STATE BOARD OF OPTOMETRY
2450 DEL PASO ROAD, SUITE 105, SACRAMENTO, CA 95834
P (916) 575-7170 F (916) 575-7292 www.optometry .ca.gov

Continuing Education Course Approval Checklist

Title: IOL Designs and Materials 2017

Provider Name: Dr. Jeong-Ah Jennifer Kim

☑Completed Application
Open to all Optometrists? ☑Yes ☐No
Maintain Record Agreement? ☑Yes ☐No

☑Correct Application Fee

☑Detailed Course Summary

☑Detailed Course Outline

☑PowerPoint and/or other Presentation Materials

☐Advertising (optional)

☑CV for EACH Course Instructor

☑License Verification for Each Course Instructor
Disciplinary History? ☐Yes ☑No

OPTOMETRY PM 5:11
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Cashiering and Board Use Only			
Receipt #	Payor ID	Beneficiary ID	Amount
1-2769	3815685	890747	50

CONTINUING EDUCATION COURSE APPROVAL APPLICATION

$50 Mandatory Fee

Pursuant to California Code of Regulations (CCR) § 1536, the Board will approve continuing education (CE) courses after receiving the applicable fee, the requested information below and it has been determined that the course meets criteria specified in CCR § 1536(g).

In addition to the information requested below, please attach a copy of the course schedule, a detailed course outline and presentation materials (e.g., PowerPoint presentation). Applications must be submitted 45 days prior to the course presentation date.

Please type or print clearly.

Course Title: I IOL DESIGNS AND MATERIALS 2017

Course Presentation Date: 03/14/2017

Course Provider Contact Information

Provider Name

JEONG-AH (First) KIM (Last) JENNIFER (Middle)

Provider Mailing Address

Street 27107 TOURNEY RD **City** SANTA CLARITA **State** CA **Zip** 91355

Provider Email Address jenniferkim100@hotmail.com

Will the proposed course be open to all California licensed optometrists? ☒ YES ☐ NO

Do you agree to maintain and furnish to the Board and/or attending licensee such records of course content and attendance as the Board requires, for a period of at least three years from the date of course presentation? ☒ YES ☐ NO

Course Instructor Information

Please provide the information below and attach the curriculum vitae for each instructor or lecturer involved in the course. If there are more instructors in the course, please provide the requested information on a separate sheet of paper.

Instructor Name

GARY (First) GROESBECK (Last) (Middle)

License Number G52329 **License Type** MD

Phone Number (760) 599-2409 **Email Address** gary.d.groesbeck@gmail.com

I declare under penalty of perjury under the laws of the State of California that all the information submitted on this form and on any accompanying attachments submitted is true and correct.

[signature] ***Signature of Course Provider*** 2-1-17 ***Date***

27107 Tourney Road

Santa Clarita, CA 91355

February 9, 2017

CALIFORNIA BOARD OF OPTOMETRY
2450 Del Paso Road, Suite 105

Sacramento, CA 95834

To whom it may concern:

I am submitting a request for continuing education approval for the Kaiser Permanente Mammoth Ocular Symposium (3/12/17-3/14/17) less than the required 45 days because we have had a last minute cancellation from one of our speakers. Thus, Drs. Howard Cohen and Gary Groesbeck have volunteered to give lectures to replace the speaker who had to cancel.

Thank you so much for your understanding and my apologies for this unforeseeable change in our speakers.

If you need to contact me, please email me at jenniferkim100@hotmail.com or call me at 323-574-8957.

Sincerely,

Jeong-Ah Jennifer Kim, OD
CA Lic 11674TLG

27107 Tourney Road
Santa Clarita, CA 91355
March 4, 2017

State Board of Optometry
2450 Del Paso Road, Suite 105
Sacramento, CA 95834

To whom it may concern:

Thank you for your attention to the Kaiser Permanente Mammoth Ocular Symposium 2017 continuing education approval submission. In anticipation of receiving deficiency notifications for the other lectures, I have included a summary of each of the lectures and the respective powerpoint presentations.

There will be 7 lectures from 3/12/17-3/14/17:

The Retinal and Choroidal Dystrophies lecture is relevant to diagnosing and providing proper care as optometrists perform retinal exams on a regular basis. As optometrists continue to go toward medical aspects of eye care, this lecture will keep us well informed regarding various retinal conditions.

The Update on Cataract Surgery is relevant to optometrists because this is one of the most common referrals we make. It is important for optometrists to remain informed about advancements and changes to cataract surgeries so that we can properly educate our patients.

The Retinal White Dot Syndromes lecture is relevant in providing proper optometric care with respect to retinal diseases. Such retinal conditions may lead to discovering the underlying systemic condition giving rise to the specific white dot syndrome.

The Corneal Ectasias and Cross-Linking lecture provides information for conditions such as keratoconus and its treatment with cross-linking. Optometrists are often the first to diagnose keratoconus thus it's important that we know about various medical treatments, in addition to contact lenses and glasses.

The IOL Materials and Design lecture provides information regarding the details of lens implants for cataract patients. IOL materials and designs are topics that are commonly discussed between optometrists and their patients.

The Sports Injuries lecture is relevant as patients come into our clinics with various sports injuries sustained at school, sporting teams/clubs, and times of recreation. It is important to anticipate and know what injuries can be sustained as optometrists provide a wide range of eye care.

The Benign Eyelid Lesions lecture provides information and visuals regarding eyelid lesions that optometrists observe daily. This will help to properly diagnose benign lesions and contrast those with lesions that need further work ups and/or referrals.

I apologize for submitting the lectures less than the 45 day request. I was waiting for all the presentations so that the lectures can be submitted together. The Benign Eyelid Lesions and Sports Injuries lectures were submitted less than the 45 request because there was a last minute cancellation of one of the original speakers, thus Drs. Groesbeck and Cohen prepared the presentations thereafter. In the future, an earlier deadline will be proposed so that the submissions will be on time.

I am attaching 2 checks that have already been deposited, one for $250 and the other for $100. All the files could not be sent in one email because the files were too large so there are 3 emails total which contain the required documents.

Thank you very much for your attention.

Sincerely,

Jeong-Ah Jennifer Kim, OD
CA Lic 11674TLG

Gary Groesbeck, MD
Review of IOL Designs and Materials 2017

I. History of IOL's
- A. The Ridley IOL
- B. Iris-fixated IOL's
- C. Anterior Chamber IOL's
- D. Posterior Chamber IOL's
- E. In the Bag IOL's

II. IOL Materials
- A. PMMA
- B. Silicone
- C. Flexible Acylic
- D. Hydrophilic IOL's
- E. UV-blockers and Chromophores

III. IOL Designs
- A. Three piece IOL's
- B. One piece IOL's
- C. Optical Designs
  - 1. Plano-convex
  - 2. Biconvex
  - 3. Aspheric
  - 4. Multifocal
  - 5. Extended Depth of Focus
  - 6. Accomodating IOL's

IV. IOL selection
- A. Post refractive surgery patients
  - 1. Effect of Spherical Aberration
- B. Hyperopes
- C. Emmetropes
- D. Myopes
- E. Blue-blocking IOL's
- F. Presbyopic Solutions
  - 1. Monovision
  - 2. Presbyopic IOL's

IV. Complications of IOL's
- A. Secondary Cataract
- B. Late Dislocation
- C. Dysphotopsias
- D. Loss of optic clarity

V. Conclusions

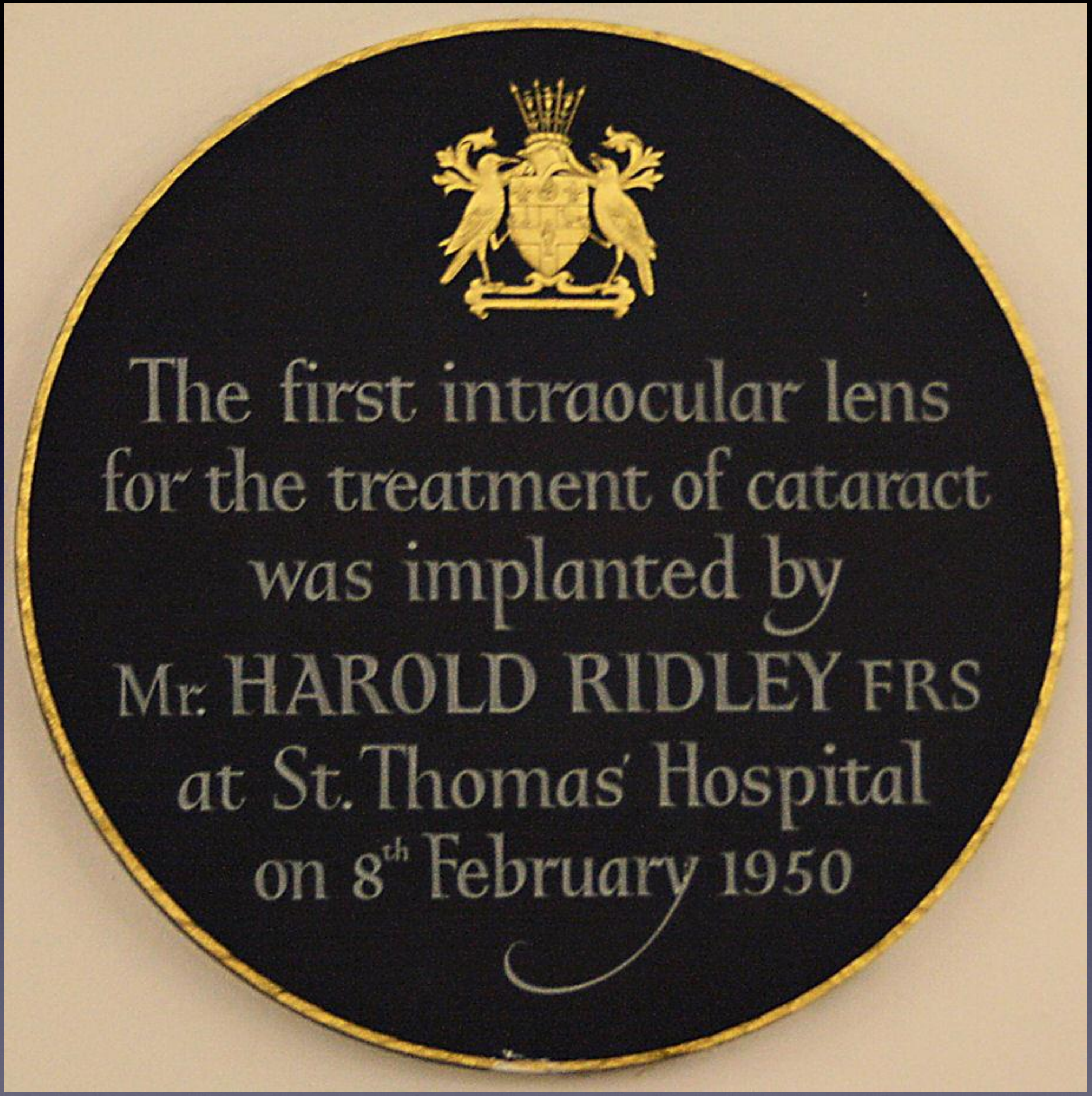
IOL Materials and Designs 2017

Gary Groesbeck MD
Vista Ophthalmology

Kaiser Ocular Symposium XXIV

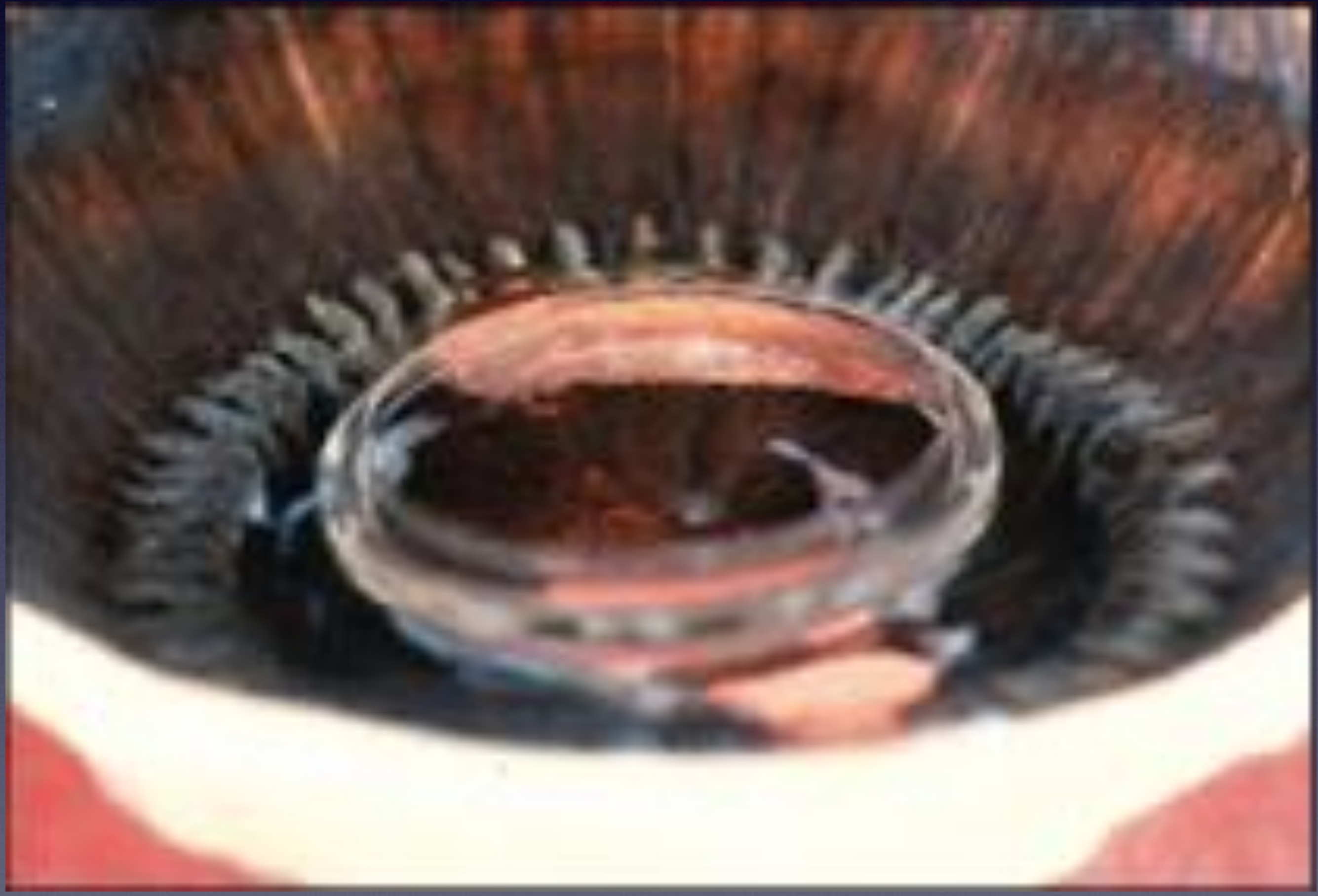
Financial Disclosure

I have no financial or non-financial relationships to disclose as to any devices or products mentioned in this presentation.


The first intraocular lens
for the treatment of cataract
was implanted by
Mr. HAROLD RIDLEY FRS
at St. Thomas' Hospital
on 8th February 1950

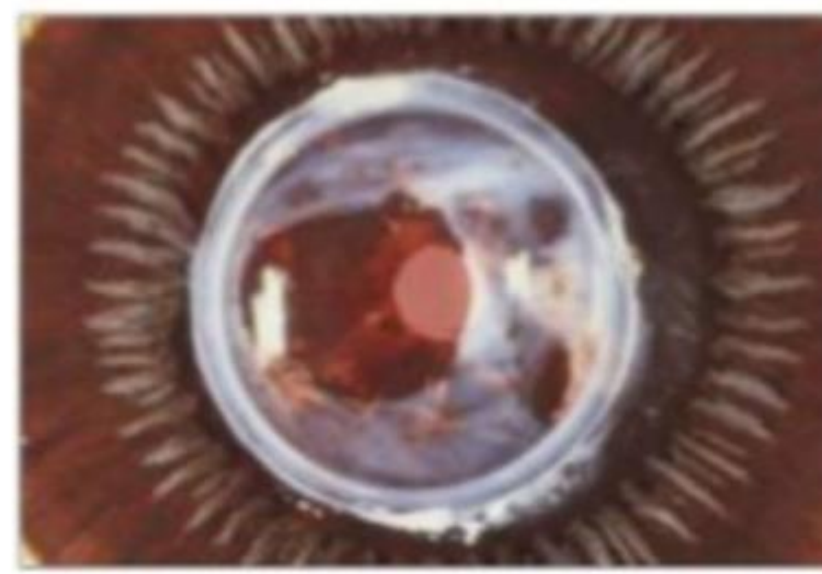
Ridley’s Intraocular Lens

Ridley’s Intraocular Lens



- INSPIRATION
  - Inertness of intraocular plexiglass shards
  - A medical student, Steve Perry questioned him why was he not replacing the lens after removal

- Approximately 1000 Ridley IOLs implanted in the next 12 years



- Complications*
  - Disclocation : approx 20%
  - Glaucoma : 10 %
  - Uveitis

- Went into disrepute
  - Strongly opposed by Sir Duke-Elders

* Ridley H: Intraocular acrylic lenses—past, present and future. Trans Ophthalmol Soc UK 1964;84:5–14

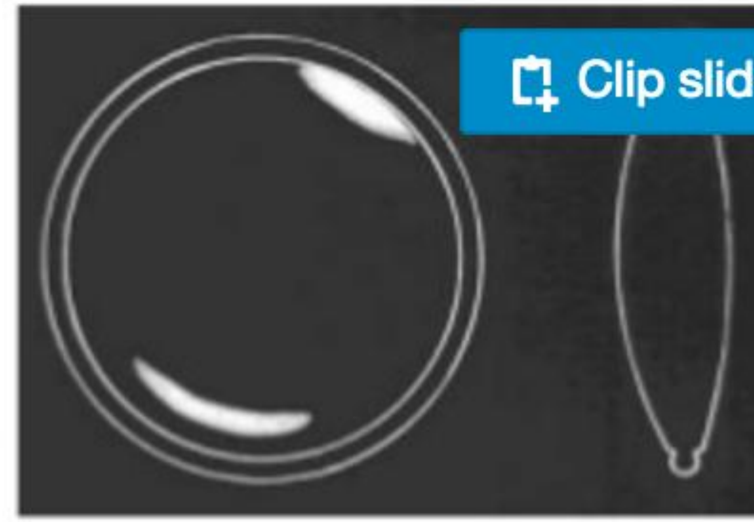
Ridley's Intraocular Lens

INTRODUCTION

- Sir Harold Ridley was the first to successfully implant an intraocular lens in 1949. The procedure was performed on a 45-year-old woman at St Thomas Hospital at London.
- That first IOL was manufactured by the Rayner company from PMMA.
- The surgery was an anatomic success, but the patient was left highly myopic.
- Her postoperative visual acuity was 6/18, requiring a refractive correction of **-18.0 -6.0 × 120**. There was clearly an error in the calculation.
- Baron designed and implanted the first Anterior Chamber IOL (ACIOL) in 1952.

HISTORY

In 1795, Casamata implanted glass IOL which sank posteriorly.



8.5 mm diameter, 2.4 mm thick, 108 mg

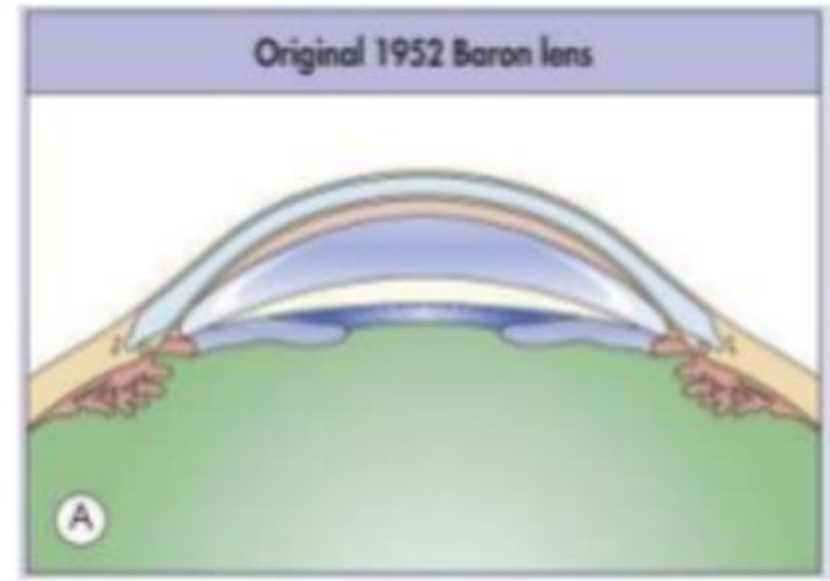
- First IOL implantation
  - Sir Harold Ridley
    - November 29, 1949 at St. Thomas Hospital, London
    - 49 year woman
    - ECCE with in-the-bag placement
    - Biconvex perspex (Transpex 1) disc; 138 mg
    - Rayners Optical Company, Brighton
    - Substantial post op myopia (-24.0 Ds/ +6.0 Dcyl X 30 degrees)
    - IOL exchange in February, 1950
    - Revealed only in 1951 at the Oxford Ophthalmic Congress

History : ICCE and ECCE

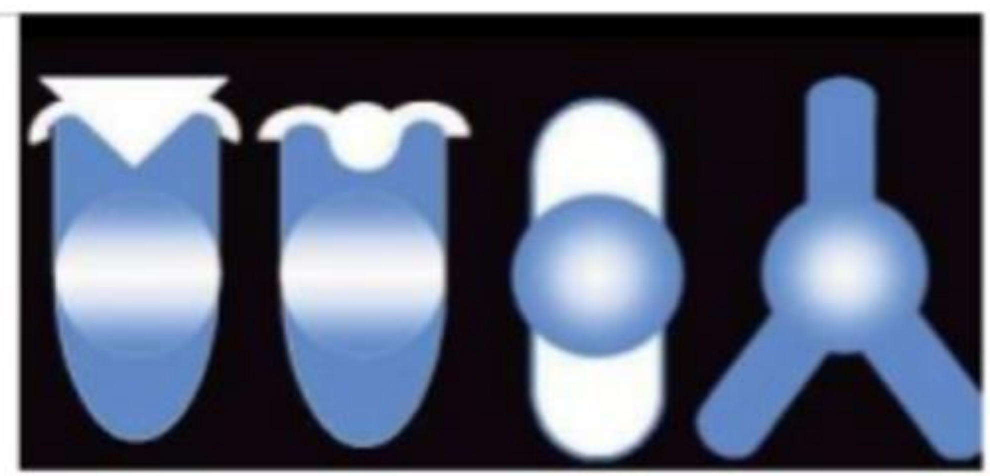
- 1949 Harold Ridley (GB) : ICCE c IOL
  - 29 Nov 1949 : the first IOL was implanted → failed
  - 8 th Feb 1950 : the first permanent insertion of intraocular lens
- 1953 Harold Ridley (GB) : ECCE c IOL

EARLY ANTERIOR CHAMBER IOLs

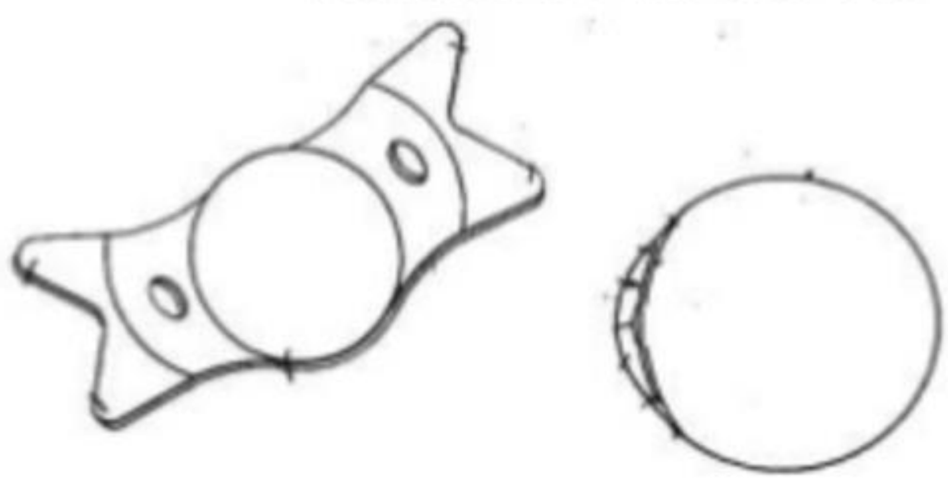
- Rigid or semirigid AC-IOL
  - Baron, in France; May 13, 1952
  - Scharf and Strampelli
- Flexible or semiflexible AC-IOL
  - Open haptic loops
  - Closed haptic loops
  - Peter Choyce
    - Mark I to Mark VII



Large Strampelli Lens

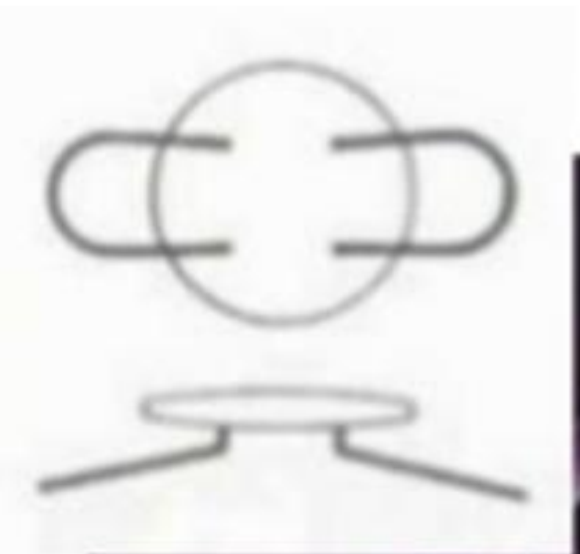


Strampelli Tripod AC-IOL (1953)
Choyce Mark I AC-IOL(1956)
Dannheim AC-IOL with closed haptics (1952)
Ridley Tripod AC-IOL (1957–60)



- Cornelius Binkhorst,
  - Iris clip lens; four-loop (1957)
  - Iridocapsular fixation; two loop (1965)
    - Forerunner to capsular sac (in-the-bag) fixation of modern posterior chamber IOLs



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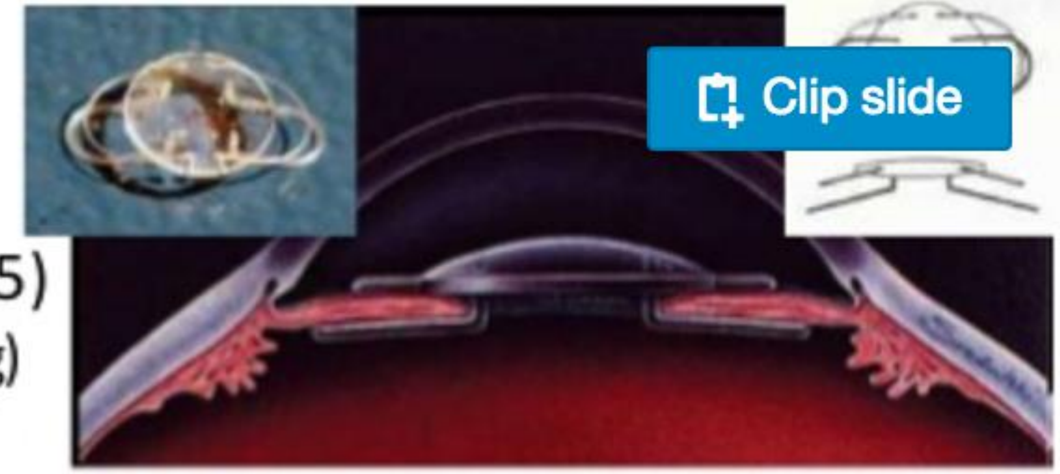
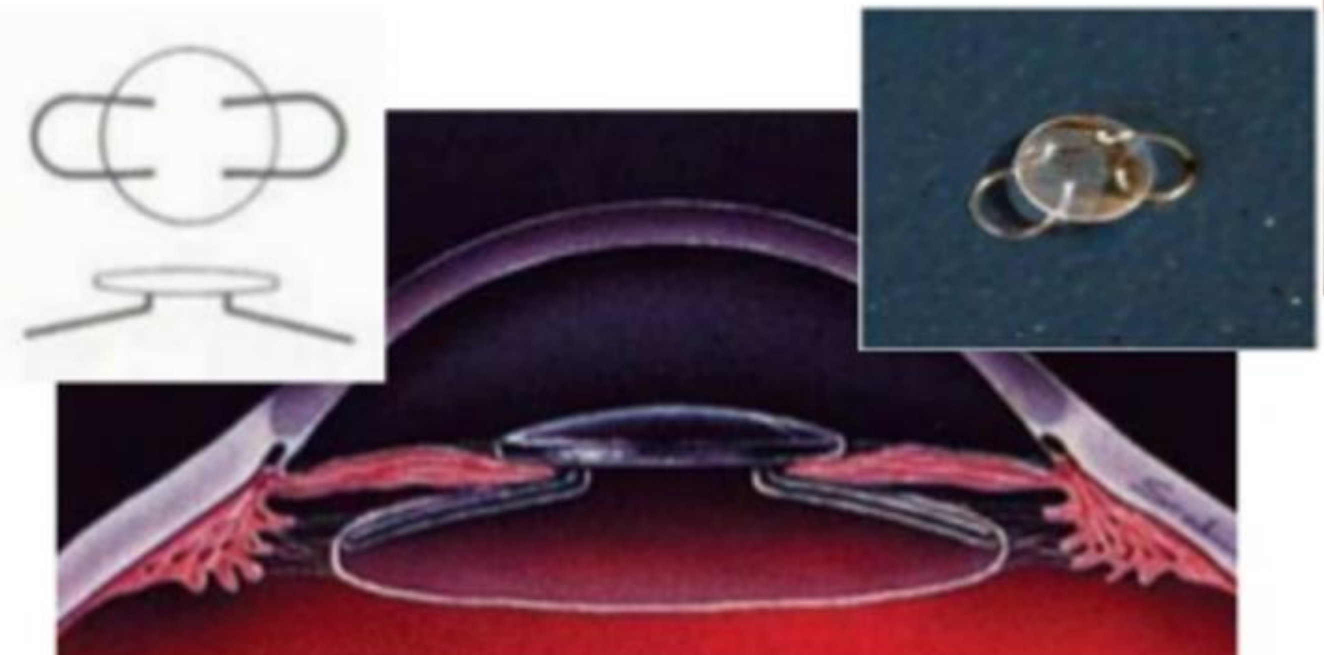
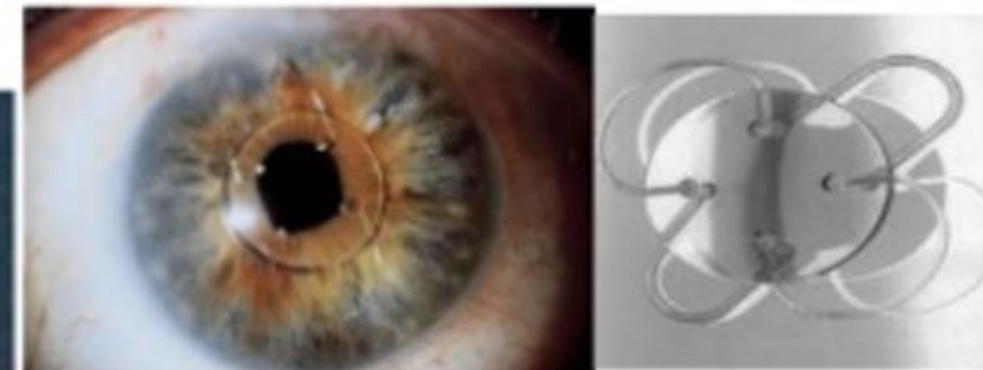
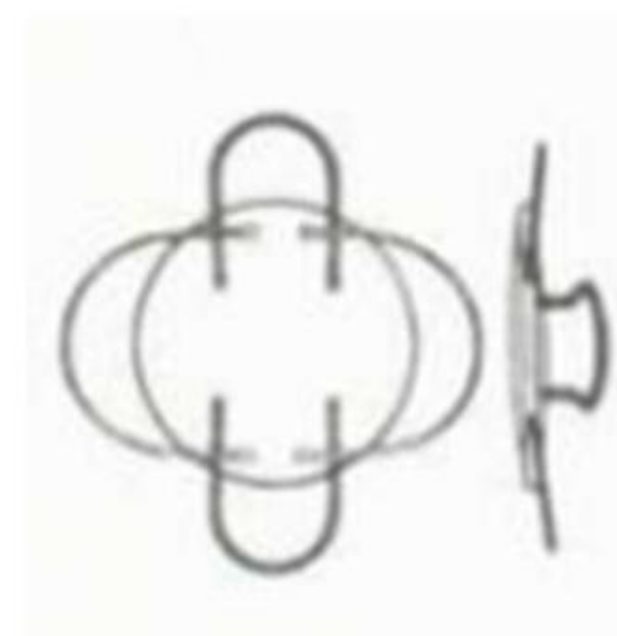
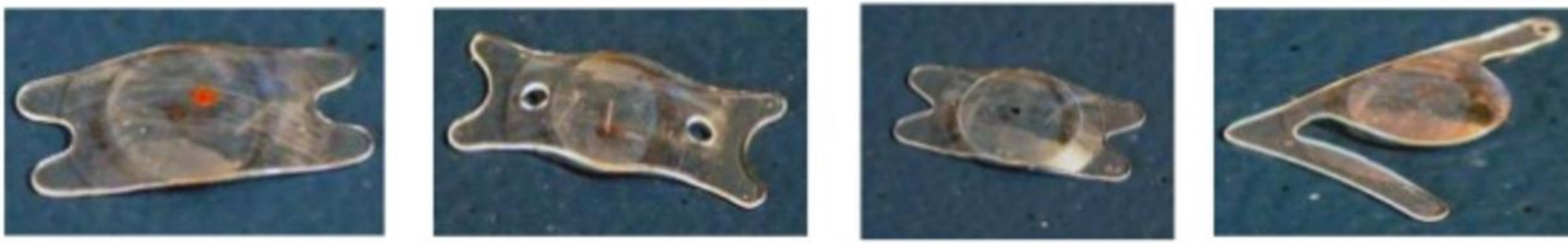




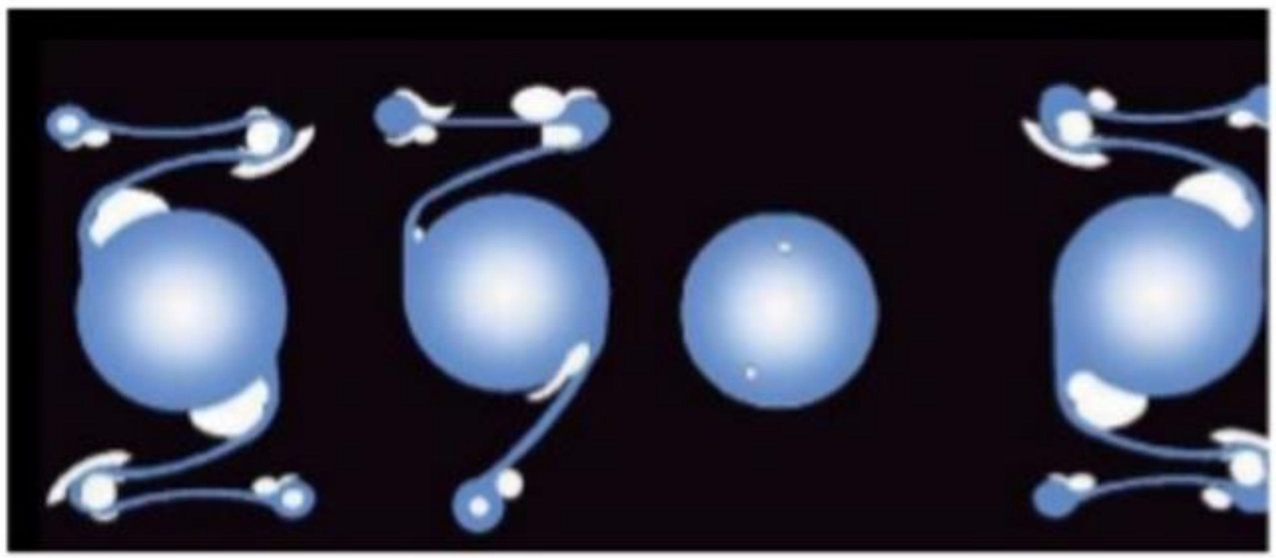


- Fyodorov modification (1966)
  - Fyodorov I
  - Fyodorov II (Sputnik)
    - Three haptics in front and three behind the iris

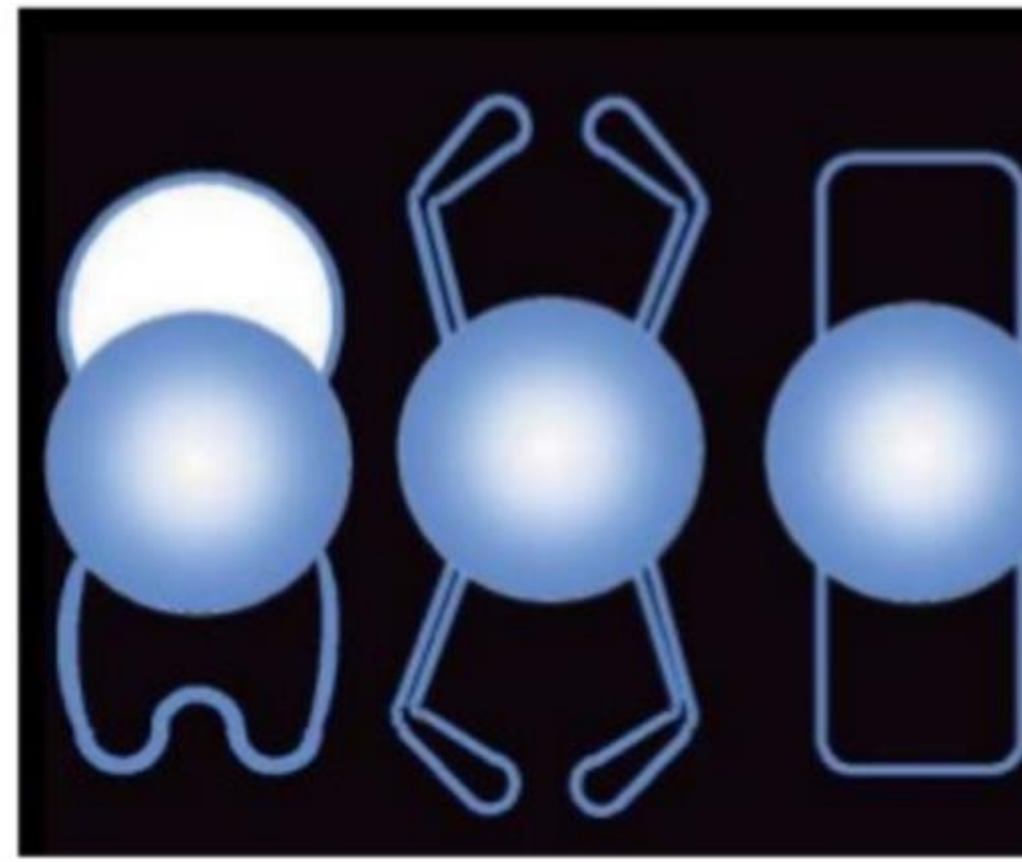




Mark VIII, Mark IX, flexible ACIOL, Kelman,
Kelman flexible tripod, Kelman quadraflex,
Kelman multiplex 4 point fixation



Kelman multiflex AC-IOL (1982)
Kelman flexible Tripod AC-IOL (1981),
Intermedics Inc Dubroff AC-IOL (1981),
Modern, one-piece, flexible PMMA AC-IOL
(Kelman design) with Choyce foot plates
(various manufacturers).



Azar 91Z AC-IOL (1982)
ORC Inc Stableflex AC-IOL (1983)
Surgidev Inc Style 10 Leiske ACIOL
(1978)

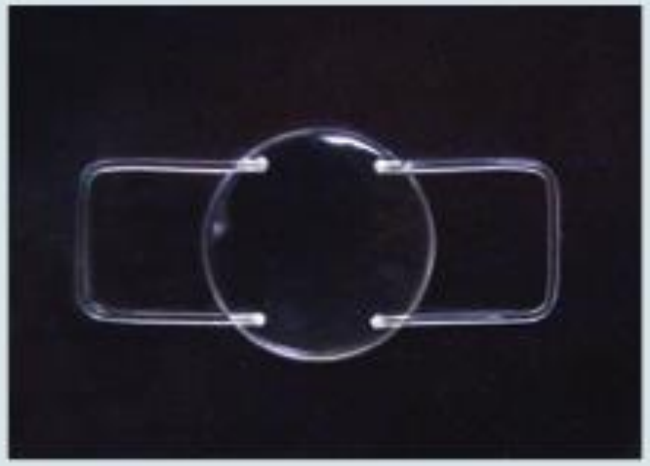


Figure 3 Leiske semi-flexible anterior chamber intraocular lens, circa 1978, manufactured by American Medical Optics. (Courtesy of the Museum of Vision and the American Academy of Ophthalmology.)

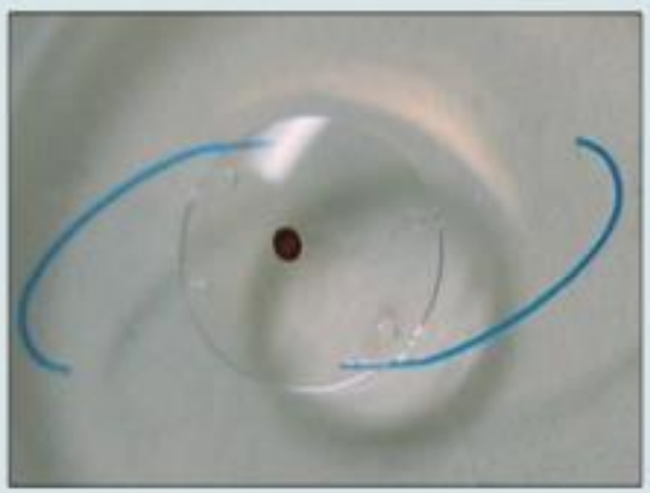


Figure 4 Kratz Model 7251 intraocular lens, manufactured by Precision-Cosmet Co, Inc. (Courtesy of the Museum of Vision and the American Academy of Ophthalmology.)

by Dr. Edward Epstein in South Africa in the 1960s and 1970s and by Dr. Thomas Mazzocco in the United States in 1984 allowed for further improvement in surgical technique by helping to give to the rise to small-incision surgery in the late 1980s. Deformable IOLs could be inserted through smaller incisions, which led to lower rates of postoperative astigmatism and reduced wound-related complications.

Drs. Howard Gimbel and Thomas Neuhann pro-

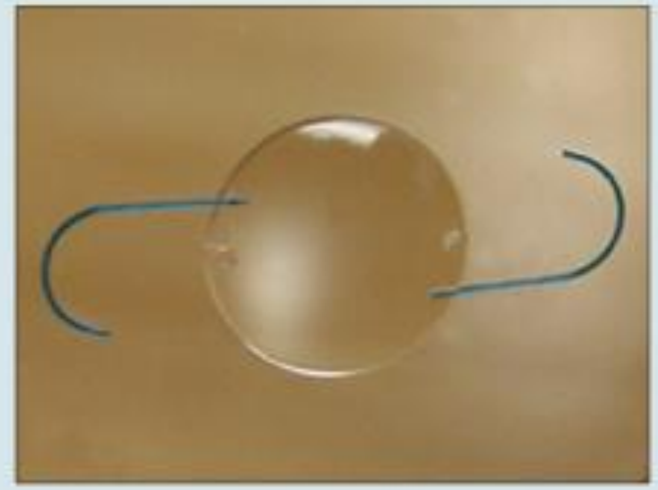


Figure 5 Style 500 J-loop intraocular lens, manufactured by CooperVision, Inc. (Courtesy of the Museum of Vision and the American Academy of Ophthalmology.)

Figure 6 Open-loop anterior chamber IOL. The Kelman-style open-loop IOL allowed for significant reductions in UGH syndrome, fostering an alternative means of IOL fixation in patients with compromised posterior capsules. (Courtesy of Liliana Werner, MD, PhD.)

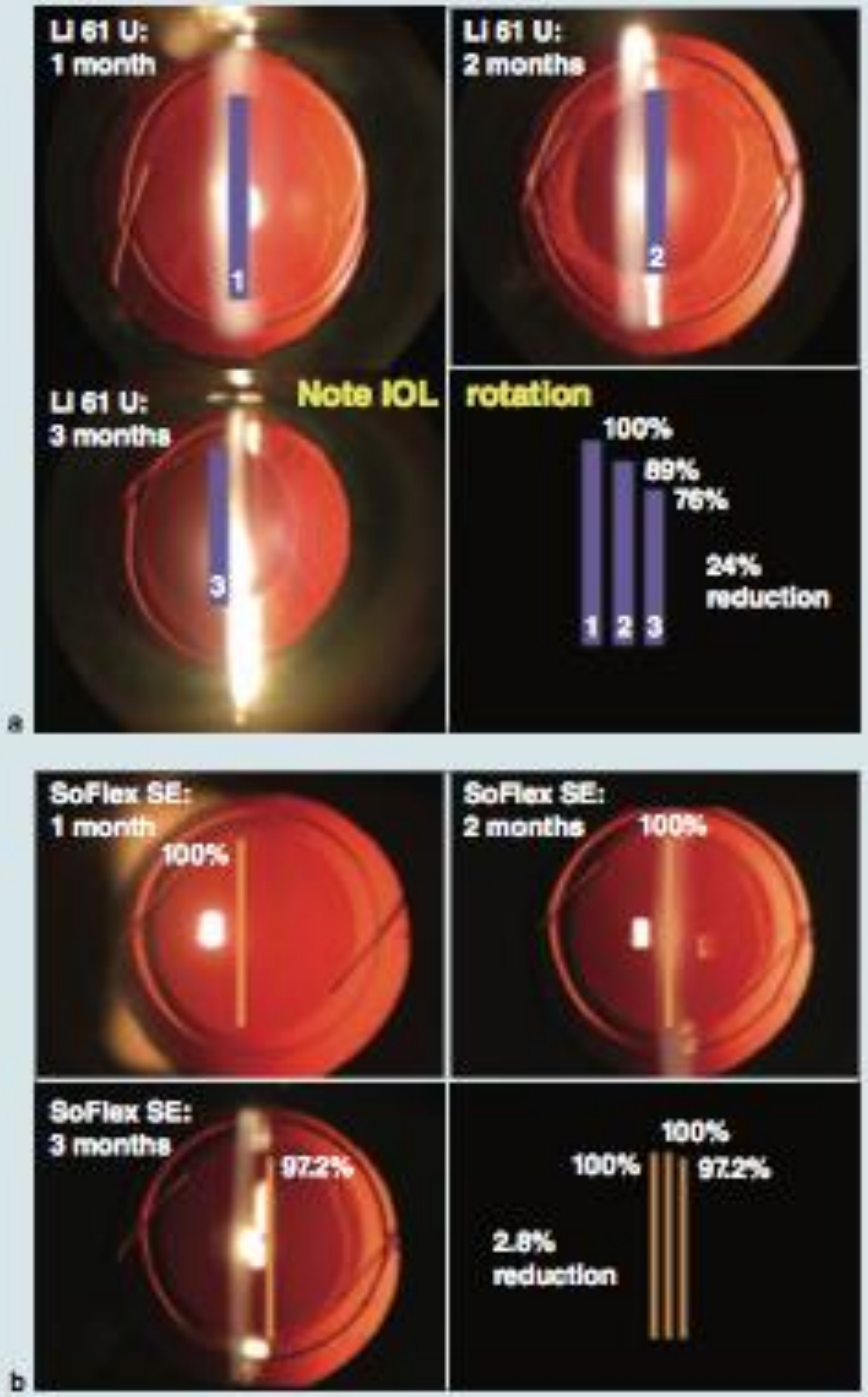
stability and improved centration. By improving the consistency of the anatomical result, the capsulorrhexis improved outcomes in general and allowed for the evolution of IOLs to the present-day standards.

Overview of IOL

ity is kept in balance between fibrosis and proliferation and the posterior capsule remains clear.

Compared to hydrophobic and silicone IOLs, hydrophilic acrylic materials have an increased tendency

IOLs to sharp-edged IOLs show clear benefits to a sharp edge in reducing PCO, improved rotational stability, and reduced anterior capsule contraction (Figure 7). More recently, a specific rounded-edge silicone IOL (SI-40



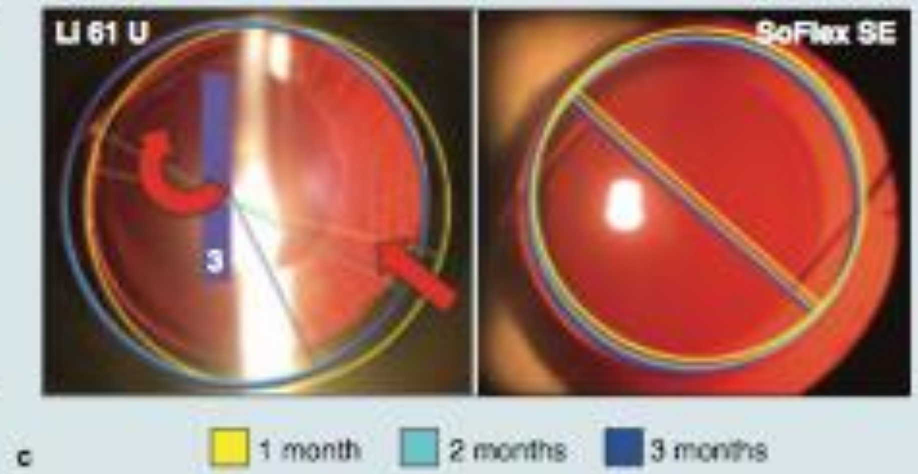


Figure 7 In vivo digital imaging of the effect of the square optic edge on capsule healing. Two silicone IOLs of nearly identical design, the LI61U **(a)** and the SoFlex SE **(b)**, from Bausch + Lomb, are distinguished only by the presence of a square edge on the SoFlex SE. Dr. Donald R. Nixon used a novel PhotoShop technique to document the differences in capsular reaction to the IOLs over several months. **c.** IOL movement after implantation on the LI6IU (left) and the SoFlex SE (right). The presence of a squared edge virtually eliminated anterior capsule contraction and IOL rotation compared to the round-edged IOL. (Reprinted, with permission from Elsevier, from Nixon DR. In vivo imaging of square-barrier effect of silicone IOL. *J Cataract Refract Surg.* 2004;30(12):2574–84. Courtesy of Donald R. Nixon, MD, FRCSC, DipABO.)

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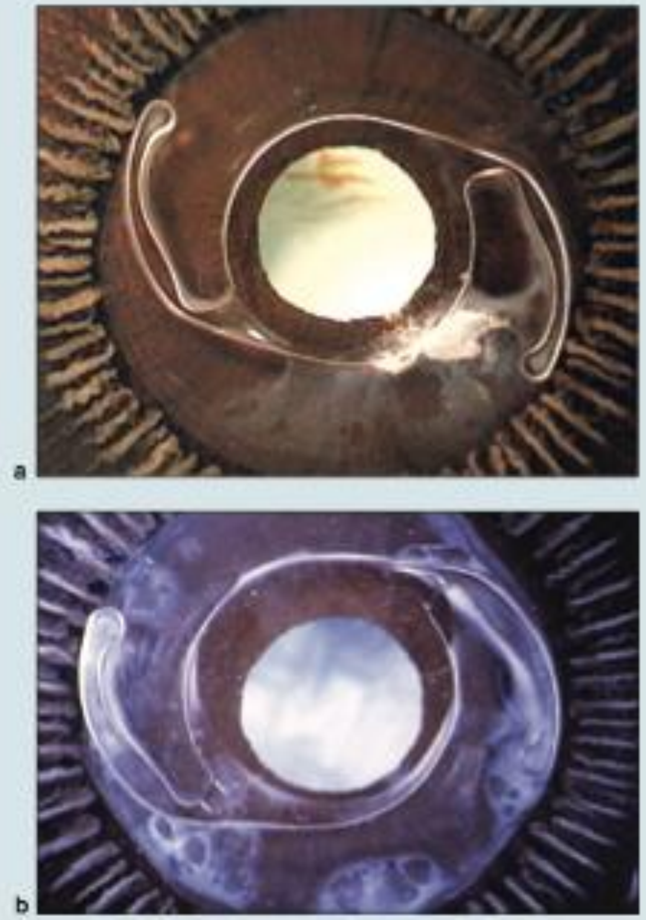


Figure 9 AcrySof single-piece hydrophobic acrylic IOL (Alcon Laboratories). In this pair of cadaver-eye micrographs, perfectly positioned single-piece hydrophobic acrylic IOLs reside within the capsular bag. The whitish material represents regenerating cortex, which would have grown to form Soemmering ring. **a.** Very thorough cortical removal was achieved, and very little cortical regeneration has taken place. **b.** A capsule with a greater degree of regenerated cortex indicating possibly poorer cortical removal, or much more likely, a greater passage of time between IOL implantation and specimen collection. While this design has several advantages over traditional 3-piece IOLs, placement of this lens outside of the capsular bag can result in uveal chafing, with pigmentary glaucoma and recurrent hyphema as potential complications of a malposition.

Three-piece foldable IOLs have haptics of a much more rigid material, such as PMMA or polyamide. These haptics have considerable outward compression

Overall IOL length from haptic to haptic is generally 13 mm for 1-piece IOLs, but may be shorter in a 3-piece lens. In cases of capsule compromise in which the 3-piece IOL is to be placed in the sulcus without optic capture through the capsulorhexis, it is generally accepted that 13 mm is the minimum haptic length to achieve stable sulcus fixation. While it is generally considered that sulcus diameter will correlate to the white-to-white corneal diameter, this is not always the case and larger IOL length may be needed. In the United States, only the rounded-edge, silicone Staar AQ series IOLs have haptic lengths greater than 13 mm.

Two clinical situations arising specifically as a complication of IOL placement are capsule phimosis and late within-the-bag IOL dislocation. These frequently occur together in the same eye, and many of the affected patients will demonstrate pseudoexfoliation. Each condition can occur even in the presence of a capsular tension ring, and aspects of IOL material and haptic design to reduce these problems continue to be an area of research. In general, if a patient is considered to be at risk of capsule phimosis or late IOL-bag dislocation, silicone lenses should be avoided. Consideration should be given for 3-piece lenses with the haptics in the sulcus and optic captured in the capsulorhexis.

As mentioned previously, the sharp-edged haptics of a single-piece IOL can cause significant uveal chafing with concomitant pigment dispersion, uveitis, hyphema, and glaucoma. The only single-piece IOL designed for sulcus placement is the Sulcoflex, manufactured by Rayner (East Sussex, UK), and is currently unavailable in the United States.

OPTIC CONFIGURATION AND POWER

Optic size is most commonly 6.0 mm, and considerably less than a millimeter in thickness. There are theoretical advantages to varying optic size. As the optic contributes to the greatest bulk of the IOL, by reducing the diameter of the optic, the IOL can be made smaller to be inserted through a smaller incision. However, a smaller diameter optic increases the likelihood of optical phenomena such as glare and haloes, a problem made worse with larger diameter pupils, but not improved necessarily by larger diameter IOL optics.

The optic bears the IOL power that is determined by the radius of curvature and the index of refraction. In manufacturing, it is simpler to vary the IOL power by changing only one surface of the IOL, leaving the other surface constant. The balance of power on the surface of the optic describes its configuration. The term

IOL Specifications

- Success of IOL depends on
  - properties of material
    - Biocompatible
    - Optically clear
    - Lightweight
    - Durable, moldable
    - Sterilizable

IOL Specifications

- Success of IOL depends on:
  - Resilient to implantation
    - Resistant to marking by insertion devices
    - Foldable
  - Resilient to YAG laser capsulotomy
  - Inert for a lifetime
  - Tackiness

IOL Materials

- PMMA
- Silicone
- Acrylic
    - Hydrophobic
    - Hydrophilic

IOL materials

- PMMA
  - only rigid material in use today
  - PC IOL's - primarily for sutured placement
  - AC IOL's

IOL materials

- Silicone
    - Staar IOL's
    - Crystalens
        - Crystalens AO
        - Trulign (toric crystalens)
- Foldable, springs back when released
- optically very clear
- Slippery

IOL materials

- Hydrophobic Acrylic
  - Tacky surface
    - Can stick to insertion instruments
    - More stable in capsular bag
  - Stiffer than silicone IOL’s
    - harder to fold
    - slower to unfold (easier surgeon’s learning curve)

Hydrophobic Acrylic IOL’s

- Alcon
  - SN60WF - aspheric
  - SA60AT - spherical
  - SN6AT3-9 - toric
  - ReSTOR Multifocal
  - MN60MA - 3 piece IOL

Hydrophobic Acrylic IOL’s

- Abbott Labs
  - Tecnis ZA9002 3 piece
  - Toric
  - ZKB00, ZLB00, ZMB00 Multifocal
  - ZRT00, ZRT150, SRT225, ZRT350 Symphony

Hydrophilic Acrylic IOLs

- First generation hydrophilic IOL
    - PolyHEMA with 38% water content
    - used outside of USA
    - easy to fold
    - Opacified in vivo, many explanted

Hydrophilic Acrylic IOLs

- Second generation hydrophilic IOL's
  - copolymers of HEMA and PMMA w 35% water
  - more resistant to deformation and calcification
  - Lenstec Softec HD IOL (piggyback)
  - Star Collamer
  - Bausch & Lomb Akreos

Biocompatibility of IOL

- Material
    - Inert
    - Not incite giant cell reaction
    - Hydrophilic tend to be most biocompatible
- Design
    - Square edge haptics chafe outside the bag
    - Angulated haptics on 3 piece IOL’s

Capsular biocompatability

- Hydrophilic
  - Greater lens epithelial cell ongrowth
  - more PCO
  - more capsular contraction

Capsular biocompatability

- Silicone
  - greater fibrosis
  - More decentration, capsule phimosis
  - Pea pod effect
  - Z-syndrome with Crystalens style IOL’s

conditions. While useful in certain circumstances, such as placement in the case of retained silicone oil, IOLs with a plano surface have largely been abandoned due to their increased relative optic thickness. The power and configuration of the IOL in combination with its material will also determine the true "sharpness" of the posterior edge (Figure 10).

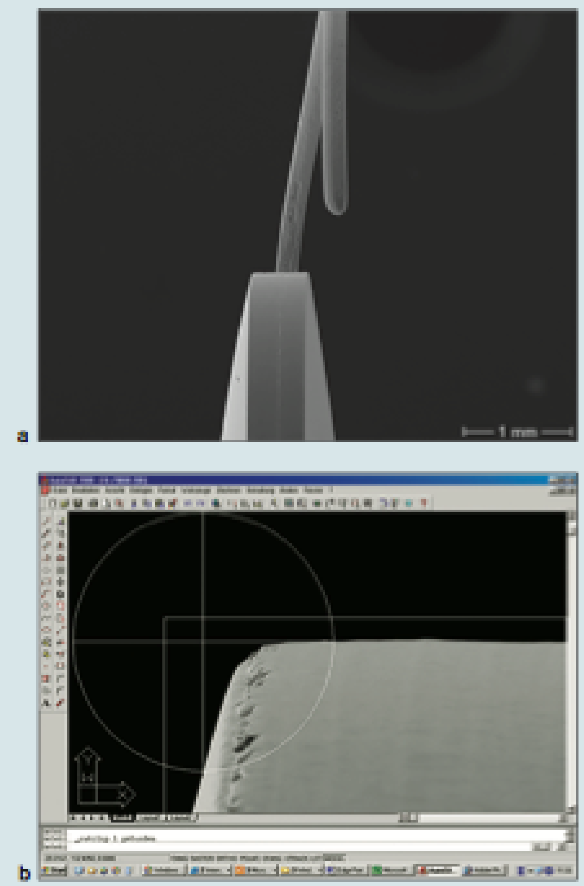


Figure 10 While the squared optic edge is considered one of the most significant advances in IOL design, the actual geometry of the optic edge is dependent on the configuration of the optic and the IOL power. In these scanning electron micrographs, the IOL is positioned horizontally, as if in an eye in an upright position. **a.** Shows the IOL at 25× magnification, with the anterior aspect to the right and the posterior aspect to the left. **b.** Shows the junction of the posterior surface with the lateral edge of the optic at 1000× magnification. AutoCAD was used to demonstrate the deviation of the posterior optic edge from a true right angle. Increasing the power of the IOL on the posterior surface increases the curvature of that surface, and increases the obtuse angle of the intersecting surfaces. (Reprinted, with permission from Werner L, Müller M, Tetz M. *J Cataract Refract Surg.* 2008;34(2):310–17.)

Note that labeled IOL powers are, in reality, only a close approximation of the actual IOL power based on the planned final placement of the lens. For example, an 18.50 D labeled lens for posterior capsule placement may actually be 18.20 or 18.80 in dioptric power, depending on the manufacturer's standards within the FDA's labeling guidelines. Variability in IOL power is not the only determinant of refractive outcome, as placement of the IOL in the sulcus will increase the effective power of the IOL and leave a myopic result compared to the intended result. Preoperative estimation of IOL position, postoperative refraction estimation, and preoperative corneal power as well as axial length determination and pupil size are among the sources of error that affect refractive outcome.

ASPHERIC OPTICS

Spherical aberration occurs when peripheral light rays and axial light rays come to different foci, which causes images to appear blurred. This results in a decrease in contrast sensitivity. While loss of contrast sensitivity may not be identified on a standard Snellen acuity chart, loss of contrast will affect functional vision (eg, how well people see in less-than-optimum lighting conditions). In 2004, the Tecnis silicone IOL (Abbott Medical Optics) was the first lens approved by the FDA to feature aspheric optical correction. This feature is now offered in lenses from Alcon, Bausch + Lomb, Hoya, Rayner, Zeiss, and virtually every other IOL manufacturer.

Spherical aberration is positive when the peripheral light rays focus anterior to the axial light rays. The aspheric lens design is intended to correct the positive spherical aberration of the cornea. In the young eye, negative spherical aberration of the young crystalline lens balances the positive spherical aberration of the cornea. With age, the spherical aberration of the crystalline lens becomes more positive and the lens no longer compensates for corneal spherical aberration.

Traditionally, spherical IOLs were made with a positive spherical aberration adding to corneal spherical aberration and reducing functional vision. Early attempts to correct for spherical aberration were disrupted by the relatively inconsistent surgical results of the day. The Tecnis IOL (Figure 11) is negatively aspheric with a modified prolate surface, and is designed to correct 27 microns of spherical aberration. As the first lens to correct spherical aberration, the Tecnis provided statistically and functionally significant improvements in contrast sensitivity relative to the spherical controls, and enhanced functional vision under both mesopic and photopic conditions. The AcrySof (Figure 12) aspheric lens (Alcon) is designed with 18 µm of negative spherical aberration to compensate for the positive spherical aberration of the cornea; contrast sensitivity testing showed equivalence with the spherical monofocal control subjects. Most patients undergoing cataract surgery

Design features of IOL’s

- Sharp edged hydrophobic IOL’s
  - inhibit LED migration
  - Less PCO
- Silicone SI-40
  - Less PCO at 10 years then MA60BM acrylic
- Design and materials both play a role in PCO

Light blocking chromophores

- All IOL’s in USA have UV-blocking chromophore
  - except Crystalens
- Blue blocking chromophores
  - Attempt to reduce risk of ARMD
  - No definitive studies
    - Hoya in Japan
    - Alcon in USA

Does IOL surgery increase the risk of ARMD?

- Studies in 1980s and 1990’s yielded conflicting results
  - all were hampered by design or sample size
    - some mixed IOL, no IOL, IOL w UV block

Does IOL surgery increase the risk of ARMD?

- AREDS 1 - 1992-2002
  - 1700 underwent IOL surgery during study
    - 750 had ARMD
  - Predating blue-blocker IOL's, no increased risk of ARMD was found in these high risk patients

Do blue blocking IOL's reduce the risk of ARMD?

- IOL's without blue blocking chromophore let more light into eye than natural human eye at any age
- Artificial in-vitro studies showed damage to animal cells at supra-physiologic exposure to intense blue and violet light.
- No definitive studies linking blue light blocking IOL's as protective in development of ARMD
- Other factors play a role in ARMD including genetics, smoking, circulation, lipofuscin, retinoid deficiency,

Blue-blocking IOL's

- 1. Are they protective - no proof exists
- 2. Are they harmful?
  - Circadian rhythms
  - sleep-wake patterns
  - mood and depression
  - pupillary response
  - Melatonin metabolism

Optical clarity

- All IOL materials today have modular transfer function values that exceed the resolution ability of the retina

IOL Glistenings

- Glistenings is a frequent criticism of Alcon IOL's, but can be seen in all hydrophobic acrylic IOL's except B&L's enVista.
  - Glistenings represent small microscopic spheres of water trapped inside the polymerizing materials in manufacturing process for IOL's
  - The severity of glistening correlates w manufacturing process for acrylic IOL's
  - Glistenings can increase with time, and can have a measurable effect of clarity

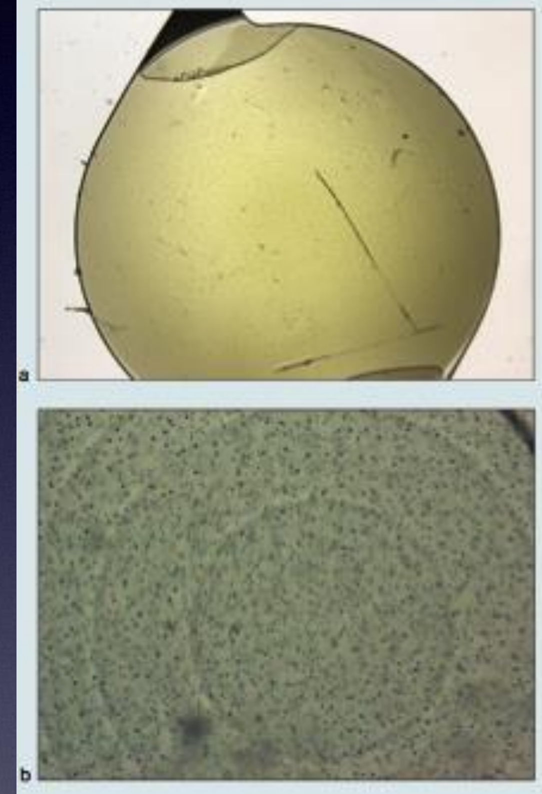


Figure 8 Glistenings. This hydrophobic acrylic IOL was explanted due to a loss of visual acuity associated with the increasing formation of glistenings. The patient received bilateral implants and reported good function from the multifocal IOL in each eye. The fellow implant had only trace glistenings, and no subjective complaints were reported from that eye. **a.** Micrograph shows the gross explanted specimen, with the linear mark on the IOL surface created during explantation. **b.** Micrograph shows the density of glistenings. (Images courtesy of of Steven Dewey, MD.)

More recent single-piece IOLs are crafted from hy
ophobic or hydrophilic acrylic materials, and they
perficially resemble their 3-piece counterparts (Fig
e 9). As the material has a high degree of compress
lity, the outward force of the haptic on the capsula
g is negligible but serves to stabilize the optic in th
sired capsular location during the process of capsul

One piece vs three piece IOL designs

- One piece -
  - Reverse S Alcon, Tennis, etc
  - Plate haptic Staar, B&L Akreos
  - Sharp edges provide stability and prevent rotation or displacement which could otherwise occur
  - Sharp bulky haptics make sulcus placement contraindicated due to iris chafe and UGH syndrome
  - Around 13 mm edge to edge

One piece vs three piece IOL designs

- 3 Piece IOL’s
  - more rigid haptics of PMMA or polyamide
  - more significant outward compression than single piece foldable IOL’s
  - haptics thinner, better tolerated in sulcus
  - haptics more easily damaged during insertion

Capsule complications

- Capsule phimosis
  - more common in pseudo exfoliation
  - more common in silicone optics
- Late capsular bag IOL dislocation

IOL optic characteristics

- 6.0 mm optic diameters
  - compromise between insertion ease and edge awareness, glare, haloes
- Optic configuration
  - Plano-convex
  - Biconvex
  - Aspheric
  - Multifocal - ReStor, Tecnis,
  - Extended range of focus - Symphony

IOL optic characteristics

- Powers are approximations
  - FDA requirements are +/- 0.3 D of labelled power
- Spherical aberration correction
  - Cornea induces postive spherical aberration
    - Myopic LASIK and RK induce even more positive spherical aberration
    - Hyperopic LASIK induces (-) spherical aberration -

IOL optic characteristics

- Aspheric IOL’s attempt to counteract corneal related aberration
  - Tecnis -0.27 microns of (-) spherical aberration
  - Acrysof -0.18 microns of (-) spherical aberration
  - Alcon SA60AT - non-aspheric - used for hyperopic LASIK patients
- Research is evaluating added depth of field with some residual spherical aberration - eg Symfony IOL

Figure 11 The hydrophobic Tecnis single-piece IOL is transparent with an optic incorporating negative spherical aberration to improve contrast sensitivity. (Courtesy of Abbott Medical Optics.)

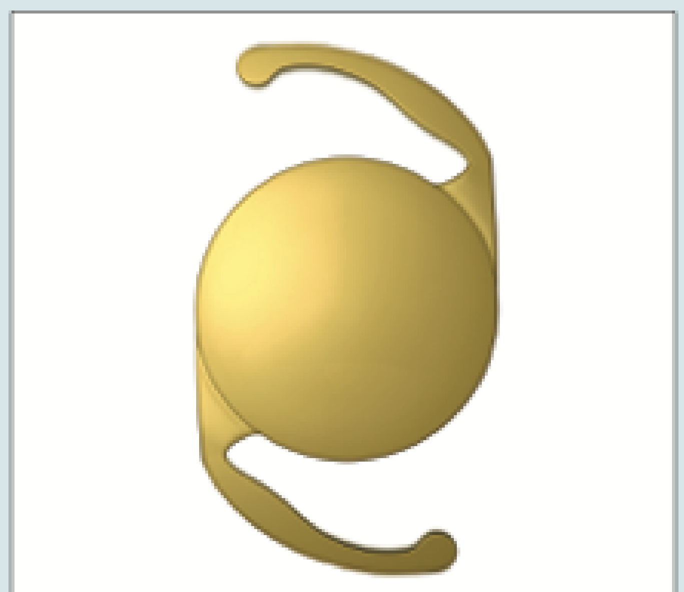


Figure 12 The hydrophobic AcrySof single-piece IOL contains a yellow chromophore with an optic incorporating negative spherical aberration to improve contrast sensitivity. (Courtesy of Alcon Laboratories.)

will potentially benefit from a negatively aspheric IOL. Patients who have undergone myopic LASIK or PRK

degradation associated with IOL decentration or tilt. Decentered IOLs with an aspheric correction will induce coma to varying degrees. Neutral aspheric IOLs can be decentered without degrading contrast sensitivity. These lenses are suitable in cases of previous refractive surgery in which the corneal correction was off-center, or if the patient has a naturally neutrally aspheric cornea.

While it would seem that there is no longer a benefit from a simple spherical IOL, positive asphericity is useful in reducing optical aberrations in patients who have undergone hyperopic LASIK or PRK.

As spherical aberration is highly varied in the population, and does not correlate with keratometry or a corneal Q value, the best method of selecting an aspheric IOL for a given patient is by specifically measuring corneal aberration with topography. Research continues as to the ideal residual value of spherical aberration as small amounts are felt to convey some depth of field.

MULTIFOCAL DESIGN

Assuming little residual astigmatism is present, monofocal intraocular lenses correct vision at one focal position—either near, intermediate, or distance. Bifocal and multifocal intraocular lenses direct light to two or more focal points. Three examples of multifocal design are diffractive optics, as exemplified by the Tecnis multifocal IOL (Figure 13a, b); refractive optics, as seen with the ReZoom multifocal lenses (Abbott Medical Optics; Figure 14) and a combination of apodized diffractive optics, as seen with the AcrySof ReSTOR (Figure 15) multifocal IOL.

While the technology behind each of these lens designs is highly sophisticated, the fundamental principle is one of compromise. In particular, multifocal lenses demonstrate reduced contrast sensitivity compared to their current aspheric monofocal counterparts. This is due to the division of light between the focal points, and the loss of some focused light due to blend zones or diffractive optics. Patients to be considered for these IOLs must display pristine ocular health to fully appreciate the benefits of the technology. Even under the best of circumstances, a significant number of patients will have extraneous light images that do not improve over time.

Refractive optics were the first to be FDA-approved and are found on the Array (Abbott Medical Optics) and ReZoom multifocal lenses. Concentric wave-like rings, or zones, provide simultaneous near and distance vision in alternate zones and the aspheric transition between the zones provides intermediate vision. The near add is +3.50 D at the IOL plane, which is +2.85 D at the spectacle plane. This multifocal design has lost consider-

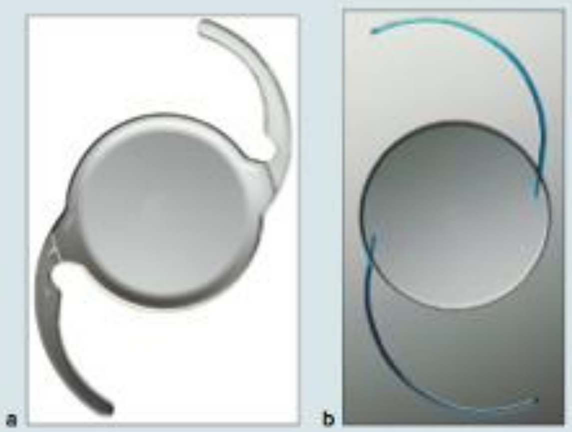


Figure 13 Tecnis multifocal IOL. **a, b.** The Tecnis diffractive multifocal IOLs are designed to function at near and distance independent of pupil size. (Courtesy of Abbott Medical Optics.)

Figure 14 The ReZoom refractive multifocal IOL. (Courtesy of Abbott Medical Optics.)

and 50% far foci at virtually all pupil diameters. However, some light is lost due to the nature of the diffractive process. The three different models have optical power adds of 4.00 D, 3.25 D and 2.75 D on the posterior surface of the optic. These adds correspond to 3.00 D, 2.40 D, and 2.00 D at the spectacle plane.

An apodized diffractive optic, as found on the ReSTOR lens, merges a diffractive optic on the anterior

Figure 15 The apodized optic of the ReStor balances the need for near vision with a refractive aspect designed to improve distance performance. (Courtesy of Alcon Laboratories.)

vision. The add powers are 4.0, 3.0 and 2.5 on the optic, resulting in adds of 3.2, 2.5 and 2.0 diopters, respectively, at the spectacle plane.

ACCOMMODATIVE DESIGN. While multifocal lenses provide a significant benefit for near and intermediate vision for select patients, they do not restore accommodation. Some patients receiving monofocal lenses achieve a balance between distance and near vision, but this achievement is sporadic and typically regarded as the result of optical aberrations that result in pseudoaccommodation. Forward movement of a nondeformable optic or change in curvature of a deformable optic could achieve the goal of accommodation. Unfortunately, a full millimeter of movement in an average eye will only yield about 1.30 D of near power, with higher-power lenses in shorter eyes giving better results, and lower-power lenses in longer eyes giving worse results.

A truly accommodating lens design has yet to be developed, but a number of designs emulate features of accommodation to provide varying degrees of near vision. While many of these are undergoing the FDA approval process, the first IOL to receive an FDA indication for accommodation is the Crystalens (Bausch + Lomb; Figure 16). The original design was conceived by Dr. J. Stuart Cumming, who noted that plate haptic silicone lenses seemed to have a higher likelihood of pseudoaccommodation than standard 3-piece IOLs. He proposed that the plate lenses rest further posteriorly in the capsule, and the flexing of the IOL forward within

Tecnis Multifocal

- Diffractive optics
    - +4.00 ZMB00 (3.00 at spectacle plane)
    - +3.25 ZLB00. (+2.40 at spectacle plane)
    - +2.75 ZKB00 (+2.00 at spectacle plane)
- not affected by pupil size or decantation

Alcon ReSTOR

- ReSTOR
  - +4.00 (3.20 at spectacle plane)
  - +3.00 (+2.50 at spectacle plane)
  - +2.50. (+2.00 at spectacle plane)
- Pupil size and dislocation dependent

Alcon IQ ReSTOR toric

- Acrysof IQ ReSTOR +2.5 and +3.0
  - Pupil adaptive design
  - Central intermediate zone
  - Apodized 9 diffractive steps near zone 3.5 mm
  - 60% near light distribution
  - Outer Distance zone

Alcon IQ ReSTOR toric

- approved 12-22-2016
- Central zone 100% distance compared to 40% with original ReSTOR (less glare w small pupil)
- Fewer diffractive rings = less glare
- Intermediate peak for near vision
- Retains peripheral distance only area
- Corrects from 1.0 to 2.6 D corneal astigmatism
- IQ ReSTOR +3.0 SND1T3 to SND1T6

Extended Depth of Focus IOL’s

- Abbott Symfony - approved August, 2016
- Spherical aberration is intentionally manipulated to provide greater depth of focus
- Chromatic aberration is reduced thru diffractive gradient on optic surface
- Available in spherical and toric powers

Symfony IOL

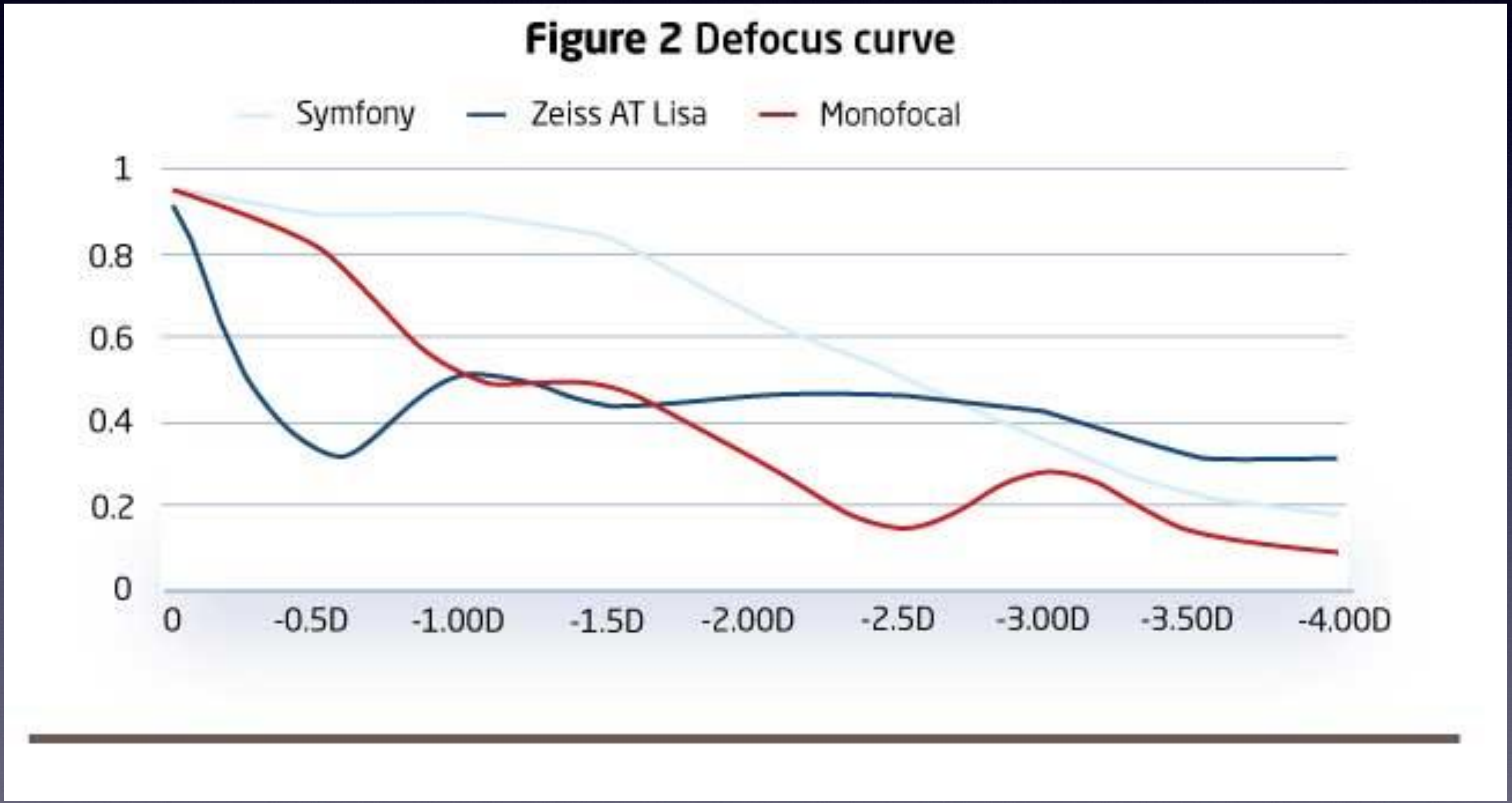
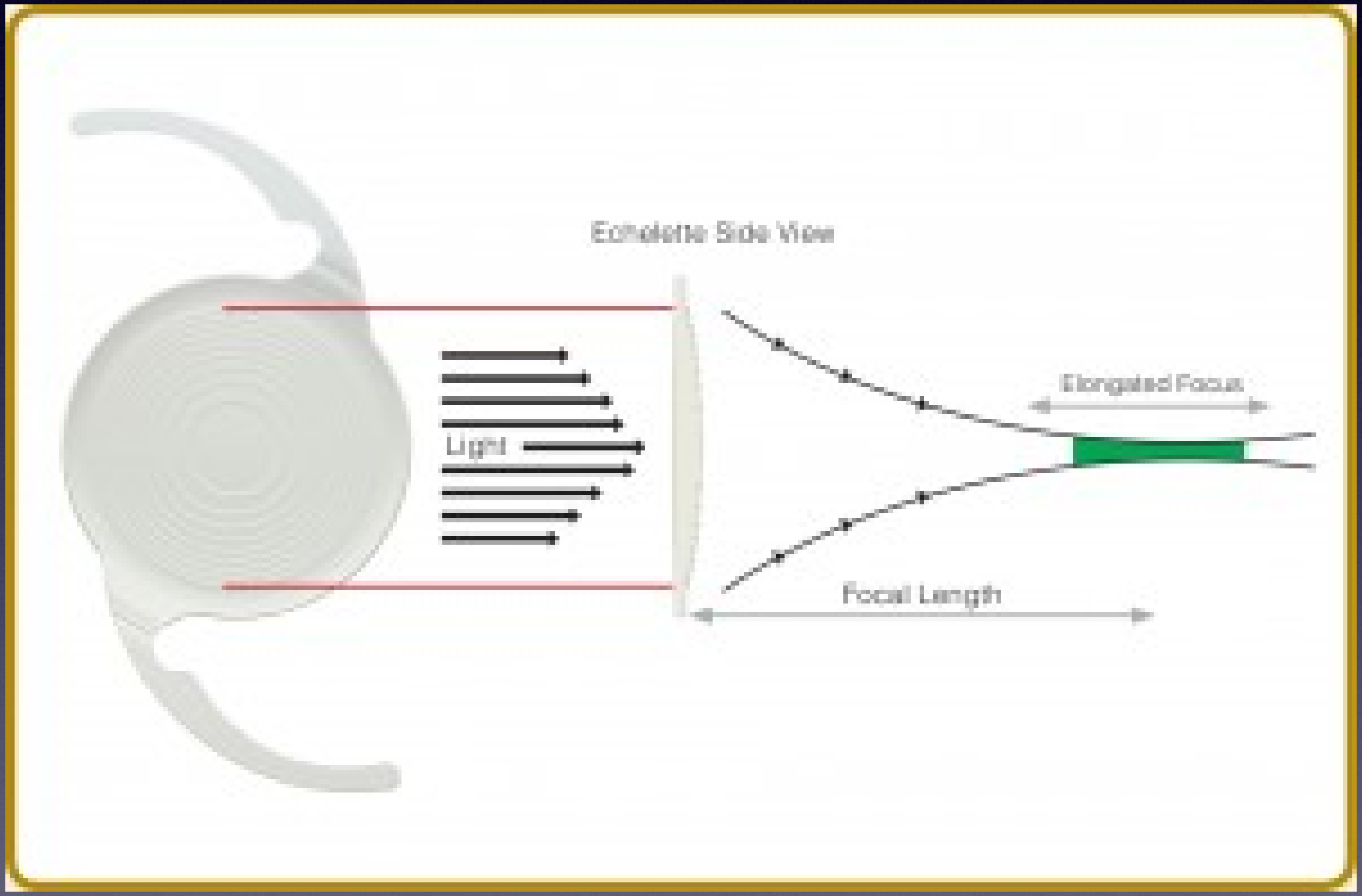


Figure 2 Defocus curve
Symfony
Zeiss AT Lisa
Monofocal
1
0.8
0.6
0.4
0.2
0
0
-0.5D
-1.00D
-1.5D
-2.00D
-2.5D
-3.00D
-3.50D
-4.00D

Symfony IOL



Symfony patients

Hi,

I'm 44 years old and just had the first of two eyes implanted with the new (I'm in the U.S.) Symfony Toric lens, which I've researched extensively and was very eager and excited to get.

Now four days since having the surgery, I'm mostly satisfied: colors are much brighter and more vibrant (and more pinkish, bluish, interestingly), my distance vision is now restored and fine, and I can see pretty well at intermediate distances, i.e. objects are clearly defined all the way in to about 23 inches away, perhaps even 21 inches away in bright light (yes, I notice some degradation in low light, more than I'd expected).

The real issue for me is my near vision, which is much worse than I was expecting. I do know that the Symfony isn't all-around perfect, that e.g. I might expect only 20/32 or so (mean uncorrected near achieved in the U.S. clinical trials). And I know that's just an average, but even the distributions left me hopeful, with 81% of trials patients achieving 20/40 or better (that's monofocally; 96% were better than 20/40 bifocally). Meanwhile, I'm struggling to make out these words as I type, pretty much anything inside of 23 inches is blurry, and in good light I can only make out the 20/80 line (if I really exert myself, I can barely make out, mostly by guessing, some of the 20/60 letters, but mostly they're entirely unrecognizable). I feel as if I could have gotten results like this simply by going with monofocals, and I'm beginning to fear this is as good as it'll get, which is depressing.

Some background facts: Pre-op, I was mildly myopic (-1.75) in this eye and mildly astigmatic (about 0.94 cylinder). Also, at 44 I'd already gotten used to presbyopia, and typically would wear +1.25 readers for near. The specific lens implanted was the ZXT150 +16.5 (1.5 D cylinder). I doubt lens alignment is off, as my distance and intermediate vision feels non-astigmatic. My other eye (right) is scheduled for another Symfony lens 10 days from now.

So, I wonder:

1) Have others had similar experiences, i.e. poorer than expected near vision?

2) Does anyone have any idea what might have caused this?

3) Can anything be done to correct it?

4) If anything can be done, should I expect my ophthalmologist to do it (without having to pay more than the significant amount I've already paid)?

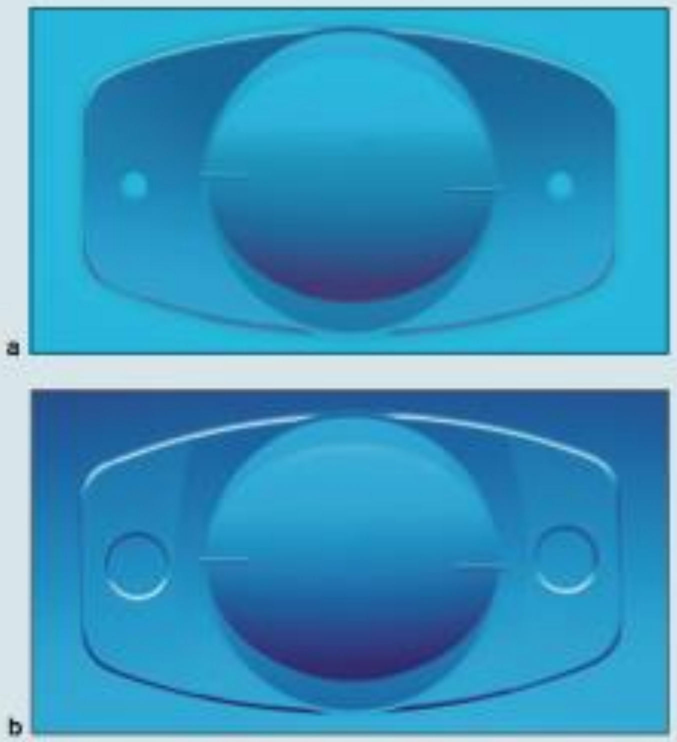
Thanks for any info and advice!

Figure 16 The Crystalens is the only FDA-approved IOL to treat loss of accommodation. This modified plate-haptic lens is designed to flex with contraction of the ciliary body, increasing the effective lens power and thus near function. (Courtesy of Bausch + Lomb.)

showing great promise through any number of testing parameters, these designs are not available in the United States.

TORIC IOL DESIGN. Forty percent of patients undergoing cataract surgery will have one or more diopters of pre-existing corneal astigmatism. Cataract surgery with a simple monofocal IOL will treat astigmatism existing within the lens, but will not treat astigmatism at the level of the cornea. Prior to the advent of current small-incision phacoemulsification, highly variable amounts of astigmatism would be induced by cataract surgery, with the potential for increasing amounts of against-the-incision astigmatism developing years following surgery.

Correction of astigmatism is performed to decrease



a

b

Figure 17 Staar toric plate haptic IOL. **a.** Original design with shorter haptic length and smaller fixation holes. **b.** Improved design with larger fixation holes and longer overall length. The improved design significantly improved rotational stability, and thus astigmatic correction. (Courtesy of Staar Surgical.)

correction. Early designs of this lens had smaller holes in the plate-haptic, and rotation and decentration were relatively common. Larger holes in the haptic created greater areas of capsule apposition and improved these issues considerably (Figure 17b).

The single-piece hydrophobic acrylic AcrySof toric IOL received FDA approval in 2005 (Figure 18). The original lens treated astigmatism up to 3.00 D at the corneal plane. It was subsequently expanded to cover up to 4.50 D and modified to incorporate aspheric optics in 2009. More recently, the Tecnis single-piece hydrophobic

Complications of IOL’s

- PCO
- Late dislocation
- Dysphotopsias

Dysphotopsias

- Dysphotopsia = unwanted light images
- “positive” dysphotopsia = light flashes
- “negative” dysphotopsia = dark areas

Dysphotopsias

- Both positive and negative dysphotopsias are seen in otherwise perfect uncomplicated surgery
- 20% report this in the first month
- Nearly all resolve within a month

Positive Dysphotopsia

- First described in early 1990s
- Associated w introduction of truncated edge of IOLs
- Internal reflection from the flat edge of IOL in the presence of a strong point light source at night
- Most commonly temporal visual field
- May reduce as anterior capsule fibrosis and blocks some light from entering and reflecting off the edge of the IOL

Negative Dysphotopsia

- First described as “horse blinder” effect
- Almost exclusively temporal
- Initially felt to be due to temporal incisions and clearing post-op edema
- Persistent negative dysphotosias more likely caused by IOL

Persistent Dysphotopsias

- High index of refraction for optic materials
- Ironically, smallest incisions have higher incidence of dysphotopsias.
    - smallest incisions
    - Thinner optic with higher index of refraction

Persistent Dysphotopsias

- Truncated edge of IOL’s
  - Reduced rate of PCO
    - Fewer capsulotomies
    - Fewer visits
  - Higher incidence of dysphotopsias

Persistent Dysphotopsias

- Edge treatments
  - Frosted edges = less internal reflectivity and less positive dysphotopsias
  - Hybrid contour of squared off edge - AMO IOL's have sharp 90° posterior edge with rounded anterior edge = diminished dysphotopsias

Persistent Positive Dysphotopsias - Surgical Solutions

- IOL exchange
- Piggyback IOL
- Most effective replacement IOL's have rounded edges with less truncated edges and lower refractive index

Persistent Negative Dysphotopsias -

- Ring scotoma due to higher constant index of refraction
  - present 360, but symptomatic temporally
- Not relieved by IOL exchange
- Some get relief with YAG removal of anterior capsule or reverse optic capture
- Unclear whether improvement if from anterior capsule opacification or neuroadaptation
- Incisions generally not a factor in persistent symptoms

Routine IOL

- One piece acrylic
  - Truncated edges
  - Centers well
  - “Tacky” surface prevents late subluxation or pea-podding
  - Aspheric optic
  - Forgiving insertion

LASIK patients

- Each diopter of myopic LASIK correction induces +0.04 um of corneal spherical aberration
    - Aspheric IOLs have negative corneal spherical aberration, and help compensate
    - Alcon SN60WF = -0.19 um. Tecnis ZA9002 = -0.27 um
- Each diopter of hyperopic LASIK correction induces -0.19 um of corneal spherical aberration
    - Avoid aspheric IOL’s
    - SA60AT = +0.28 um spherical aberration
    - AR40e = +0.1 um spherical aberration

1 piece or 3 piece IOL?

- Posterior capsule defect => 3 piece w optic capture if possible
  - reduce power by 0.5 to 1.0 D for sulcus fixation
- Anterior capsule tear - one piece in the bag, or 3 piece in the sulcus (with power reduction)

Preferred Presbyopia Strategies

- Bilateral emmetropia
  - Bifocals or readers
- Monovision for experience mono vision users
  - Distance eye first
  - Aim for -0.75 to 2.00 D myopia in the near eye

Preferred Presbyopia Strategies

- Multifocal
  - Alcon ReSTOR - (pupil dependent, glare, low light requirement for glasses)
  - AMO Tecnis - pupil independent, less glare, better low light performance

Preferred Presbyopia Strategies

- First eye with +3 or +2.25 add, depending on patients visual needs and requirements

Preferred Presbyopia Strategies

- For patients with astigmatism:
  - Symphony extended range of focus IOL
    - Compensates for up to 3 D of corneal cylinder
    - Great distance, intermediate - may need glasses for smallest print
  - Alcon SND6T +3.0 toric ReSTOR
    - compensates for 2.5 D corneal cylinder
    - less clear for computer distance, but excellent reading

Questions?

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Professional Activities:

Full-time clinical comprehensive ophthalmology practice, Southern California Permanente Medical Group:

- ~12,000 cataract surgeries performed since 1985
- Chief of Ophthalmology Dept, San Diego area (22 MD's) 2005-2011
- Lead ophthalmologist, Vista Eye Center, 1992-present
- Kaiser-Bellflower, 1986-1988, San Diego, 1988-present

Clinical Instructor, UCSD Dept. of Ophthalmology, 1992-2006
Fellow, American Academy of Ophthalmology 1988-present
Board-certified, American Board of Ophthalmology, 1988

Education:

Pasadena High School, Pasadena, California

Brigham Young University, Provo, Utah

- B. S., Zoology, 1978 summa cum laude
- Phi Kappa Phi
- Varsity Water Polo team

University of California, San Diego, School of Medicine

- M.D., 1982
- Research:
  "Current Concepts on Endophthalmitis" (senior thesis)
- Ranking: No rankings, honors, or honor societies were permitted during the years of my attendance at UCSD School of Medicine

L.D.S. Hospital, Salt Lake City, Utah

- Rotating internship, 1982-1983

University of California, San Diego, Dept. of Ophthalmology

- Ophthalmology residency, 1983-1986
- OKAP Scores: 1984: 83% 1985: 79% 1986: 85%

Community Activities:

Church youth leader

References:

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Gary Groesbeck, MD
Review of IOL Designs and Materials 2017

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- C. Anterior Chamber IOL's
- D. Posterior Chamber IOL's
- E. In the Bag IOL's

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- C. Flexible Acylic
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- B. One piece IOL's
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  - 2. Biconvex
  - 3. Aspheric
  - 4. Multifocal
  - 5. Extended Depth of Focus
  - 6. Accomodating IOL's

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V. Conclusions