American Society of Cataract and Refractive Surgery

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Boston, Massachusetts
Boston Convention Center

Course 27-310 BCEC
Room 259 AB

“Multifocal, Toric Multifocal and Accommodating IOLs: Face the Challenge”

Senior Instructor:
Matteo Piovella MD

Instructor:
David F. Chang MD
Jack Holladay MD, MSEE, FACS
Richard L. Lindstrom MD
Jay S. Pepose MD

Sunday, April 27, 2014
1.00 PM – 2.30 PM
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David F Chang MD

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Jack T Holladay MD, MSEE, FACS

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Richard L. Lindstrom MD

ADDRESESS
“Multifocal IOLs: Directions to Improve Patient Satisfaction”
Matteo Piovella MD; Barbara Kusa MD
Tecnis® MIOL
Sphere Equivalent and BCVA Visual Acuity

Monocular Uncorrected Near Vision Visual Acuity

Monocular defocus curve Multifocal IOL
Tecnis® AMO ABBOTT

Residual Refractive Error as Function of Pupil Size and Defocus

Diffractive Technology
Snellen Visual Acuity as Function of Pupil Size and Defocus

- Tonic vs. spherical it is two times difference: the effect of 1 D cylinder error on VA is about 0.5 D spherical refractive error.
- In Multifocal lenses, VA sensitivity to refractive error depends on a multifocal design.
- Refractive Multifocal Technology was close to monofocal for the width of the Distance Peak in Defocus Curves measurements.
- Diffractive Multifocal Technology width of the Distance Peak was about half the monofocal width.
- The effect of refractive error was about twice more sensitive to than in case of a monofocal optic.
Weak Points of Diffractive Multifocal IOLs

- Reduction of Contrast Sensitivity (up to 30%)
- Diffraction Grooves (Blaze height) Creates Different Diffraction Efficiency and Light Loss
- Toric Multifocal when 0.76 D of Corneal Astigmatism
- Heales, Glare and Ghost Images are Difficult to Manage in Suspicious Patients
- Poor Intermediate Distance Vision
- 0.60 Dioptr SE generates loss of one line of Visual Acuity
- Perfect Target: Plane Post-op Refractive Results

MTF (50 lp/mm) sensitivity to IOL rotation error up to 2.0 D cylinder correction—Pupil size 5 mm

OptiVis™ MIOL (Aaron Scientific, Inc)

- Posterior multifocal surface consists of 3 zones:
  - Zone 1 of Progressive Refractive powers for Far and Intermediate within central 1.5 mm diameter
  - Apodized Diffractive Zone 2 for Far with 2.6 D Effective Add for Near within 1.5 to 2.5 mm diameter
  - Peripheral Refractive Zone 3 is shaped for bi-axial asphericity

OptiVis multifocal surface shape deviation from equivalent power sphere

OptiVis multifocal surface shape deviation from equivalent power sphere

Central Progressive power zone

- Zone 1 Power profile starts with Intermediate power at the center of the lens
- Power profile shape is to extend focus range from Far to Intermediate distances
- Negative surface sign of Zone 1 and part of Base Surface of the Diffractive Zone 2 is to expand Depth of Focus at Far to Intermediate
- A Refraction zone has advantage of utilizing 100% of light for retinal image thus reducing the overall light loss as compare with any other diffractive optic

Apopization Zone 2

- Initial Diffraction groove is to direct light to Near focus
- Zone 2 groove heights reduces towards periphery in order to direct more light to Far
- Light Loss is smaller with more apopization Far to Near light split
- OptiVis apopization allocates the smallest surface area for equal Far to Near light split where light loss is the largest
**OptiVis Multifocal Surface Shape**

- Lens body
  - Zone 1
  - Zone 2
  - Zone 3

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**LSC of Bi-Sign Aspheric**

- LSC graph can be divided into two regions:
  1. Arrows towards positive direction to indicate positive spherical ray aberration for up to about 3 mm diameter.
  2. Arrows towards negative direction to indicate negative spherical ray aberration beyond 3 mm diameter.

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**RMS and Aspheric IOL**

- Total RMS and fraction of RMS corresponding to HOA RMS in the Nominal Eye at 6 mm pupil with best focus position set at 3 mm pupil for the corresponding IOL position in the eye.

<table>
<thead>
<tr>
<th>IOL Position in Eye Model</th>
<th>Total RMS</th>
<th>HOA RMS</th>
<th>Other RMS</th>
<th>Combined RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center</td>
<td>0.59</td>
<td>0.03</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Descattered 0.5 mm</td>
<td>0.25</td>
<td>0.09</td>
<td>0.08</td>
<td>0.05</td>
</tr>
<tr>
<td>Descattered 1.0 mm</td>
<td>0.53</td>
<td>0.01</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>2 Degree x y tilt and 0.5 mm y decentration</td>
<td>0.20</td>
<td>0.06</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>2 Degree x y tilt and 0.5 mm x decentration</td>
<td>0.20</td>
<td>0.06</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

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**OptiVis MIOL (Aaren Scientific)**

- Advantages:
  1. Intermediate focus in addition to far and near focus.
  2. Improved apodization to minimize light “loss”.
  3. Reduction in both, light “loss” and fraction of light to near focus at large pupil – this is to reduce nighttime dysphotopsia.

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**Second Generation Multifocal Diffractive IOL**

- **What is the Difference?**

- OptiVis Central Area is 2.1 sq. mm.
- ReStor and AcriLis Central Area is 1.3 sq. mm.
- ReStor and AcriLis Central Area is the first Diffraction Groove that works together with the other diffraction grooves.
- OptiVis Central Area acts as a stand-alone refractive zone of progressive power range which complements the lens diffraction grooves to provide intermediate focus.
- Other differences: Optimized Apodization to reduce light outside the range of vision and improved Aspherization to minimize effect of lens tilt and decentration.
**OptiVis™ MIOL (Aaron Scientific, Inc) Materials and Methods**

OptiVis™ Implant in 82 eyes of 42 patients (40 Bilateral Implantation)
Mean age: 70.37 ± 6.25 years.
Follow-up: 3 years

- Uncorrected Distance (UCDVA), Intermediate (UCIVA) and Near (UCNVA) Visual Acuity
- Best Corrected Distance (BCDVA), Intermediate (BCIVA) and Near (BCNVA) Visual Acuity

**Manifest Refraction: Spherical Equivalent 82 Eyes**

Outcome for targeted refraction

**Monocular Far Visual Acuity: 82 Eyes**

Far Vision Outcome

**Two years Binocular Near® Vision Visual Acuity 40 Patients – 80 Eyes**

<table>
<thead>
<tr>
<th>MEAN ETORIS™</th>
<th>MEAN JANDER</th>
<th>BEST VISION MEAN DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCDVA PHOTOPIC</td>
<td>51.20</td>
<td>3</td>
</tr>
<tr>
<td>DCDVA PHOTOPIC</td>
<td>51.20</td>
<td>3</td>
</tr>
</tbody>
</table>

**Two years Binocular Intermediate® Vision at 70 cm 40 Patients – 80 Eyes**

<table>
<thead>
<tr>
<th>UNCORRECTED</th>
<th>MEAN ETORIS™</th>
<th>MEAN JANDER</th>
<th>DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERMEDIATE VISION</td>
<td>41.57</td>
<td>4</td>
<td>70 cm</td>
</tr>
</tbody>
</table>

**AT LISA® tri MIOL - Trifocal Optic**

The optical zone of the AT LISA® tri 835MP provides
- a near addition of +0.33 D for a comfortable reading distance
- an intermediate addition of +1.68 D

It improves intermediate vision without compromising near or far vision.

AT LISA® tri has fewer rings on the IOL optic surface for reduced potential visual disturbances and improved night vision.

**AT LISA® tri FOCAL Implantation**
ATLISA® tri No correction Intermediate Vision

ATLISA® tri No correction Near Vision

ATLISA® Tri IOL contrast sensitivity
Daytime, Nighttime and Nighttime with glare

Acrl.LISA® Toric® Study
Materials and Methods

Acrl.LISA® MIOL implanted in 36 eyes of 22 patients
Mean age: 81.80 ± 14.04 years.
Follow-up: 3 years
- Best corrected distance VA (BCVA) Distance
- Post-op Mean Refractive Astigmatism
- Post-op Sphere Equivalent
- Binocular Near VA

Acrl.LISA® Toric
3 Years Post-op Result

Post-op Mean Refractive Astigmatism (36 Eyes)
(Pre-op Mean Corneal Astigmatism 1.63 D)

Pre-op Mean Corneal Astigmatism 1.63 D
Pre-op Mean Refractive Astigmatism 1.26 D
Mean IOL Astigmatism 1.66 D
Acrl.LISA®Toric
% YAG LASER CAPSULOTOMY - 35 EYES

EARLY YAG LASER TREATMENTS (within one year postop)
7 Eyes: YAG laser treatments (21.2%)

Acrl.LISA®Toric Implantation

Rotational stability and centration
Mandatory for a good long-term postoperative outcome after the implantation of a toric multifocal IOL, the rotational stability and centration of the lens.
Because of the special 4-haptic design, ZEISS MICS IOLs have proven excellent rotational stability and stable centration in more than 250,000 implantations.

Acrl.LISA® MIOL

Materials and Methods

Acrl.LISA® MIOL Implantation in 15 eyes of 9 patients
Mean age: 68.7 ± 12.08 years.
Follow-up: 3 years
• Best corrected distance VA (BCVA) Distance
• Post-op Mean Refractive Astigmatism
• Post-op Sphere Equivalent
• Binocular Near VA

Acrl.LISA®
BCVA (15 Eyes) 3 Years Post-op Result

Sphere Equivalent (16 Eyes)

Near Vision (EDTRS)

Acrl.LISA®
3 Years Post-op Result
Monocular defocus curve AcriLISA®

Conclusions

- Diffractive IOLs technology is difficult to manage to avoid quality of vision penalization on a significant number of patients.
- 3 mm pupil size condition works at the best to minimize patient complaints. Larger pupils have to be detected preop and the mandatory
- Perfect Target™ is plano postop results.
- Diffractive multifocal technology has no significant % of light for intermediate distance and an important amount of light loss. The Trifocal technology overcome this weak point providing specific % of light for intermediate distance and reduces the light loss improving diffractive efficiency and quality of vision.
- Halos, Glare and Ghost Images are difficult to manage in demanding Patients. Trifocal technology is an effective tool to improve contrast sensitivity and reduce night driving problems. It is really important a proper patient selection related to pupil dynamics.

High Quality Distance And Near Vision With Dual Optic Accommodating IOL

Synchrony Dual-Optic AIOL

What is the Synchrony AIOL?

- Single-piece, dual-optic silicone IOL
- Three dimensional lens designed to fill the capsular bag
- 6.6 mm high plus anterior optic (+3D)
- 6.0 mm variable negative posterior optic
- Optics connected by spring haptic
- Size 9.5 mm x 8.8 mm

Barbara Kusa MD
CMA, Centro di Microchirurgia Ambulatoriale
Monza – (Milan)
Italy

Synchrony Dual Optics AIOL – 18 Months Clinical Results

- 33 eyes of 18 patients
- Mean Age 71.62 ± 7.02
- Mean Preoperative BCVA 0.67 ± 1.61
- Mean Time Follow Up Days 66.08 ± 44.63
- Mean Preoperative Sphere Equivalent 0.48 ± 1.42
- Inclusion Size: 3.75 mm using calibrate metal knife

Synchrony Implantation Technique

- Insert injector tip to CCC edge
- Release 1st optic
- Open capsular bag by pushing leading optic against the posterior capsule
- Deliver 2nd optic into capsular bag
**New Generation: Synchrony VU Accommodating IOL**

- The new generation Synchrony® VU Accommodating IOL is designed to provide enhanced near vision without compromising quality of vision.
- Central blended aspherial zone designed to extend depth of focus.
- Latest innovation advancing the Synchrony platform.
- The lens is CE Mark approved.

**Monocular defocus curve Synchrony Dual Optics AIOL**

- TECNOS + S2OLs
- AT USA + M2OLs
- Synchrony Dual Optics AIOL

**Synchrony Surgical Focal Points**

- [Images of surgical focal points]

**Accommodating IOLs Best**

- No Contrast Sensitivity Penaltation
- Halos or Glare similar to Monofocal IOLs
- Future AMD: No Future Visual Penaltation due to IOLs Technology
- Best Choice for Suspicious Patient, with Possible High Sensitivity to Glare and Halos, but Highly Demanding for New Technology IOLs
- Provide Intermediate Vision

**Quality of Vision**

- Contrast Sensitivity and Control Values

- Control values for CS are derived from Hohberger paper.

- 10-14 healthy phakic subjects for the following age group: 30; 35-39; 40-44; 50-54; 60-64; 70

- Functional Image Analyzer OPTEC 6600P

- Daytime (86 cd m²), Nighttime (3 cd m²) and Nighttime with Glare (3 cd m²)

- Monocular testing

- Paper demonstrated strong age dependence of CS with age
Multifocal IOLs Contrast Sensitivity

Synchrony contrast sensitivity
Daytime, Nighttime and Nighttime with glare

Multifocal IOLs Contrast Sensitivity

Multifocal IOLs Contrast Sensitivity

Cataract Surgery Main Complications - National Register
Where are we?

Cataract Surgery Main Complications
Where are we?

27% Posterior Capsule Opening
33% Endophthalmitis
26% Corneal Decompensation

Only 81% of eyes see 20/20 after cataract surgery
Biometry 91% within ±1 D
The expanding use of multifocal intraocular lenses (IOLs) has increased the frequency with which ophthalmologists must evaluate postoperative patients complaining about poor quality vision following implantation of these lenses. A variety of treatable factors must be evaluated, treated, or ruled out in the unhappy multifocal IOL patient. These include residual spherocylindrical refractive error, a dry or inflamed ocular surface, poor IOL centration, posterior capsular opacification, and subtle macular pathology, such as subclinical cystoid macular edema. Absent any such treatable problems, the patient and ophthalmologist face the dilemma of whether or not to exchange the IOL. This decision is complicated by competing considerations - the possibility that symptoms may improve over time versus the knowledge that IOL explantation will become progressively more difficult with time.

The iTrace Combo technology allows the ophthalmologist to separately evaluate and quantify higher order aberrations originating from either the lens or the cornea in both phakic and pseudophakic eyes. With an unhappy premium IOL patient, this information can greatly aid the decision of whether or not to explant the lens. I will present three representative cases to illustrate the diagnostic benefit of pseudophakic wavefront aberrometry in unhappy multifocal IOL patients. All patients were evaluated with the iTrace Combo unit using the 4.4 software. Wavefront and topographic data are displayed for each eye as follows [Figure 1-6]. The lower right screen displays the axial topography map. The upper right screen displays a root mean square (RMS) bar graph of higher order aberrations of the total eye, which are then broken down between those associated with the lens (upper left screen) and those associated with the cornea (bottom left screen).

Case Reports

Case 1: A 64 yo white female presented for a second opinion 26 months following uncomplicated cataract surgery in her right eye, with implantation of a SN D3 ReSTOR 4.0 multifocal IOL. She noted poor quality vision almost immediately following surgery. Because of this, she delayed surgery in her left eye until 10 months later, and eventually opted to have a monofocal IOL in this eye. A YAG capsulotomy in the right eye had failed to improve her symptoms, which were not improving.

Her vision was 20/25+ with a +0.25 + 0.50 x 15 refraction in the right eye, and 20/20 with a Plano + 1.00 x 160 refraction in the left eye. Slit lamp examination of the anterior segment and fundus were normal in each eye, and a macular OCT examination performed by her ophthalmologist was normal. The diffractive rings of her multifocal IOL were perfectly centered with the undilated pupil.

To further evaluate her complaints, topography and wavefront aberrometry were performed. The individual wavefront analysis showed that significant HOA in the right eye were primarily caused by the lens. These consisted of high amounts of coma and spherical aberration [Fig 1]. The left eye had no HOA [Fig 2].

Based upon the diagnosis of IOL-related HOA, the option of IOL exchange was offered to the patient, which she elected because of her symptoms of visual distortion. During the explantation procedure, the capsular bag seemed rather loose due to zonular laxity. A monofocal IOL was placed in the ciliary sulcus. Postoperatively, her subjective symptoms of blur improved significantly, and were consistent with a reduction in lenticular HOA based upon postoperative wavefront aberrometry [Fig 3]. The cause of the right eye HOA was felt to be subtle tilting of her multifocal IOL due to significant zonular weakness and laxity.

Case 2: A 55yo white male presented with complaints of halos and monocular double vision in his left eye. One and one half years earlier, this eye had been implanted with a ReZoom multifocal IOL following an uncomplicated phacoemulsification procedure. The patient complained that the left vision was hazy with poor contrast, “as though he were looking through something”. Although he had been repeatedly reassured that his eye was “normal” and that his symptoms would likely improve with adaptation over time, he was frustrated by the lack of any perceived symptomatic improvement. The uncorrected distance acuity was 20/20 with a plano refraction in this eye, and the near acuity was J2+ uncorrected. The phakic right eye was BCVA 20/20 through a -1.75 + 1.75 x 80 refraction. The anterior segment and fundus examination were entirely normal. Specifically, the ReZoom IOL was well centered and the intact posterior capsule was clear.
A wavefront and topography evaluation using the iTrace was performed in both eyes, and showed that the left eye had significant HOA. Some HOA originated from the IOL and some HOA were associated with the cornea (most notably some coma) [Fig 4]. The right eye did not reveal any HOA. On this basis of his poor visual quality, the patient elected to undergo a right IOL exchange with a monofocal lens. Postoperatively, the patient was delighted with a significant subjective improvement in the quality of his vision. He was 20/25+ uncorrected in the distance, with BCVA of 20/20-, with a refraction of -0.50 + 0.50 x 90.  

There was an improvement in his HOA in the left eye as measured postoperatively at one month with the iTrace [Fig 5]. In retrospect, his left eye had significant corneal coma, and was not a good candidate for a multifocal IOL.

Case 3: A 63 yo female executive sought a second opinion because of poor quality vision two months following a right eye refractive lens exchange. She was previously hyperopic and because she hated wearing eyeglasses and was contact lens intolerant, she elected to have implantation of an aspheric ReSTOR 3.0 multifocal IOL, combined with astigmatic keratotomy.  

On examination, her right eye had uncorrected distance acuity of 20/25, and J8 at near. The refractive error was -0.25, and she improved to J3- with a +2.50 add. Although the uncorrected and best corrected Snellen acuity was 20/25, she complained that the letters ran together and the vision seemed blurry. She saw lots of halos, and had difficulty seeing at night and with fluorescent lighting during the daytime. These symptoms had been present immediately after surgery and the patient felt that there had been no adaptation or improvement over time. With a refraction of +3.50, her left eye had best corrected visual acuity (BCVA) of 20/20 in the distance, and J1 with a +2.50 add. Despite the obvious difference in uncorrected acuity, she felt that the left eye had noticeably better vision. She was very bothered by the anisometropia, but was reluctant to have a multifocal IOL in the second eye saying that a visual result like that of the first eye would be “a disaster”. The slit lamp examination was unremarkable, and the diffractive multifocal IOL was perfectly centered. A dilated examination revealed a clear posterior capsule and a normal macula. A macular OCT was normal. Wavefront aberrometry with the iTrace was performed [Fig 6]. The topography appeared normal in both eyes, with 0.26 D of astigmatism on simulated keratometry in the operated right eye. There were no significant higher order aberrations in either eye with a 4.0 mm pupil size.  

The question of whether to exchange the multifocal IOL remained very difficult in the face of the normal aberrometry evaluation. Further questioning revealed that at one point, the patient had worn an eye patch as a child. A four prism diopter base-out cover test was performed and demonstrated that the patient was a left eye monofixator. This, together with her childhood history of patching one eye, indicated a diagnosis of mild right amblyopia. The patient was told that her amblyopia was responsible for the poorer quality vision in the right eye, and because of her monofixation, it was recommended that she have a monofocal IOL in her left eye.

**Conclusion**

No one would dispute the advantages of using OCT to get as much anatomic information about the macula in evaluating prospective multifocal IOL candidates preoperatively, or unhappy multifocal IOL patients postoperatively. However, cataract surgeons have traditionally had very little information about the optical quality and anatomy of the cornea. Although corneal topography is widely used in these situations, patients in a typical cataract population often have mild topographic irregularities that are difficult to interpret. The ability to separately detect and quantify higher order wavefront aberrations coming from the lens or from the cornea is a major diagnostic advantage in analyzing postoperative optical complaints in pseudophakic eyes.
Screening And Counseling Refractive IOL Patients

David F Chang MD

Since the Centers for Medicare & Medicaid Services’ 2005 ruling made them available to every cataract patient, each new presbyopia-correcting IOL has been greeted with great interest and excitement. For experienced IOL surgeons, the technical transition was easy. What we were not prepared for was the unpredictable and substantial increase in chair time that offering these premium IOLs would entail.

Does this sound familiar? Drawn-out explanations are met with confusion, blank stares, or even a postponement of surgery. Indecision results in repeated telephone calls and requests to speak to other patients. You fall so far behind schedule from an endless consultation that you pray that the next patient wants a standard IOL. I offer all three presbyopia-correcting IOLs and an accommodating IOL in clinical trial, but too many choices will overwhelm most patients, and can result in what Steven Dell, MD, calls an “information-seeking spiral.”

It is all too easy for patients to develop unrealistic expectations about eliminating glasses and about perfect “20/20” vision. Indeed, the greater the emotional and financial investment in the refractive outcome, the higher the expectations will be. Postoperative dissatisfaction is excruciating to both the patient and the surgeon for this reason. Residual astigmatism, myopia or hyperopia, or macular pathology that may have been missed preoperatively are much more disappointing for a refractive cataract patient. Despite flawless surgery, emmetropia, and a healthy eye, dissatisfaction may still arise because of halos, glare, waxy vision, and other imperfections that may correctly or incorrectly be attributed to the “special” IOL.

To promote or not?
For appropriate candidates, toric IOLs or astigmatic keratotomy have no major downside aside from their additional cost. Compared to the alternative of postoperative laser vision correction, they represent a good value and I am comfortable encouraging a patient to have them if they are desirable and affordable for that individual. How strongly we should promote the option of presbyopia-correcting (Pr-C) IOLs, however, is controversial and is more a matter of the surgeon’s personal style, opinion, and philosophy.

Our current presbyopia IOL technologies are not without tradeoffs, and knowing that we don’t have a powerful accommodating IOL, I am uncomfortable with promoting these options too strongly. I believe that they are a great solution for many patients, but not for everyone. Realizing the power of my influence, I therefore strive to educate patients about these options in a neutral way. For this reason, I avoid the term “deluxe” lenses and I avoid third party promotional brochures and displays. I do not advertise, nor do I enlist my staff to market these products internally. I am collaborating with Eyemaginations to script a Pr-C IOL education video that is more neutral, and less promotional than some that I have seen. Such decisions will depend upon your personal style and your own assessment of and experience with the technologies. It is important to note that I do not perform laser vision correction, and that mine is primarily a cataract referral practice.

Undecided cataract patients often ask whether I would recommend that they choose the presbyopia correcting IOL option. I explain that I would recommend that anyone moving to California should buy a car. In doing so, they will be given options such as leather seats, a GPS system, or a sun roof. Whether or not they want or value these add-on luxury options enough is a very personal choice. Once they decide to have a presbyopia correcting IOL, however, I will make a recommendation as to which option I believe will best match their priorities.

Educating patients efficiently and effectively
Most patients understandably need a lot of time to make this complex decision. It is therefore far more efficient and effective to initiate presbyopia correcting IOL education in advance of their office visit. My staff now sends a packet of handouts that I personally wrote to every patient who is referred (or self-referred) with a diagnosis of cataract. Besides a basic brochure on cataract surgery, they receive a general handout describing the option of Pr-C IOLs. This handout attempts to explain presbyopia, and the concept of paying extra to upgrade to a Pr-C IOL that reduces but doesn’t eliminate the need to wear spectacles.

Patients also receive and are asked to complete the Dell questionnaire (which I have personalized and slightly modified for my practice) at home. In addition to eliciting personal preferences and goals, the process of completing this survey makes it clear to the patient that 1) they utilize and require multiple different working distances, and that 2) there are tradeoffs with these lenses that require each patient to establish certain priorities. When they come in, interested patients are prepared to hear whether they are a good candidate for these IOLs and to discuss their cost. Some immediately volunteer that they do or do not want these IOLs. The Dell questionnaire gives me an instant indication of their interest and functional profile.

Presbyopia Correcting IOL Handouts
During their visit, interested patients without medical or refractive contraindications are given a longer 4-page handout that I wrote about multifocal IOLs. I first introduce the multifocal option to most patients who desire spectacle independence, because it is the technology most likely to meet this specific goal. My handout covers must-read information about adapting to halos, the possible need for a laser enhancement, and unpredictable results due to variable macular function. It is also provides formal informed consent, and includes far more detail than I would want to give cataract patients who don’t express a strong interest in the subject. I do not mention or compare different multifocal IOL designs, but rather discuss the generic product.

Because manufacturer-supplied brochures optimistically promote a single product, I also wrote this handout in order to temper expectations (it stresses a reduction rather than an elimination of spectacle use). Although they are asked to read it while they are dilating, this take home handout allows patients to review the important points at home with their family. After the examination, most undecided patients can make up their minds by reviewing the handout at home without any further input from me. If patients are dissatisfied about something postoperatively, this handout provides a clear reminder that we did present certain pros and cons in advance.

If the patient is interested in reducing spectacle dependence, but either they or I have reservations about multifocal IOL, I explain the option of an accommodating IOL (Crystalens). I find that the pros and cons of this option are easier to understand once the patient is already familiar with how multifocal IOLs work. Again, I have prepared a take-home handout to explain certain pros and cons about the Crystalens.

Who does the Patient Counseling?

By saving me from having to repeat the basics every time, these handouts allow me to personally do the patient counseling, as opposed to entrusting this to a staff member. In many refractive practices staff counselors educate patients about how laser vision correction works and how much it will cost. This makes sense if most patients want to hear about and are presented with the same options. It is tempting to delegate the lengthy patient education process about Pr-C IOL options as well. I view this decision, however, as being much more complex than deciding to have LASIK.

Most of my Pr-C IOL candidates with cataracts didn’t come to me seeking refractive surgery. There is no consensus as to the best technology. None of the choices is without significant tradeoffs, and satisfaction will depend upon realistic and informed expectations. Because of this, I may determine that many motivated patients are not ideal candidates, despite their being able to afford the procedure and having a healthy eye. Patients who are willing to invest thousands of extra dollars in this technology deserve my expertise in patient selection, and I get subtle clues regarding their personality and priorities as we discuss the option and the costs together. We’ll both be happier if I am able to determine if, because of their personality, their glass will be half full or half empty postoperatively, and I can factor this information into steering their expectations and decision. This approach has definitely lengthened the average preoperative chair time for my cataract patients. However, that is the essence of why this service commands a premium. Just a few unhappy postoperative Pr-C IOL patients can easily offset the preoperative time savings of having your staff do the majority of patient counseling.

After taking the history, we perform automated keratometry and IOL Master biometry as part of every cataract patient’s pre-testing. If, on their Dell Survey, they have expressed an interest in spectacle independence for either far or near (or both), corneal topography is performed. My optometrist refracts the patient and determines their best corrected distance and near acuity. If indicated, Amsler Grid and BAT glare testing is performed. As determined by the optometrist, interested patients who appear to be appropriate candidates are given handouts or shown videos (astigmatic keratotomy, Pr-C or toric IOLs) while they dilate.

In addition to the history, I review the refraction, current eyeglasses, and visual acuity. I check the biometry and keratometry readings and read the patient’s responses to the Dell survey. After performing the dilated slit lamp and ophthalmoscopic exams, I generally know whether or not we will be discussing refractive IOLs at length. I mention the option to everyone as it is better to address this preoperatively, than to have the patient wonder later why they weren’t told about this choice. I therefore explain to patients with ocular pathology or high astigmatism why they are poor candidates for Pr-C IOLs.

The Concept of Convenience

I first explain to my cataract patients that they would be happy with a standard IOL following surgery. Realizing that the majority of my cataract patients will receive a monofocal IOL, I do not want the process of refractive IOL education to send subliminal messages that monofocal IOLs are an inferior technology. In next explaining the advantages of Pr-C IOLs, I emphasize the concept of convenience. This properly defines what is at stake - namely, that these IOLs are not “better” for their eye or of “better” quality. Nor is this a life-or-death decision to agonize over. Finally for Pr-C IOL patients, having emphasized the concept of “convenience” will help them to better accept that having to wear glasses postoperatively may be disappointing but is not a disability.

Many consultants and practitioners prefer to have staff members discuss pricing with the patient. For my own practice, I disagree. I mention the additional cost early in the discussion and explain that the convenience of reduced spectacle dependence is not covered by insurance because it is not “medically necessary”. Upon hearing what the premium cost is, some previously interested patients immediately volunteer that they’ve been wearing eyeglasses all along and that they really don’t mind them. This is their way of saying “I can’t or don’t want to spend that kind of money for this convenience”. At this point I take the hint, and we can now skip the lengthier explanation of multifocal IOL pros, cons, and expectations. I like to have them feeling positive about their surgery, and so I confirm that they will “do great” with the standard IOL. I have my own bias about
the financial value of these Pr-C IOLs and it is hard not to be influenced by the fact some patients must struggle to afford the premium, while other patients dismiss cost as a “non-issue”. I was ready to implant a multifocal IOL in one patient until I learned that he was going to take out a home equity loan to afford it. After I clarified once more that the advantage was one of convenience and not what was “better” for his eyesight, he opted for a monofocal IOL instead.

The Process of Re-setting Expectations

Most patients want and will tend to believe that refractive IOLs will eliminate glasses. This idea may have first been planted in their mind by LASIK advertising, by third party brochures depicting a smiling spectacle-free patient, or by hearing a contemporary brag that they “no longer wear glasses” after surgery. An important goal of patient counseling, therefore, is to reset and manage these expectations. The oft stated dictum of “under-promising and over-delivering” is another way of saying that we want to be confident that we can meet or exceed the patients’ expectations. This is certainly easier to do if they have a dense cataract or are completely spectacle dependent from high myopia or hyperopia to begin with.

Optical concepts such as focus, depth of field, contrast sensitivity, astigmatism and refractive error are difficult for many patients to grasp. How effectively you explain these concepts is just as important as how much time you spend doing so. It is best to honestly emphasize that these IOLs don’t reliably eliminate glasses. A frequent response is, “If I still need to wear reading glasses then what is the advantage?” I use the analogy that our winter weather is so much better here in California than in Minnesota – but it isn’t perfect and we still own a coat. We just own a lighter weight coat that we wear much less frequently. In other words, “better” is a good result, even if it is not “perfect”.

In summary, besides the advanced IOL technology, the “premium” part of the refractive IOL channel isn’t necessarily the way we perform surgery or the extra preoperative testing that we perform. Rather, it is our judgment, experience, and expertise in both patient and IOL selection that defines ours to be a premium service. The critical elements of patient selection and education are as much art as science. With so many IOL options, each with different pros and cons, and with the wide range of individual personalities and lifestyles, this art is not easily mastered.
Patient satisfaction with their uncorrected vision following a refractive IOL reflects success in four separate areas. There must be (1) uncomplicated surgery, (2) avoidance or reduction of astigmatism, (3) selection of the optimal IOL power, and (4) reasonable expectations on the part of the patient. The first three prerequisites have long been the goal of every cataract surgeon. It is in this fourth area of patient selection where the availability of presbyopia correcting IOLs has required us to develop and refine our skills.

Choosing to implant a presbyopia correcting IOL certainly increases the demands placed upon the cataract surgeon. The patient has agreed to pay extra for and accept the possible optical disadvantages of this lens because of the expectation of reduced spectacle dependence. Contrast these expectations with those of a patient whose procedure is entirely covered by insurance, and who anticipates wearing bifocals following bilateral cataract surgery. If we miss the spherical target by + 1 D, the correction simply ends up in the eyeglasses. This is also true for 1-2 D of surgically induced astigmatism or 1-2 D of unintended anisometropia. The patient will likely be unaware of 0.5 - 1 mm of optic decentration and, barring late complications, the patient will probably be just as happy with an AC IOL in the event of posterior capsule rupture.

Unfortunately, all of these scenarios compromise the uncorrected visual function of the bilateral multifocal IOL patient, particularly if the two eyes are compared. The expectation of good vision without glasses reduces our margin for error, and increases the potential for patients to become dissatisfied. The results of the various clinical studies of these lenses, however, indicate that skilled IOL surgeons are indeed able to meet this challenge.

With respect to our outcomes, we can readily measure objective parameters such as uncorrected Snellen and Jaeger acuity, and spherical or cylindrical refractive error. Nevertheless, we must remember that patient satisfaction and the perceived benefits and drawbacks of these lenses are largely subjective. For example, two bilateral multifocal IOL patients with identical refractive and anatomical results may differ greatly in their frequency of wearing glasses. This is influenced by the individual’s lifestyle and vocation, expectations, comparative preoperative function, and the motivation or determination to function without glasses.

We know from keratorefractive surgery that there is great variability in just how much patients value having good uncorrected vision. For some individuals, the motivation to see without glasses was so strong that even the tremendous glare and fluctuating vision characteristic of a 16-incision RK was a very acceptable tradeoff. Individuals with such strong motivation are also more likely to accept and adapt to the optical aberrations of a multifocal IOL. These are the patients who, after hearing about the potential for nighttime aberrations with a multifocal lens, start trying to convince me why they should not have any problems. “Oh, I already have plenty of halos now anyway.” “Well, I really don’t do that much night driving.”

While we certainly leave the final decision up to the patient, refractive error, pseudoaccommodation, contrast sensitivity, and optical aberrations are confusing topics for most patients to comprehend. Appropriately, they depend on our experience and understanding of the available options for guidance. With the heightened financial and emotional investment in the refractive outcome, it is the potential intensity of patient dissatisfaction that truly frightens us. Clearly, not every refractive IOL patient will achieve a superb functional result. If that patient, however, is still able to understand the advantages of their presbyopia correcting IOL? To get a sense of their motivation to avoid glasses, I usually ask prospective candidates how often they wear their bifocals during the average day. As we know, there are a number of people with significant refractive error who don’t wear their glasses that often. These individuals are apparently willing to tolerate the extra blur rather than be inconvenienced with wearing spectacles. On the other hand, a nearly emmetropic patient who wears bifocals all daylong because he or she is too blurred without that -0.50 + 0.50 x 90 correction may be equally intolerant of multifocal IOL ghost images.

We also know from our general ophthalmology practices that individual patients vary greatly in their ability to adapt to distracting imperfections in their vision. Whether it be a floater, an oily contact lens, monovision, or the distortions of progressive add bifocals, patients who are highly intolerant of such flaws might be at higher risk of dissatisfaction with the unwanted images from a multifocal IOL. The degree of cataract and visual complaint is also telling in this regard. A patient with advanced brunescent lenses, 20/80 acuity, and yet relatively understated complaints is telling you that they are not a very “picky” person. This is in contrast to the 20/25 patient with minor lens opacities who, despite being reassured 3 months ago, is
already back again feeling utterly disabled by their deteriorating vision. Obviously, this person may be equally intolerant of the glare and halos from a multifocal IOL.

Pupil size is important with respect to both night vision and near acuity. A patient with small pupils will enjoy greater depth of field, and will experience less optical aberration at night. A patient with large pupils will more likely experience halos with the ReZoom or Crystalens, and it is important to inquire about that patient’s nighttime lifestyle. Finally, expect patients to compare their postoperative uncorrected visual function to their preoperative state. For example, uncorrected J5 vision will seem miraculous to someone who was +3.00 preoperatively, but will be disappointing to someone who was formerly -3.00. Likewise, it is hard to imagine a patient starting with a 20/400 PSC cataract not being ecstatic with or without glasses postoperatively.

We cataract surgeons are accustomed to routinely exceeding our patients’ expectations. Our patients are typically surprised and unexpectedly pleased with the lack of pain during and after surgery, the speed of the surgery and their visual recovery, the unanticipated clarity and enhanced color vision, the improvement in refractive error (in highly ametropic individuals), etc. Contrast this with the frustrating prospect that flawless surgery may still disappoint a refractive IOL patient with unrealistic expectations.

Because expectations are such a critical determinant of patient satisfaction, all refractive surgeons have no doubt mastered the art of understating the anticipated results. Who should we be particularly cautious about? Be careful with patients who are depressed, obsessive compulsive, passive-aggressive, or manipulative (patients with a so-called borderline personality). Some of these patients will be unhappy no matter what the outcome, and if they perceive that you promoted a more expensive option, they may unfairly blame all of their woes on this decision, which you “pressured” them into making. Patients with a strong sense of “entitlement” may also be hard to please. Examples would be patients who are uncooperative with your staff, or who tend to feel that every problem or inconvenience is someone else’s fault. These may be hints that they will hold you responsible for providing a perfect refractive result.

What makes some engineers so difficult? Their livelihood depends upon precision and they are conditioned to detect and uncover imperfection and subtle “bugs” that, if undiscovered, might undermine performance. Some engineers are so accustomed to solving problems with precise technical solutions that they have difficulty accepting that we don’t have a perfect answer for refractive error and presbyopia. The process of adaptation will be stalled if an obsessive individual cannot accept any imperfection, distraction, or inconvenience, and in fact dwells on these problems. This is not to say that these patients should not be given the same options as everyone else. Rather, we should emphasize the risk of dissatisfaction due to any number of potential scenarios when we counsel that particular patient. I may diplomatically point out that they seem to be a very “precise” individual who may be more bothered by certain optical characteristics of a multifocal IOL that otherwise go unnoticed by the general patient population.

Particularly when getting started with multifocal and refractive IOLs, it is important to select patients who will be among the easiest to satisfy. I liken this to taking high percentage shots in basketball. Easy going patients with advanced cataracts and significant preoperative myopia or hyperopia will have the most to gain and will be the easiest to please. Performing cataract surgery with presbyopia correcting IOLs in these patients is like shooting layups. On the other hand, obsessive or perfectionist patients with minor lens opacities will be more difficult to impress. This is particularly true if they have low myopia, or are already achieving monovision with contact lenses, and satisfying these patients is the basketball equivalent of an off balanced 3-point shot. In my basketball analogy, the inexperienced surgeon is better off sticking to short shots from the lane, rather than attempting low percentage long range bombs. As more and more success begets confidence, one can start to think about moving further away from the basket.

Overall, electing to implant a premium refractive IOL is analogous to other non-medical decisions that we make with our patients every day - e.g., decisions to pursue refractive surgery, cosmetic surgery, monovision contact lenses, progressive bifocals, etc. Each of these options has pros & cons that are time consuming to discuss, but which prevent them from being the universal best solution for everyone. However, just as it would be inappropriate to push these options upon every patient, it would be just as wrong to conceal or routinely discourage these options because of potential drawbacks or because some patients are dissatisfied. In each of these instances, there is a subset of informed patients who are delighted to have had these options, and grateful to the physician who explained and provided them. For this reason, I believe we all owe it to our cataract patients to acquire the skills needed to offer presbyopia correcting IOLs, and to spend the necessary time discussing and considering these options with them.
The goal of having a sufficiently powerful accommodating intraocular lens (IOL) continues to elude us [1]. Compared to multifocal IOLs, the optical quality of such a lens would not be compromised by nighttime haloes or reduced contrast sensitivity [2]. Patients could dynamically shift their focus along a continuous range of distances from far to intermediate to near. With no major drawbacks, the choice of IOL would simply depend upon the patient’s desire and willingness to pay for this technology. Despite significant improvements in current designs, multifocal IOLs will always fall short of these lofty goals. Image splitting designs require an inherent compromise in both optical quality and pseudoaccommodative performance. Because of these necessary tradeoffs, proper patient selection is especially critical.

The optical differences in the design of current diffractive multifocal IOLs and refractive multifocal IOLs should be well understood by all refractive IOL surgeons [3]. Eyes with high or irregular astigmatism, with maculopathy or reduced vision potential, and with zonular problems predisposing to IOL decentration are poor candidates. However, assuming that an interested patient is a good multifocal candidate, each design has different pros and cons. It is the job of the ophthalmologist to determine the best match for each individual patient.

**ReZoom**

The central distance-only zone of the ReZoom makes this multifocal “distance-dominant” with normal pupil sizes [3]. This means that uncorrected reading vision is poor through small pupils, and patients may read better if ambient light is reduced enough to avoid miosis. Haloes, although less severe than with the Array, are still quite noticeable to patients whenever the pupil dilates widely, such as in younger patients at night. ReZoom has a lower effective near add (+2.6 D) than ReSTOR (+3.2 D). In addition, the blending of ReZoom’s refractive zones creates a progressive add, which devotes some focus to intermediate distances. However, having more light emanating from distance and intermediate points reduces the near vision performance of ReZoom, compared to ReSTOR.

The zonal refractive design seems to make this technology slightly more forgiving of being ± 0.5 D hyperopic or myopic. Distance contrast sensitivity should be superior to that with refractive IOL surgeons [3]. Eyes with high or irregular astigmatism, with maculopathy or reduced vision potential, and with zonular problems predisposing to IOL decentration are poor candidates. However, assuming that an interested patient is a good multifocal candidate, each design has different pros and cons. It is the job of the ophthalmologist to determine the best match for each individual patient.

**ReSTOR**

The apodized diffractive design of ReSTOR provides excellent near and distance function despite the loss of some incoming light due to diffractive scattering [3, 4]. The 50:50 distance/near split throughout the center of the lens provides good reading ability even with small pupil sizes. The higher near add allows a closer reading distance, which is the habitual preference of many myopes. A closer reading distance also increases the magnification of smaller print, but the tradeoff is having less light coming from intermediate distances. When they become available, lower add models of ReSTOR should improve intermediate function much as a lower add bifocal does.

With increasing dilation, the incoming distance/near light ratio increases dramatically due to the ReSTOR design (no peripheral diffractive optic). This significantly reduces the severity of nighttime haloes, compared to the ReZoom. Although ReSTOR patients still notice haloes and rings around lights, the severity is much less compared to Array and ReZoom.

Pupil centration is very important with a diffractive optic in order to avoid coma and other aberrations. Because the pupil is usually de-centered nasally, I have found that orienting the ReSTOR haptics from 6:00 – 12:00 and slightly nudging the IOL nasally improves the centration of the diffractive pattern. Paulo Vinciguerra MD has suggested this strategy based upon improved wavefront scans and decreased patient complaints in eyes in which he re-positioned the ReSTOR because of symptomatic decentration with the pupil.

**Aspheric Multifocal IOLs**

Both the Acrysof aspheric ReSTOR and the AMO Tecnis multifocal IOL are diffractive lenses with aspheric optics that provide a high effective add power. The aspheric design better compensates for contrast sensitivity loss compared to spherical diffractive multifocal IOLs. Theoretically, aspheric multifocal IOLs should provide better visual quality at distance compared to spherical counterparts with larger pupil diameters. This difference might be particularly important for driving under dimmer illumination [5]. It is important to realize that the aspheric surface does not affect the very center of the IOL, and should not impact IOL spherical aberration when the pupil is small. The concentrated near focus of these diffractive optics results in excellent close reading ability that comes at the expense of decreased focus at intermediate distances.
When ReSTOR and ReZoom both became available in late 2005, I undertook a prospective study to evaluate and better understand their comparative performance characteristics [7]. After informed consent, I prospectively enrolled 30 patients: my first 15 consecutive bilateral ReSTOR and my first 15 consecutive bilateral ReZoom patients that were younger than age 70. Multifocal IOL selection was not randomized, but was determined based upon what I thought would best match that individual patient’s needs. I chose this arbitrary age cutoff in order to evaluate IOL performance in younger patients who, as a whole, could be expected to be more demanding. I reasoned that these patients would be more likely to use computers, to drive at night, and to perform more visually demanding tasks. Furthermore, testing was performed at 6 months postoperatively to allow for adaptation to nighttime optical aberrations and to the new visual system. For further comparison, 9 patients under the age of 70 implanted with bilateral Crystalens 4.5 IOLs were also tested at 6 months postoperatively.

After 6 months, we evaluated uncorrected distance, intermediate (50 cm), and near acuity using standard ETDRS charts. In order to understand the intrinsic near and intermediate properties of an IOL, however, you must correct for any residual refractive error so that testing is conducted in an eye that is functionally emmetropic. We therefore also tested distance-corrected near and intermediate vision. We recorded pupil size and tested contrast sensitivity. Patients were asked to complete a standardized quality of life questionnaire, and we attempted to correlate this with a functional vision evaluation using standardized real-life props such as newspapers, magazines, medicine bottles, and a laptop computer.

Bilateral uncorrected visual acuity is represented with a logMAR scale in Figure 1. The last column (preferred reading distance) measures near vision when the patient is allowed to hold the reading card at any distance they want. The mean spherical equivalent for right and left eyes is listed at the bottom of the chart, and shows that the Crystalens patients tended to be slightly myopic. Figure 2 shows the results of best distance corrected visual acuity. As expected, all three IOLs show excellent distance acuity. However, the Crystalens performance at near and intermediate was decreased when these eyes were made emmetropic. This demonstrates that the Crystalens had less intrinsic near function when compared to a multifocal IOL. ReSTOR clearly performed the best at near. Both multifocal IOLs were comparable at an intermediate distance of 50 cm.

According to a standardized lifestyle questionnaire, patients in all 3 groups had excellent uncorrected vision for driving, store signs, television, and cooking. All patients reported excellent spectacle free distance vision (Figure 3). Most patients could read a menu without glasses, although ReSTOR was the best for this task (Figure 4). More patients struggled with fine handiwork (Figure 5). ReSTOR performed the best for these near tasks. One fourth of both ReSTOR and ReZoom patients needed glasses all the time to view the computer, while Crystalens patients enjoyed the most spectacle independence for this activity (Figure 6).

Approximately 60% of subjects in each multifocal IOL group reported halos, which was roughly double the incidence of halos in Crystalens patients (Figure 7a). However, halo severity was rated much higher by ReZoom patients (Figure 7b). In fact, two patients in the ReZoom group refused to have their second eye implanted following their first surgery. Although both patients achieved uncorrected monocular 20/20 and J1, they had great difficulty adapting to halos. One patient had the ReZoom IOL explanted, and the other eventually chose a monofocal IOL for the second eye.

As shown in Figure 8, roughly 70% of bilateral ReSTOR and Crystalens patients achieved spectacle freedom in this study, compared to only 50% of bilateral ReZoom patients. Although these percentages are lower than in other studies, this was a selective population of younger patients all under the age of 70. This may reflect a greater range of demanding visual requirements in the study group compared to an older pseudophakic population. Given these results, it might seem surprising that overall satisfaction with all 3 IOLs was extremely high (Figure 9). Clearly, this would not have occurred if patients had expected never to need glasses. Having realistic expectations clearly impacts patient satisfaction.
Selecting Presbyopia Correcting IOLs

Based upon these observations, I tend to favor ReSTOR for patients with smaller or larger pupils, or if the patient frequently drives at night. ReSTOR is more likely to satisfy the reading expectations of myopes, who tend to hold reading material fairly close without glasses and are unaccustomed to having good uncorrected intermediate vision. ReZoom works very well for hyperopes and taller patients with longer arms and for whom intermediate vision is important. Hyperopes usually don’t hold reading material very close and have lower expectations for uncorrected reading ability. Emmetropia is less consistently attained in higher hyperopes with short axial lengths, and ReZoom is more forgiving of slight ametropia. Finally, only ReZoom is available in low diopter powers at present.

Patients with possible mild macular degeneration are not good multifocal candidates because they would be less likely to reap the benefits and may be impacted by reduced contrast sensitivity. However, when using reading glasses, there should be less contrast sensitivity loss with ReZoom compared to ReSTOR should a patient later develop macular degeneration. Based upon these guidelines, bilateral ReSTOR matches the profile for more of my refractive IOL patients than bilateral ReZoom. Both groups performed well without glasses and had high satisfaction scores in my own small study. ReZoom gave slightly better distance performance, and ReSTOR was superior at near. Although the incidence of haloes was similar in both groups, they were more severe in the ReZoom group. It should be mentioned that at the time of this writing, the Tecnis multifocal IOL is not available in the United States.

Mixing Presbyopia Correcting IOLs

As pointed out by Frank Bucci, Jr. MD, Dick Lindstrom MD, John Doane MD, and others, the strengths and weaknesses of different presbyopia IOL designs are complimentary in many respects. The growing interest in a mixing approach affirms that no available IOL is perfect, and we are learning that many patients tolerate and achieve functional advantages with these combinations [8]. With respect to mixing different multifocal IOLs ReZoom can potentially fill the intermediate gap found with ReSTOR. ReSTOR or the Tecnis multifocal provide a stronger reading add, and allow patients to read even when their pupils constrict under brighter illumination. ReZoom should provide better contrast sensitivity in the distance, while ReSTOR can make it easier to suppress the nighttime haloes from the ReZoom eye. Pairing a Crystalens in the dominant eye with a diffractive multifocal IOL in the non-dominant eye is another excellent mixing strategy. ReSTOR and the Tecnis multifocal offer much better near reading ability. The Crystalens provides better intermediate function, however, and should provide better quality of vision at distance, particularly at night.

Presently, the biggest impetus for mixing IOLs seems to be refractive lens exchange (RLE) patients, who certainly have much higher refractive expectations than senior citizens with cataracts. The latter group is usually thrilled with any IOL, and attaining good pseudoaccommodation is a surprising bonus for someone who lost accommodation two decades ago. My older cataract patients are usually so happy after their first surgery that they would question the notion of doing anything different for their second eye. Most of my cataract patients have the same multifocal IOL in both eyes for this reason.

In contrast, the presbyopic refractive lens exchange patient already has excellent spectacle corrected vision and will be less forgiving of new optical aberrations and haloes. They wouldn’t be considering expensive refractive surgery if they didn’t expect to be spectacle free for most activities afterwards. Younger cataract surgery patients also have a different concept of presbyopia than 75 year olds, and their refractive expectations are more similar to those of RLE patients. Baby boomers are accustomed to having technology solve most problems and like to research which technology is the best. Those who spend many hours on the Internet researching which cell phone to buy will feel that their IOL decision deserves the same careful analysis. They are more open to a mixing strategy in order to attain the complimentary benefits which no single lens can provide.

Stage the IOL decision also makes sense if there is any question as to which IOL to choose. Both the patient and the surgeon can assess the result of the first eye implantation, before deciding which IOL to implant in the second eye. For example, implanting a multifocal or accommodating IOL in the second eye can be an excellent fall back strategy for patients having trouble adapting to multifocal IOL halos or aberrations in their first eye. Such a contingency plan helps reassure patients preoperatively who are worried about being “locked in” to a multifocal that they may not tolerate well. Likewise, if a patient were disappointed with their reading ability following implantation of a Crystalens or ReZoom in one eye, the ReSTOR IOL can be implanted in the second eye.

Conclusion

The premium IOL channel appropriately allows surgeons and patients to differentiate between cataract treatment and optional refractive surgical goals. That we have no universally perfect solution increases the importance of careful patient selection. Understanding the differences between the available presbyopia correcting IOL designs permits us to individualize our approach, which for some patients may include mixing different lenses.
6 Month UCVA

6 Month DCVA

Functional Vision: Do you have difficulty reading traffic signs, street signs, and store signs in daylight without your glasses?

How often do you use glasses to read a menu in dim light (Evaluation)?

How often do you use glasses to use a computer?

Functional Vision
Do you have difficulty doing fine handwork like sewing, knitting, crocheting, or carpentry without your glasses?
Incidence of Halos

Severity of Halos

Did you achieve spectacle freedom from this surgery?

Functional Vision Overall satisfaction with vision

(1-Poor; 4-Excellent)
“The Promise of No Glasses or Contact Lenses!”
Jack T. Holladay MD, MSEE, FACS

Requirements
- Accurate Biometry – Optical (IOL Master or LenStar)
- Accurate K’s- Repeatable
- 4th Generation Formula (WTW)
- Personalized Lens Constant
- Eliminate Corneal Astigmatism

Zaldivar-Holladay JCRS May 2000
Zeiss - IOL Master - 2000

Subtract from Ascan measured Axial Length
~ 0.8 mm
**IOL Power Calculations**
- Pentacam can measure FRONT & BACK SURFACE POWER
- Can Calculate:
  - Equivalent K-Reading (EKR)
  - 65% Mean, Peak & Average
  - NET POWER

**EKR**
- Reports Keratometry value but adjusts for Back Surface Power from Normal (Current IOL Formulas)
- If corneal front surface is 7.5 mm (45 D), but if back surface -0.3 D > normal:
  \[
  \text{EKR} = 45.0 - 0.3 = 44.7 \text{ D}
  \]
  
  **Note:** Net Power = 43.3 D

**IOL Calcs – Abnormal Cornea (Use 65% MEAN EKR)**
- Post Refractive Surgery
- Post PKP
- Keratoconus
- Corneal Scar
- Any Irregular Astigmatism

**Use 65% Mean EKR**
( @ 4.5, 4 & 3 mm zones)
**Post LASIK CALC**

- $K_{\text{mean}} = 39.8 \text{ D}$
- Used 39.8 D $\Rightarrow$ SEQ = +1.12 D
  ($+1.00 + 0.25 \times 155 = 20/20$)
- 65% mean = 38.8 D $\Rightarrow$ +0.12 D
- Use 65% mean $K$

**Conclusions**

- EKR – Use 65% Mean for all IOL Calcs
- Look @ smaller zones than 4.5 mm if pupil very small
  ($< 3.0 \text{ mm in dim light}$)

**Requirements**

- Accurate Biometry – IOL Master
- Accurate K’s – Repeatable
- 4th Generation Formula (WTW)
- Personalized Lens Constant
- Eliminate Corneal Astigmatism

**Vergence Formula**

$$IOL = \frac{1336}{AL - ELP} - \frac{1336}{1000 + K(\text{Post R})} - \frac{1336}{1000 - V} \frac{1}{D_{\text{Post Rx}}}$$
CONCLUSION: 9 EYES

Anterior Segment Size

<table>
<thead>
<tr>
<th>Axial Length</th>
<th>Large</th>
<th>Megalocornea + axial hyperopia</th>
<th>Megalocornea</th>
<th>Large Eye Buphthalmos Megalocornea + axial myopia (10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td>axial hyperopia (80%)</td>
<td>normal (96%)</td>
<td>axial myopia (90%)</td>
</tr>
<tr>
<td>Small</td>
<td></td>
<td>Small eye Nanophthalmia (20%)</td>
<td>Microcornea</td>
<td>Microcornea + axial opta (0%)</td>
</tr>
<tr>
<td>Short</td>
<td></td>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td></td>
<td>Long</td>
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FORMULA PERFORMANCE

- Holladay 1
- SRK-T
- Holladay 2

Mean Absolute Error (D)

Axial Length (mm)

Requirements

- Accurate Biometry – IOL Master
- Accurate K’s- Repeatable
- 4th Generation Formula (WTW)
- Personalized Lens Constant
- Eliminate Corneal Astigmatism

Personalized Lens Constant

- Never use Manufacturer’s Constant except to start
- 20 to 40 cases and continue
- Factors
  - IOL Style
  - Lens placement
  - Post op medications
  - Biometer, keratometer, …
Requirements

- Accurate Biometry – IOL Master
- Accurate K’s- Repeatable
- 4th Generation Formula (WTW)
- Personalized Lens Constant
- Eliminate Corneal Astigmatism

TORIC IOL Calculations

- Commercial Calculators use a constant ratio (1.46) for the corneal cylinder to the IOL cylinder
- Exact Calculation depends on IOL SEQ Power and ELP … to correct 2D of corneal astigmatism
  - 10 D IOL ≈ 3.5 D Cylinder
  - 22 D IOL ≈ 2.9 D Cylinder
  - 34 D IOL ≈ 2.4 D Cylinder
- A 1.1 D difference from 10 D to 34 D!

Toric Optimization

!Thank You!
Q. Can I mix different multifocal IOLs or multifocal with monofocal IOLs?

Multifocal intraocular lenses and accommodating intraocular lenses can be paired with a normal crystalline lens in the opposite eye, a monofocal implant in the opposite eye or a different multifocal or accommodating lens in the opposite eye. Combining complementary intraocular lenses provides for many patients a superior outcome to that achieved utilizing the same implant in both eyes. The concept of using different optical systems in each of a patient’s two eyes which are complimentary is not new. The most common example of this, familiar to all ophthalmologists, is monovision where one eye is set for distance and the other for near. If the difference between the two eyes is greater than 1.50 diopters I call that monovision and if it is less than 1.5 diopters I call it blended vision. In blended vision some stereopsis and fusion is retained and a relative amblyopia for distance is less likely. In the case of multifocal and accommodating lenses there are at least 10 potential options which can be utilized. An accommodating lens can be implanted into one eye with a normal crystalline lens in the opposite eye. A multifocal lens can be implanted into one eye with a normal crystalline lens in the other eye. Bilateral accommodating intraocular lenses can be utilized with a symmetrical refractive outcome target. Bilateral accommodating intraocular lens can be utilized with a blended vision outcome (targeting for example -0.25 diopters in one eye and -1.00 diopters in the alternate eye.) Bilateral multifocal implants with the same optical configuration can be implanted in both eyes with a symmetrical refractive outcome target. Bilateral multifocal implants with the same optical configuration can be utilized with a blended vision outcome (targeting for example plano in one eye and -0.50 diopter in the alternate eye). An accommodating intraocular lens can be implanted in one eye and a monofocal implant in the opposite eye. A multifocal intraocular lens can be implanted in one eye and the monofocal lens in the opposite eye. An accommodating intraocular lens can be implanted in one eye and a multifocal lens in the opposite eye. Complimentary multifocal intraocular lenses can be implanted in the alternate eyes. For example a zonal aspheric intraocular multifocal intraocular lens (ReZoom) in one eye and an epodized defractive/refractive multifocal intraocular lens in the opposite eye (ReStor). This has become known as “mix and match” of presbyopia correcting intraocular lenses. To best use complimentary intraocular lenses it is important for the ophthalmologist to understand the strengths and weaknesses of each intraocular lens. The standard monofocal intraocular lens is the best economic value. It gives excellent distance, fair intermediate and poor near vision. For example 20/20+, J4, J7 at the three distances. The pseudo-accommodative amplitude is approximately 2 diopters which means it has about 1 diopter of pseudo-accommodative amplitude to the minus side. This means that if the patient is targeted for a -1.50 refractive outcome they will be able to read as though they had a +2.00 to +2.50 reader. The lens has positive spherical aberration of approximately +0.10 microns, somewhat dependent on optic power and optic design. This type of spherical aberration is best in patients who have negative spherical aberrations in the cornea such as those post-hyperopic LASIK, with keratoconus or a cornea with naturally occurring negative spherical aberration (10-20%). Second, we have aspheric monofocal intraocular lenses including those with no spherical aberration (B & L Advanced Optic) and those with negative spherical aberration (AMO Tecnis, Alcon IQ). The intraocular lens with no spherical aberration is most forgiving of decentration and tilt, and might be selected in patients where decentration might occur such as in pseudoxefoliation, a capsular tear or where an ideal capsulorhexis is not available. The implants with negative spherical aberration give better quality of vision, especially mesopic vision in the patient with a typical cornea with positive spherical aberration. They also provide superior performance in the patient that has undergone myopic refractive surgery. The accommodating intraocular lens as designed by Eyeonics and called the Crystalens gives excellent distance and intermediate vision. Typically one can achieve 20/20+ and J1 at distance and intermediate respectively. It provides good near acuity with a typical outcome being J3 or better. This lens has the least night vision symptoms, the least loss of contrast sensitivity and the least color distortion of all presbyopia correcting intraocular lenses. It is also pupil size independent in its optical function. It is
excellent for blended vision. The zonal aspheric multifocal intraocular lens manufactured by AMO and called the ReZoom provides good distance acuity, good intermediate acuity, and good near acuity. Typical outcomes are 20/20 distance, J2 intermediate and J2 at near. There are some night vision symptoms, some loss of contrast sensitivity and some color distortion. This lens is pupil size dependent. The aspheric diffractive multifocal intraocular lens (AMO Tecnis Diffractive Multifocal Intraocular Lens) provides good distance acuity, fair intermediate and excellent near acuity. Typical outcomes to be expected are 20/20- at distance, J4 at intermediate and J1 at near. It also has the potential for night vision symptoms, decreased contrast sensitivity and some color distortion. The decreased contrast sensitivity usually associated with a multifocal implant is reduced by the aspheric nature of the optic. This lens is not pupil size dependent. The epodized diffractive/refractive multifocal intraocular lens (Alcon ReStor) provides good distance acuity, fair intermediate and excellent near. Distance acuity might be expected to be 20/20- , intermediate J4 and near J1. This lens also potentially generates night vision symptoms, decreased contrast sensitivity and color distortion. It is also pupil size dependent as the lens becomes more distance dominant as the pupil dilates.

The author and other members of his practice (Minnesota Eye Consultants, P.A.) have utilized all of the above combinations of implants with good success. Multifocal intraocular lenses have been used in a mix and match approach for approximately 20 years, beginning in 1985. Our experience has been that almost all patients adapt well over time to the use of complimentary optics in their alternate eyes. Neuroadaptation is a concept that is receiving increased attention as ophthalmologists use more and more optical systems dissimilar to the natural crystalline lens. It appears that there is an early and late neuroadaptation. Approximately 80 percent of patients seem to adapt easily to complimentary optics whereas 20 percent may struggle for a few months to a year or more. Late neuroadaptation appears to occur at near 100 percent and the author’s personal experience is that there are no patients in his practice with over 2 years follow-up with dissimilar optics who have not adapted well to their optical system. Select recent clinical series of mix and match with some multifocal and accommodating intraocular lenses provide insight into the outcomes that might be obtained. Leonardo Akaishi, MD and Pedro Paulo Fabri, from Sao Paulo, Brazil have performed a comparative series of ReZoom/ReZoom, ReStor/ReStor, ReZoom/ReStor and Tecnis Diffractive/ReZoom. Their outcomes are summarized in Table 1. The best outcomes were obtained with ReZoom/Restor and ReZoom/Tecnis Diffractive Intraocular Lens combinations.

<table>
<thead>
<tr>
<th></th>
<th>ReZoom/ReZoom (N=100)</th>
<th>ReStor/ReStor (N=100)</th>
<th>ReZoom/ReStor (N=88)</th>
<th>ReZoom/Tecnis Diffractive (N=15)</th>
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<tbody>
<tr>
<td>Bilateral uncorrected distance</td>
<td>20/20</td>
<td>20/25</td>
<td>20/20</td>
<td>20/20</td>
</tr>
<tr>
<td>Bilateral uncorrected intermediate</td>
<td>J2.15</td>
<td>J3.85</td>
<td>J2.30</td>
<td>J2.10</td>
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<tr>
<td>Bilateral uncorrected near</td>
<td>J2.30</td>
<td>J1.40</td>
<td>J1.50</td>
<td>J1.10</td>
</tr>
<tr>
<td>Average reading speed (words per minute)</td>
<td>125</td>
<td>165</td>
<td>155</td>
<td>185</td>
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<tr>
<td>Spectacle independence</td>
<td>75%</td>
<td>89%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Halos/glare</td>
<td>2+</td>
<td>1+</td>
<td>1+</td>
<td>1-</td>
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<tr>
<td>MTF</td>
<td>0.20</td>
<td>0.12</td>
<td>0.18</td>
<td>0.38</td>
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</table>

Rick Milne, MD from Columbia, South Carolina has also performed a comparative series looking at patient satisfaction, spectacle independence and daytime and nighttime halo. His outcomes are summarized in Table 2. Again, the ReZoom/ReStor outcomes generated higher patient satisfaction than the ReStor/ReStor outcomes in this series.

<table>
<thead>
<tr>
<th></th>
<th>ReStor/ReStor (N=30+)</th>
<th>ReZoom/ReStor (N=30+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfied/Very Satisfied</td>
<td>83%</td>
<td>96%</td>
</tr>
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</table>
### Table 3

<table>
<thead>
<tr>
<th></th>
<th>ReStor/ReStor (N=55+)</th>
<th>ReZoom/ReStor (N=39+)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral uncorrected distance</td>
<td>20/25</td>
<td>20/25</td>
<td>(P=NS)</td>
</tr>
<tr>
<td>Bilateral uncorrected intermediate</td>
<td>J3.81</td>
<td>J2.39</td>
<td>(P.001)</td>
</tr>
<tr>
<td>Bilateral uncorrected near</td>
<td>J1.00</td>
<td>J1.04</td>
<td>(P=NS)</td>
</tr>
<tr>
<td>Unhappy with intermediate</td>
<td>32%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Frank A. Bucci, Jr. MD from Wilkes-Barre, Pensylvania has also completed a series comparing ReStor/ReStor to ReZoom/ReZoom. His outcomes are summarized in Table 3. Of note, is that his intermediate vision outcomes are significantly better with ReZoom/ReStor than with ReStor/ReStor and that his patient satisfaction is also higher.

Finally, Trevor Woodhams, MD from Atlanta, Georgia has a series of patients with CrystaLens/ReStor use in alternate eyes. Again, he found excellent distance, intermediate and near vision with high patient satisfaction.

In summary, the human visual system can neuroadapt to dissimilar optics in alternate eyes. Patients should be given at least one year to neuroadapt to their new optical system before explant/exchange is considered. Multifocal or accommodating intraocular lenses can be used successfully with a monofocal intraocular lens in the opposite eye. Multifocal or accommodating intraocular lenses can also be used successfully with a natural crystalline lens in the opposite eye. Of great importance is the observation that complimentary multifocal and accommodating intraocular lenses may provide superior outcomes for many patients than symmetrical implantation of the same intraocular lens in both eyes, especially at intermediate distance. Further clinical study is ongoing but the current evidence supports the use of complimentary presbyopia correcting intraocular lenses in the alternate eyes of select patients.
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