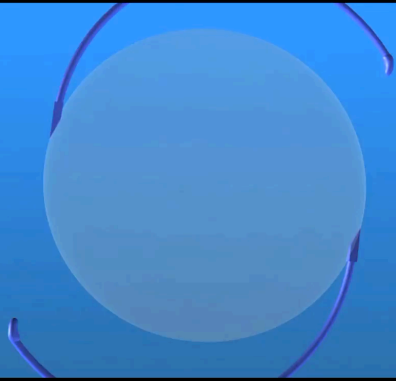
## Femtosecond Laser for Cataract



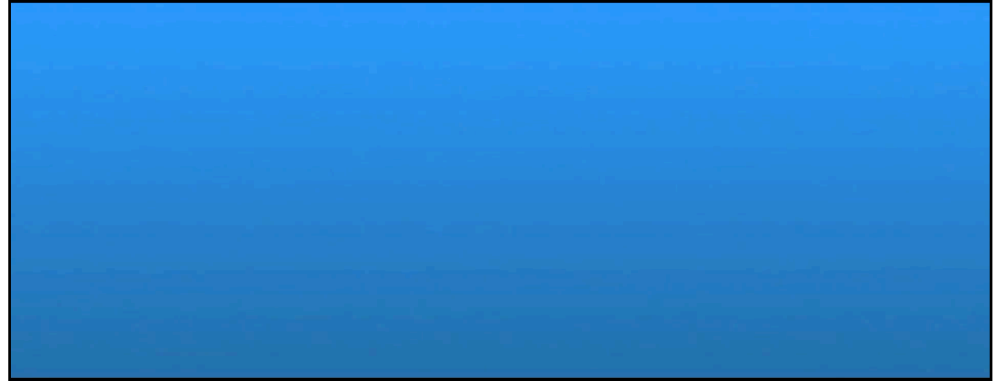
## Intraocular Lenses

- Sir Harold Ridley
  - November 29, 1949
  - PMMA
- Widespread use in 1970s
- Small incision
  - Silicone and acrylic

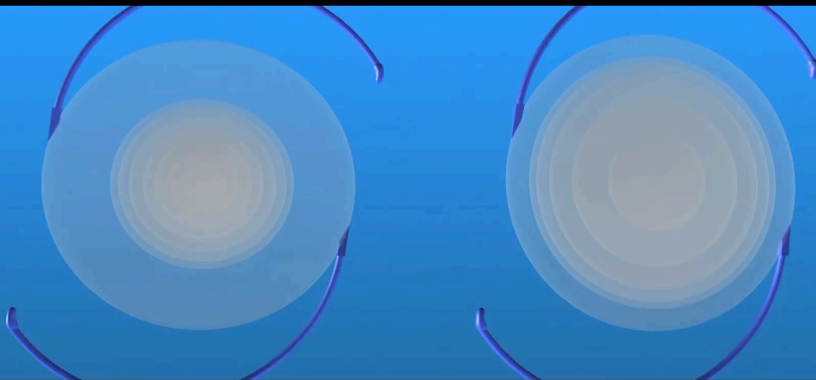
## Monofocal Intraocular Lens



## Toric Intraocular Lens



## Multifocal Intraocular Lens



## Accommodative Intraocular Lens

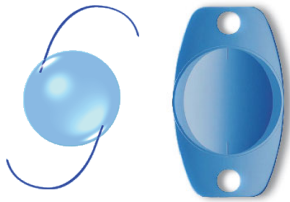




# Differentiating IOLs

IOLs come in different sizes, shapes & materials.  
Each has unique characteristics & capabilities

**Single Power Lenses (Monofocal and Toric)**   **Multifocal/Diffractive Lenses (+/- Toric)**   **Accommodative Lens (+/- Toric)**



- Corrects only distance vision
- Toric lens corrects astigmatism
- Does not accommodate in eye
- Glasses required for near work



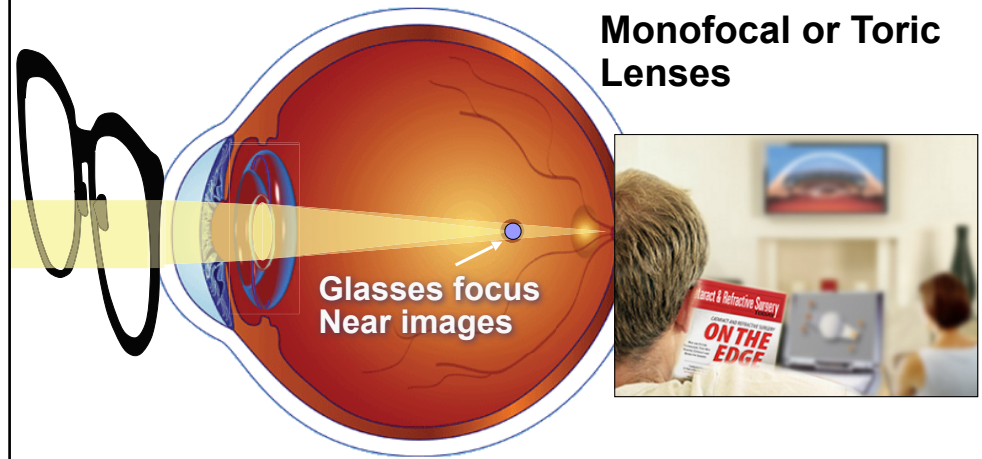
- Multiple, fixed focal points
- Does not accommodate
- Must find appropriate focal point
- Extensive neurological adaptation



- Single focal point
- Full range of distance, intermediate & near vision
- Uses eye's natural focusing mechanism
- Rapid visual recovery

# Near Vision After Cataract Surgery

**Monofocal or Toric Lenses**



Glasses focus Near images

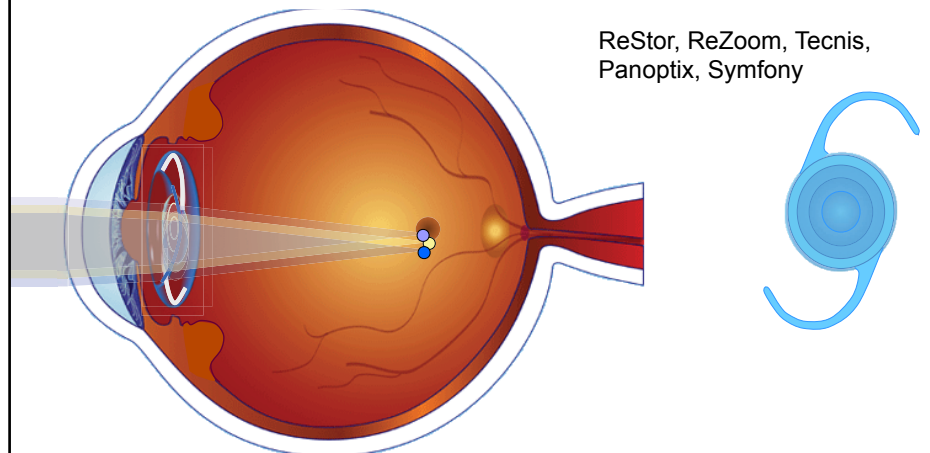
Everyone will need reading glasses after cataract surgery with a single vision lens (monofocal)

# Multifocal/Diffractive Lenses

- Multiple, fixed focal points
- Focus light for distance as well as near
  - Sacrifice some quality of vision for wider range of focus
- ReSTOR
- Rezoom/Array
- Tecnis
- Panoptix
- Symphony

# Multifocal/Diffractive Lens

ReStor, ReZoom, Tecnis, Panoptix, Symphony



Each refractive/diffractive surface on the lens creates multiple focal points in the eye. The eye has to strenuously "learn" to find the correct focal point.

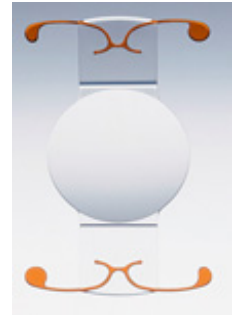
# Multifocal/Diffractive Lenses

- ReZoom FDA data

Distance Visual Acuity Cohort Patients (N = 400)			
	Uncorrected	With best correction	FDA Grid
20/20 or better	39.0% (156)	70.5% (282)	
20/40 or better	91.5% (366)	97.8% (391)	88.0%
20/41 - 20/80	7.5% (30)	1.5% (6)	
Worse than 20/80	1.0% (4)	0.8% (3)	

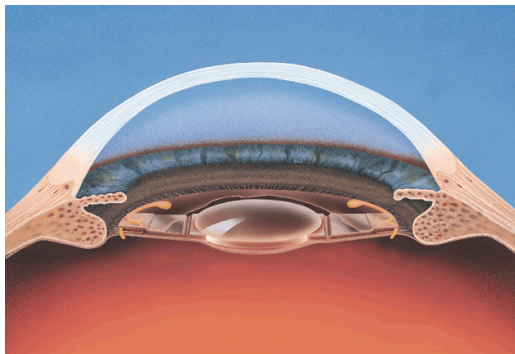
# Crystalens Accommodative Lens

- The first accommodating lens technology approved as safe & effective by the Food & Drug Administration in November 2003.
- 3<sup>rd</sup> generation silicone (biosil)
- 5<sup>th</sup> generation lens
  - Aspheric with better contrast sensitivity
- Over 200,000 crystalens implanted worldwide and more every day.
- The lens uses the natural focusing ability of the eye to provide a single focal point throughout a full range of vision from far, through intermediate to near seamlessly



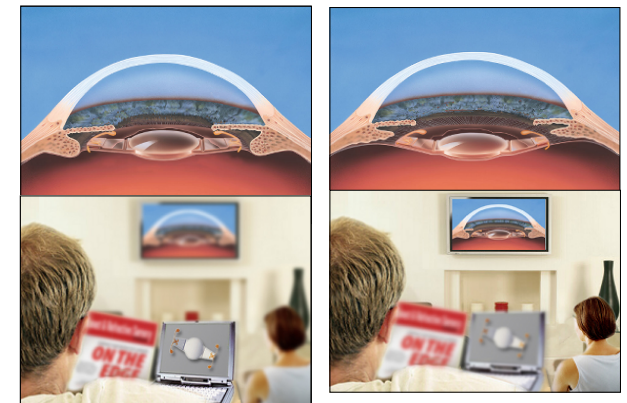
# Crystalens – moving with your own eye muscles

- Accommodation causes the ciliary muscles to contract, displacing the vitreous mass, forcing the lens forward



# Crystalens Accommodating Lens

- A single refractive surface provides a “seamless” transition of a single point of focus from far to near



Arms Length

Distance

# Crystalens

- 16 years of experience with crystalens shows us that visual outcomes and patient satisfaction continue to be excellent.

# Wall Street Journal article

ROCHESTER, Minn.—Jens Ponikau of the Mayo Clinic says he has made a

**10pt**

We sometimes take long walks together if it is warm outside

**8pt - 98.4%**



# Advil packaging

**Directions:**

- Use this product only with chart provided.

**8pt**

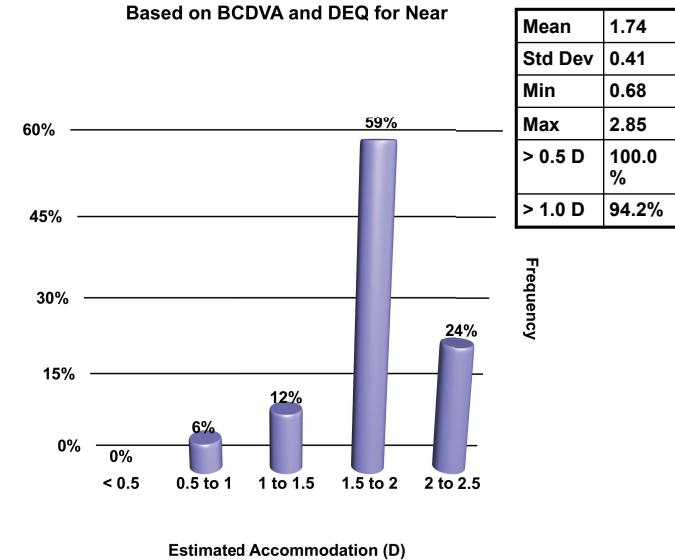
We sometimes take long walks together if it is warm outside

**8pt - 98.4%**

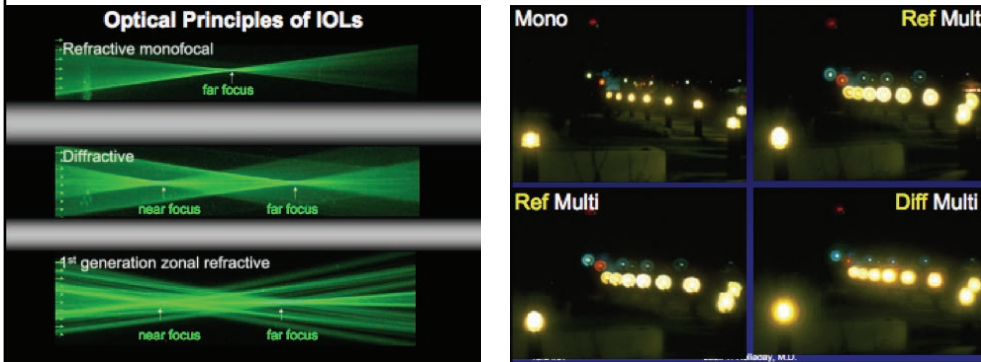


# Crystalens Accommodation

Estimated Accommodation  
Based on BCDVA and DEQ for Near



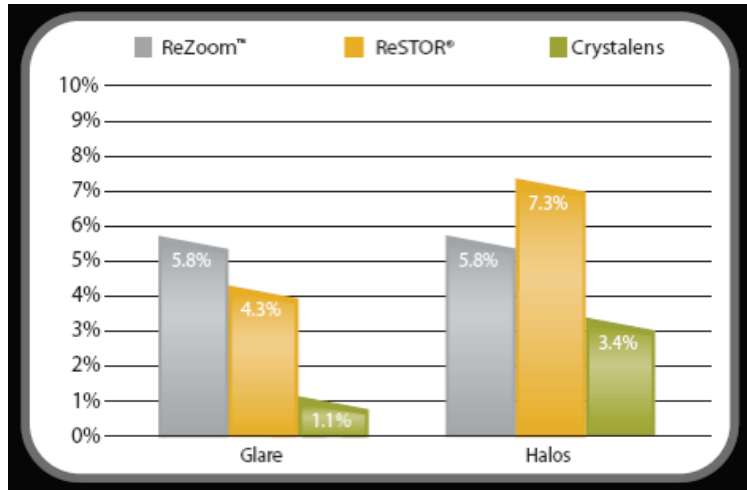
# Refractive Properties of IOLs



# Distribution of Light Rays

	Pupil	ReZoom	ReStor	crystalens
Near	2 mm	0%	40%	<b>100%</b>
	5 mm	32%	84%	<b>100%</b>
Distance	2 mm	83%	40%	<b>100%</b>
	5 mm	58%	10%	<b>100%</b>
Intermediate	2 mm	17%	0%	<b>100%</b>
	5 mm	10%	0%	<b>100%</b>
Lost	2 mm	0%	20%	<b>0%</b>
	5 mm	0%	6%	<b>0%</b>

# Halos and Glare with Multifocals

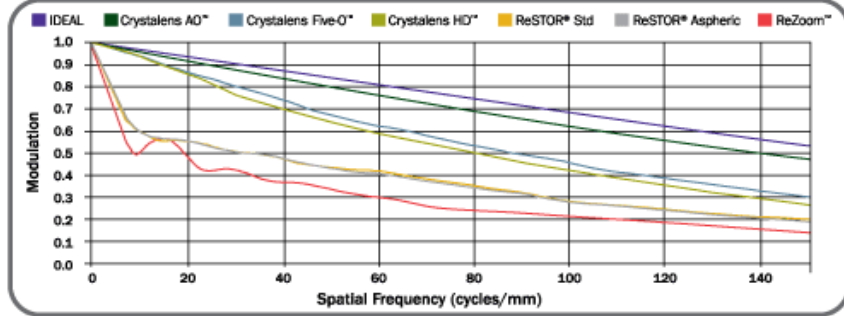


# Contrast Sensitivity

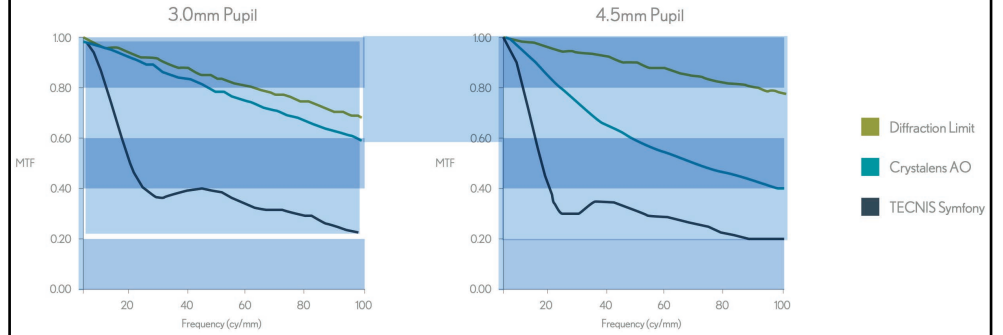
- The ability to see details under low levels of lighting and is important for:
  - Communication. The faint shadows on our faces carry information about our facial expressions.
  - Orientation and mobility. We need to see critical low-contrast things such as curbs, faint shadows, and stairs. Also necessary for safe driving in dusk, rain, fog, snow fall, and at night.
  - Every day tasks. Cutting an onion on light counter, pouring coffee in a dark mug, quality of ironing.
  - Near vision tasks like reading and writing. Poor quality copies or fancy, poorly readable invitations.

# Contrast Sensitivity Comparison

Modulation Transfer Function, +22 Diopter Lenses At 3 mm Aperture



# Contrast Sensitivity Comparison



# Contrast Sensitivity Comparison

Crystalens AO

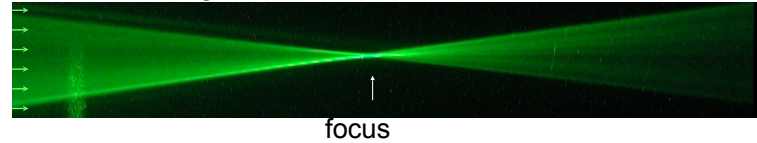


TECNIS Symfony

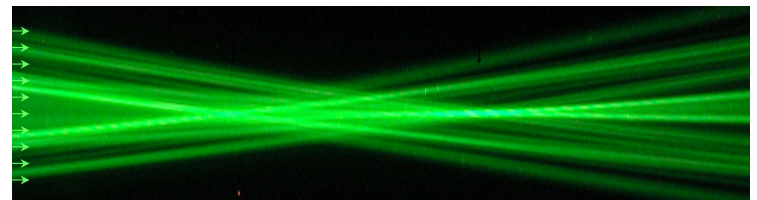
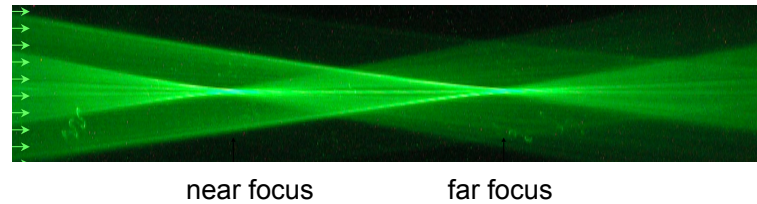


The same study then utilized dual videography to deliver visual confirmation of MTF testing. A dual camera system showed that Crystalens AO has superior optical performance when compared to TECNIS Symfony<sup>®</sup>.

Accommodating



Diffractive



## Differentiate Multifocal/Diffractive from Accommodating IOLs

### Accommodating (Crystalens)

- Directs 100% of the light rays at all distances
- No impact on contrast sensitivity just like a monofocal lens
- Proximity to the nodal point minimizes glare/halo reports
- Less complications when enhancements are necessary post-operatively
- Functions independently of the pupil size
- May need low power readers for some reading

### Multifocal/Diffractive (Symfony)

- Light rays are split which provides less than ideal images at all distances
- Vision can't be optimally corrected with glasses.
- Contrast sensitivity is reduced (driving simulation study) and glare and halos are unavoidable
- Market history (IOL/Contact) has not been good
- Performance is dependent on pupil size
- Intermediate vision suboptimal (Symfony)

## ReSTOR (Multifocal) Warning Label

1. Some visual effects may be expected due to the superposition of focused and unfocused multiple images. These may include some perceptions of halos or radial lines around point sources of light under nighttime conditions.
2. A reduction in contrast sensitivity as compared to a monofocal IOL may be experienced by some patients and may be more prevalent in low lighting conditions. Therefore, multifocal patients should exercise caution when driving at night or in poor visibility conditions.

## What Matters Most in Outcomes?

- Computer/phone usage on the rise
- Don't underestimate the importance of intermediate vision!



## Cataract Surgery Protocol 2015

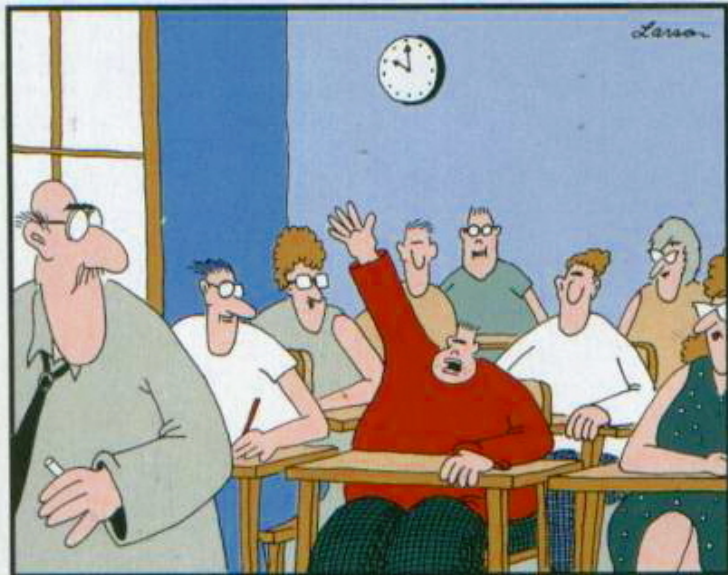
- Standard approach still an excellent option
- Pre-operative measurements and predictive models have improved
- Using multifocal intraocular lenses in selective cases
- Laser preferred
  - Adjustability

# Cataract Surgery Options

GOAL	LENS	LASER
Improved vision with glasses	Monofocal	Safety
Good distance vision without glasses; readers for near vision	Monofocal or Toric (astigmatism)	Accuracy and Safety Arcuate incisions
Good distance and intermediate vision without glasses; occasional readers for near vision	Accommodative (Multifocal)	Accuracy and Safety Arcuate incisions

# Conclusion

- Rapid evolution
- Customized personal treatment
  - Make realistic goals and work back
- Still not perfect nor guaranteed outcomes
- **Talk with your surgeon**



"Mr. Osborne, may I be excused?  
My brain is full."

# Thank you!

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Kevin Cuevas MD



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