

Presbyopia correction: Exploring surgical options, expectations, and postoperative error

Describing the stages of presbyopia: Understanding its onset and progression

by Daniel Durrie, MD



New terminology gains momentum in ophthalmic practices

A new three-stage classification system is helping cataract surgeons communicate with

their colleagues and patients about the normal phases of crystalline lens change that occur with aging. When we review the stages of dysfunctional lens syndrome (DLS), we not only describe the way the lens changes but can correlate these changes with treatments that are most appropriate at each stage.^{1,2}

Illustrative analogy

During human embryonic development, a piece of ectodermal tissue splits off to become the crystalline lens. Consequently, it ages similarly to the skin. As disulfide bonds accumulate inside the lens through all three stages, the lens loses flexibility and density increases.

“With new diagnostic tools, we can show patients the color, appearance, and density of the lens and how they affect vision.”

—Daniel Durrie, MD

When we explain this to our patients, they understand it well. Previously, patients knew their eyes changed during middle age and that cataracts may develop later, but no one explained how the lens was changing.

DLS stages

Patients usually enter stage 1 of DLS at an average age of 43. In stage 1, the lens is clear and colorless, but the lens loses the ability to change power. As a result, most patients have

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Educational Objectives

Ophthalmologists who participate in this activity will:

- Accurately describe the progressive diagnosis of presbyopia and the optical fundamentals of correction options, utilizing the appropriate current terminology of presbyopia to describe all stages of the disease state
- Compare and contrast presbyopia treatment options to match solutions to patients' needs, and describe range of vision functions as related to patients' needs
- Implement a lower threshold for acceptable pseudophakic refractive error levels in presbyopia-corrected patients, and identify steps to mitigate refractive surprises and other key variables to increase postoperative success

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John Berdahl, MD, has earned a royalty or derived other financial gain from Imprimis and Ocular Surgical Data. He has an investment interest in DigiSight, Omega Ophthalmics, and Vision 5. Dr. Berdahl has received a retainer, ad hoc fees or other consulting income from: Abbott Medical Optics, Alcon Laboratories, Avedro, Bausch + Lomb, Calhoun Vision, ClarVista, DigiSight, Envisio, Glaukos, Imprimis, Ocular Therapeutix, Omega Ophthalmics, Ocular Surgical Data, Vision 5, and Vittamed. He is a member of the speakers bureaus of Glaukos and Ocular Therapeutix.

Rosa Braga-Mele, MD, FRCSC, is a member of the speakers bureaus of Alcon Laboratories and Allergan.

Daniel Chang, MD, has an investment interest in Omega Ophthalmics. He has received a retainer, ad hoc fees, or other consulting income from: Abbott Medical Optics, Allergan, Carl Zeiss Meditec, Mynosys Cellular Devices, and Omega Ophthalmics. Dr. Chang has received expense reimbursement from and is a member of the speakers bureaus of Abbott Medical Optics and Carl Zeiss Meditec. He has received research funding from Abbott Medical Optics and Mynosys Cellular Devices. **Daniel Durrie, MD**, has an investment interest in, has received expense reimbursement from, and has received a retainer, ad hoc fees or other consulting income from: AcuFocus, Alphaeon, and Strathspey Crown. He has received research funding from AcuFocus, Alcon, Allergan, Avedro, and EyeGate Pharma. Dr. Durrie has received expense reimbursement from Avedro and Hoopes Durrie Rivera Research.

Staff members: Kristen Covington and Laura Johnson have no ophthalmic-related financial interests.

Supported by an unrestricted educational grant from Abbott Medical Optics

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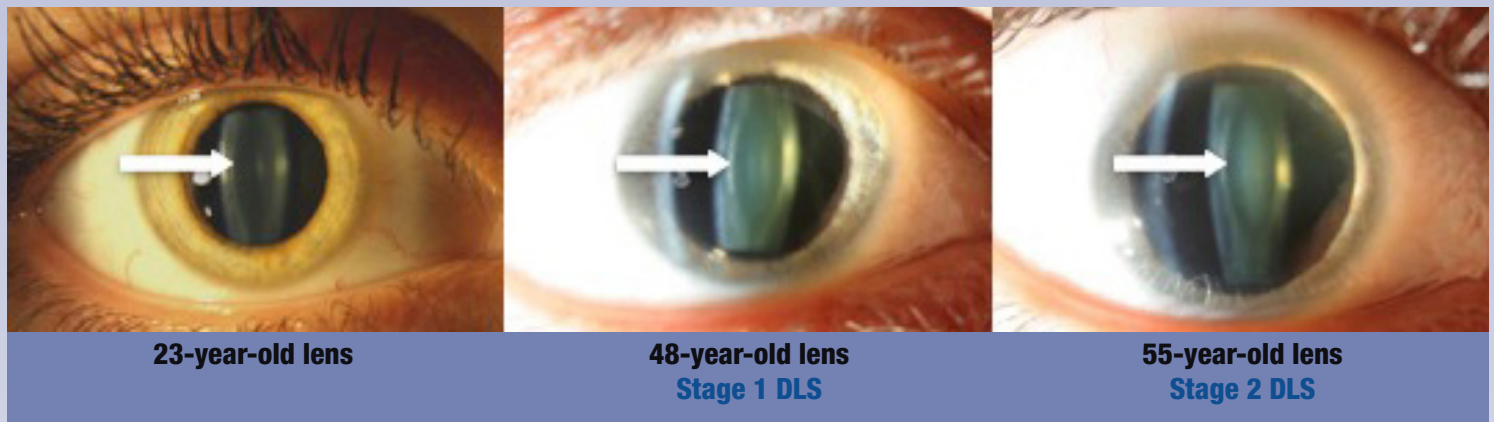


Figure 1. The first two stages of dysfunctional lens syndrome

difficulty reading up close, while a minority may struggle with distance vision, depending on which layers in the lens change.

Three surgical presbyopia-correcting options are available during this stage. Blended vision or monovision LASIK has been the standard. If a patient is a good LASIK candidate, correcting the dominant eye for plano and the non-dominant eye for -1.0 to -1.25 D has achieved satisfactory results. Almost 100% of my presbyopic patients with myopia, moderate hyperopia, or astigmatism who plan to have LASIK to achieve spectacle independence choose this option.

In addition, two corneal inlays have been approved by the U.S. Food and Drug Administration to treat presbyopia.^{3,4} They are designed for patients who still have a clear lens.

If patients in stage 1 have $+3.0$ D or greater hyperopia, most surgeons consider refractive lens exchange (RLE) in this age group. If we perform LASIK on a patient with $+4.0$ hyperopia, years later cataract surgery may be more complicated because of the

significant change in corneal curvature from refractive surgery.

Stage 2 occurs in patients in their 50s and 60s, when the lens becomes yellow and slightly clouded, with higher-order aberrations. Patients require more light to read, and their night vision is not as good.

When I explain this stage to patients, they often smile and nod, reassured to know DLS is a normal process and why it is occurring.

In refractive practices, the most common stage 2 treatment is RLE because the patient's optical quality has decreased. We can still perform LASIK monovision or blended vision, but patients need to know it will not last long term and they eventually will require lens replacement.

At this stage, optical quality is no longer adequate for corneal inlays. However, we can perform RLE without removing inlays from patients who have them. Following patients 10 years after inlay procedures, I have found that they still have good vision, but eventually we will need to replace their lenses.

In stage 3, which usually occurs at an average age of 73, patients have a cataract. The only treatment at this stage is lens replacement, which is covered by insurance once a cataract has been diagnosed.

Diagnostic technology

With new diagnostic tools, we can show patients the color, appearance, and density of the lens and how they affect vision. We take a slit lamp photograph of the lens and perform a dilated examination on a rotating Scheimpflug camera system for anterior segment analysis. This shows lens density changes.

We also use an optical quality analysis system, which provides the optical scatter index, demonstrating decreased vision quality.⁵

Conclusion

Anyone can use DLS terminology to describe lens changes and available treatment options. However, all clinicians and staff in a practice need to be trained about these stages to ensure that everyone is using the same language.

Practices should share this information with their optometric referral networks.

Optometrists frequently appreciate this tool when explaining lens changes to patients.

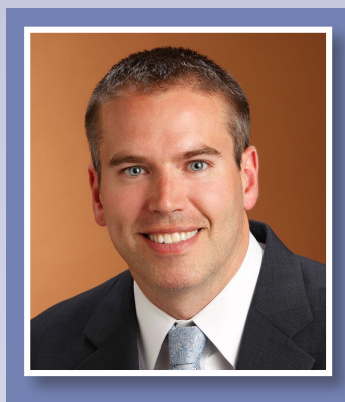
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Surgical options for presbyopia correction

by John Berdahl, MD



Surgeons need to share the complete range of possibilities with presbyopia patients

To make the most of an expanding range of presbyopia-correcting technologies and deliver the visual outcomes patients expect, it is important to understand the benefits and limitations of each.

Treatment alternatives

Two intracorneal inlays have been approved by the U.S. Food and Drug Administration to correct presbyopia.^{1,2} These are generally appropriate for that sweet spot of a new presbyope, who is in stage 1 of dysfunctional lens syndrome (DLS), without signs of a cataract.

For patients in stage 3 of DLS, I use monovision and mini-monovision only in those who have responded well to monovision contact lenses or LASIK. If patients have not had monovision in the past, we cannot perform a contact lens trial once a cataract has been diagnosed.

We use accommodating IOLs for patients who do not have a pristine ocular system, such as those with mild macular degeneration, mild glaucoma, or corneal irregularities, or patients whose profession makes minimal amounts of glare intolerable (Figure 1). I explain that the accommodating IOL will reduce their need for spectacles, but they will need glasses for fine, up-close reading.³ In addition, accommodating IOLs are associated with a small amount of variability in spherical outcomes because the effective lens position is slightly less predictable.⁴

Extended depth of focus IOLs are also a bit more tolerant of small irregularities in the eye.⁵ I prefer to use a low power multifocal or extended depth of focus IOL in the dominant eye and a medium power multifocal with approximately a 3.0 D add in the non-dominant eye. In my experience, this approach has provided good distance vision in both eyes and a good range of near vision, helping most of my patients achieve complete spectacle independence.

To deliver optimal outcomes, it is critical to precisely correct astigmatism during surgery and treat residual astigmatism. Two presbyopic toric IOLs are available to treat astigmatism. Residual astigmatism must be treated with astigmatic keratotomy or an excimer laser.⁶

Tailoring treatment

To select the best treatment for each patient, surgeons need to understand patients'

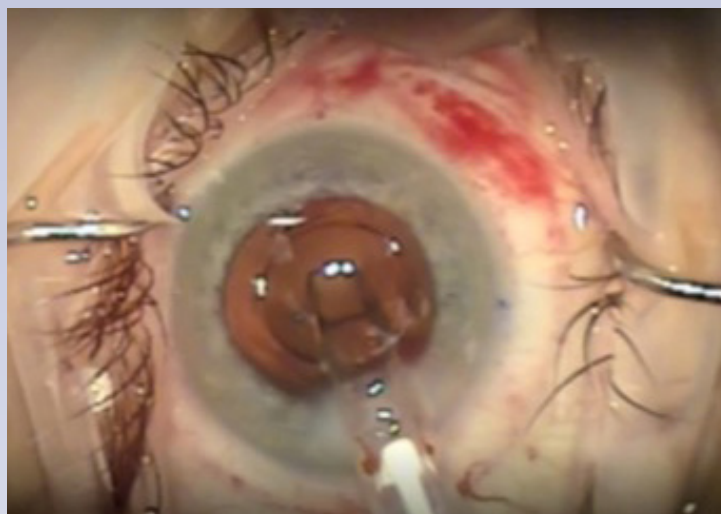


Figure 1. Insertion of Crystalens accommodating IOL

visual needs, based on their profession, hobbies, and other activities.

Although many of us are uncomfortable discussing procedures or technologies that are not covered by insurance, we should not hesitate to cover the full range of options, just as any physician would for a medical condition. That is our duty as physicians. Surgeons who are uneasy discussing costs should delegate this task to a staff member.

Conclusion

Presbyopia correction has evolved to a point where surgeons can achieve very good, predictable outcomes, but it is not yet perfect. Patients need to know all of their options, and surgeons need to develop enhancement strategies to provide optimal outcomes.

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Addressing expectations for range of vision and visual quality

by Daniel Chang, MD



Emerging technology presents new opportunities to reduce aberrations

The goal of presbyopia-correcting surgery is to increase patients' range of vision while maintaining good visual quality. Tradeoffs in visual quality and night vision symptoms should always be considered when correcting presbyopia, but advances in technology have provided more and better options for patients.

To achieve patient satisfaction, surgeons not only need to set patients' expectations, but also choose lens designs and materials that will meet patients' needs.

Patient selection and counseling

When selecting patients for presbyopia correction, surgeons should consider objective factors such as the patient's preoperative refractive error, cataract severity and type, ocular surface quality, macular health, and even the patient's height and arm

length and where he or she prefers to hold devices and reading materials. Subjectively, factors such as the patient's personality, profession, and hobbies should be considered.

These factors help create a picture of what patients hope to achieve with presbyopia-correcting surgery, particularly with respect to their past and present visual experience. They also help me to counsel patients. This is my opportunity to make sure their expectations are reasonable. I explain what the surgery offers, without overpromising.

Optimizing outcomes

Since extending depth of focus can compromise visual quality, it is important to optimize aberrations when correcting presbyopia. The cornea has spherical aberration, which is typically positive (average $+0.27 \mu\text{m}$), so surgeons should correct that with a negative spherical aberration IOL, which will minimize the spherical aberration of the eye to maximize visual quality (Figure 1).¹ If the cornea has positive spherical aberration, IOLs with positive spherical aberration will induce greater spherical aberration overall.

Furthermore, minimizing chromatic aberration can be more important than spherical aberration.^{2,3} Significant chromatic aberration in an IOL affects all patients, preventing the colors of light from focusing sharply on the retina (Figure 2). The patient's visual acuity may be 20/20, but vision will not appear sharp, particularly in low-contrast situations.

“As industry continues to provide good options, surgeons are better equipped to find the best set of tradeoffs to satisfy our patients.”

—Daniel Chang, MD

Refractive lenses, including the cornea and lens, induce chromatic aberration. Since chromatic aberration is additive, surgeons should select IOL materials that induce as little chromatic aberration as possible. Low- and mid-index materials tend to have better chromatic aberration properties, and some IOLs induce less chromatic aberration than the human lenses they replace, resulting in a net reduction in the eye's chromatic aberration after cataract surgery.

To maximize visual quality, surgeons need to choose an IOL that will compensate for corneal spherical aberration and minimize chromatic aberration.

Seeking balance

When correcting presbyopia, IOLs need to balance the three areas of visual quality, depth of field, and night vision symptoms. Reducing spherical and chromatic aberrations maximizes visual quality, but increasing depth of field decreases visual quality, resulting in night vision symptoms such as glare, halos, and starbursts. Traditional higher-add multifocal IOLs provide good depth of field, with good near

vision and a slight decrease in intermediate vision. However, this reduces contrast sensitivity and increases night vision symptoms. Reducing the add power decreases the depth of field slightly while improving night vision symptoms. Even though low-add multifocal IOLs have similar visual quality as traditional multifocals, they are now a popular option.

With monofocal and even multifocal IOLs, we only have one or two points of focus, respectively, where vision is best. Therefore, with these IOLs, we must nail the target for far, and we have to choose the near focal point (if any) preoperatively.

In contrast, an extended depth of focus IOL provides continuous vision for far (driving and watching television) through intermediate (computer and dashboard) into near (reading and smartphones).⁴ There is a functional range of vision that helps meet the range of vision needs for patients whose modern lifestyles involve the use of computers and tablets—even if the refractive outcome is a little off.

The currently available extended depth of focus IOL

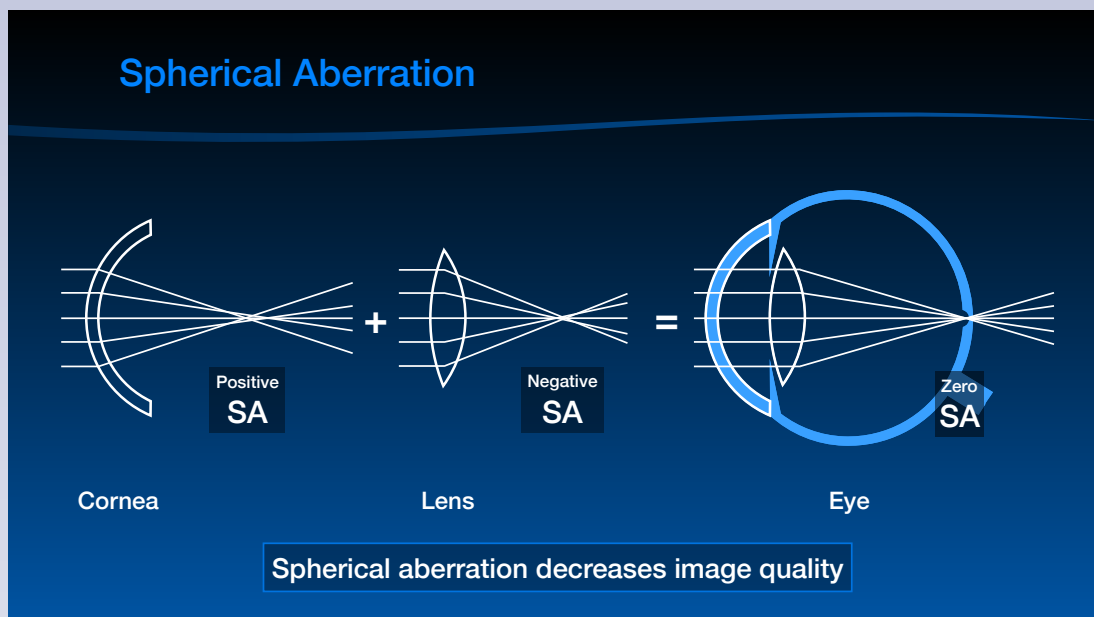


Figure 1. Minimizing spherical aberration maximizes image quality.

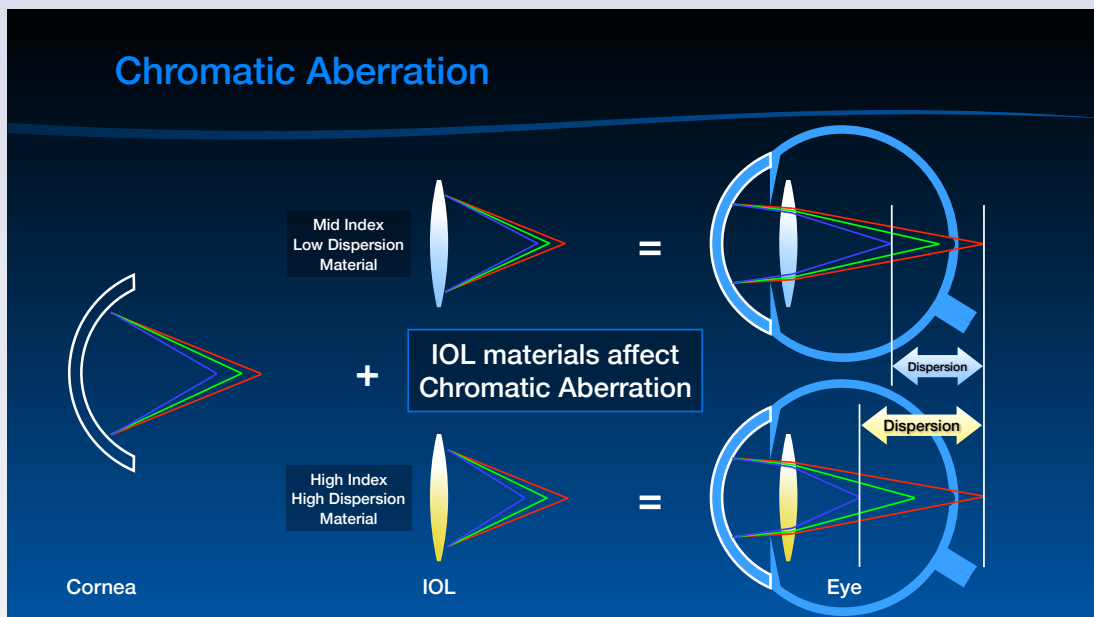


Figure 2. IOL materials affect the chromatic aberration of the pseudophakic eye.

uses diffractive technology to improve visual quality by actively correcting chromatic aberration, so the depth of field can be extended while maintaining visual quality comparable to a monofocal.

Hyper-aspheric and pinhole designs are under investigation as well.

The current generation of IOLs labeled as “accommodating” provides far and intermediate vision, but near

vision is limited.⁵ It does not provide spherical aberration correction, and its chromatic aberration properties are not particularly good. Additionally, predictability and long-term positional stability in the eye are concerns.⁶

Maximizing visual quality

Until IOLs provide true accommodation, there will always be tradeoffs. Visual quality should be considered primarily, but the balance of depth of field and night vision symptoms should also be taken into account.

As industry continues to provide good options, surgeons are better equipped to find the best set of tradeoffs to satisfy our patients. With an expanding range of options, we can help more patients to make presbyopia a thing of the past.

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After the fact: Mitigating and managing postoperative error

by Rosa Braga-Mele, MD, MEd, FRCSC



Time invested in preop assessment reduces risk of postop surprises

Surgeons need to take a two-pronged approach to address refractive surprises after presbyopia-correcting procedures—performing meticulous preoperative assessments and developing strategies to manage postoperative errors.

Preoperative protocols

Careful patient selection is key when implanting toric or presbyopia-correcting IOLs.^{1,2}

The first step is to perform corneal topography to assess corneal health (Figure 1). I prefer Placido disc

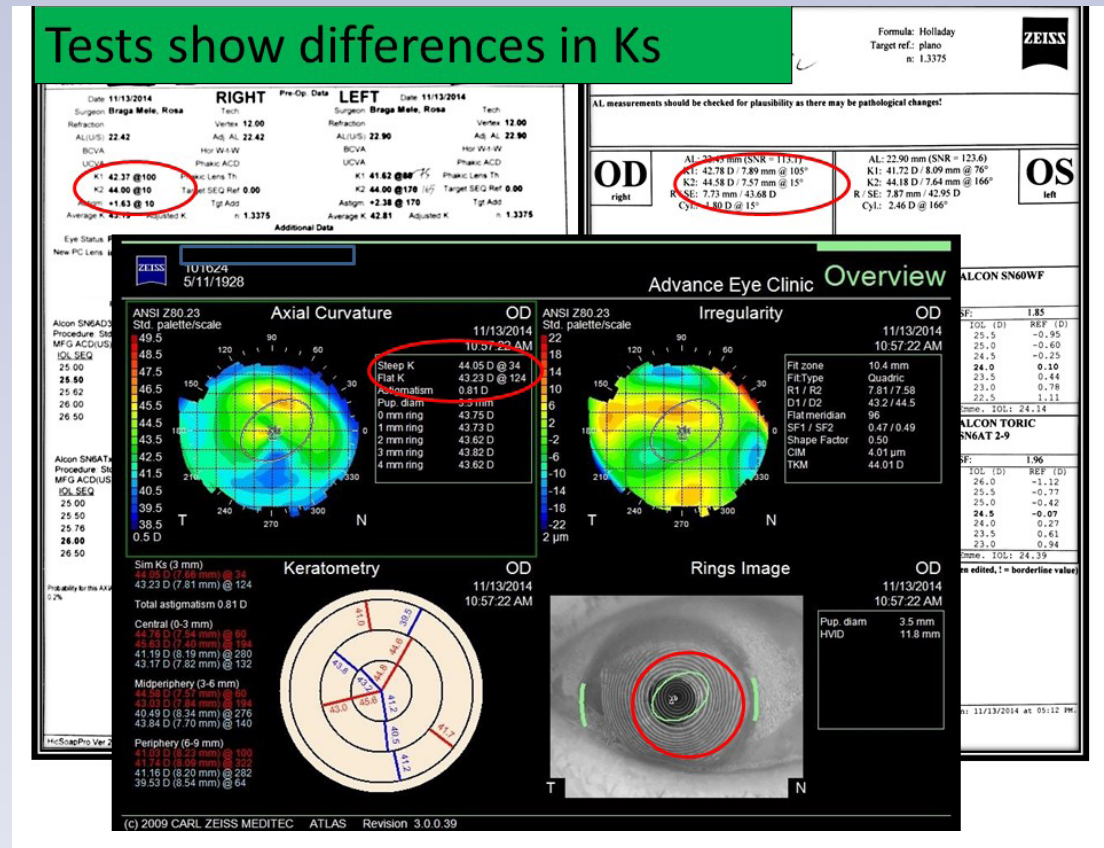


Figure 1. Surgeons should look for dry eye and multiple variable K readings. Dry eye or epithelial basement membrane disease should be treated before proceeding, and measurements should be repeated to assess corneal astigmatism.

topography to help assess the corneal surface and look for ocular surface disease. Any dry eye should be treated before other preoperative measurements are performed. Epitropoulos et al. reported hyperosmolarity increased

variability in preoperative measurements and affected IOL calculations.³ Epithelial basement membrane disease should be treated or presbyopia-correcting IOLs should be avoided in these patients.

Furthermore, macular optical coherence tomography is recommended if there is any question of macular health and to rule out macular disease, such as an epiretinal membrane or macular edema.

For every patient who will receive a toric or presbyopia-correcting IOL, it is important to have accurate biometry, with measurements from an immersion A-scan and an optical biometer device. Also, as stated before, corneal topography is important to validate K readings.

It is important when implanting toric IOLs to consider the effect of posterior corneal astigmatism and perhaps utilize the Barrett Toric Calculator (ascrs.org).

To determine each patient's needs and expectations from surgery, we also perform a mini personality survey.

Managing postop error

I usually wait at least 6 to 8 weeks before defining postoperative error because the IOL may shift or tilt and the cornea may be healing. Postoperative dry eye can change the refraction by 0.75 D, so it must be treated. In research by Donnenfeld et al., cyclosporine 0.05% treatment in eyes receiving multifocal IOLs increased visual quality and decreased signs of dry eye.⁴

I tolerate 0.5 D of myopia, hyperopia, or astigmatism with a presbyopia-correcting IOL. Errors exceeding 0.5 D must be treated because they

increase dysphotopsia, halo, and glare.

There are a number of ways to correct postoperative errors.⁵ For large IOL-based errors, a lens exchange may be necessary. If small astigmatic errors occur, surgeons can perform limbal relaxing incisions or astigmatic keratotomy at the slit lamp or with a femtosecond laser. Surgeons also can perform LASIK or PRK. I usually avoid piggyback IOLs because of risks of glaucoma or bleeding, although these risks are small.⁶

Surgeons also should consider that some patients may prefer to wear a slight corrective lens for driving rather than having a second procedure.

It is important to discuss all these options and their associated risks with your patients facing a postoperative surprise and together make an informed decision.

Conclusion

Chair time before surgery will decrease a surgeon's chair time after surgery. Surgeons need to take adequate time for preop assessments, closely examining the cornea, identifying other ocular disease, and setting patients' expectations to a reasonable level.

“Chair time before surgery will decrease a surgeon's chair time after surgery.”

—Rosa Braga-Mele, MD, MEd, FRCSC

If surgeons take this time, fewer postoperative surprises will develop and more patients will be happy with their procedures because their expectations are set and surgeons are more likely to meet them.

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Presbyopia correction:**Exploring surgical options, expectations, and postoperative error**

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CME questions (circle the correct answer)

1. Which of the following is not part of dysfunctional lens syndrome?

- A. Disulfide bonds increasing in the lens
- B. Increase in higher order aberrations
- C. Loss of accommodation
- D. Increased transparency

2. A 65-year-old woman with arthritis has decreased vision and burning, itchy, and occasionally watery eyes when using the computer. She has a clinically significant cataract and desires spectacle independence postop. What is the FIRST step you should take to determine the best IOL choice?

- A. Perform corneal topography to assess ocular health
- B. Start artificial tears on the symptomatic patient
- C. Educate the patient on various IOL options
- D. Sign the patient up for a presbyopia-correcting IOL, since she wants spectacle independence

3. A 62-year-old accountant with cataracts who spends a lot of time on the computer would like to be able to use the computer without wearing glasses but does not mind wearing reading glasses occasionally for small print. Which of the following is most likely to make this patient happy?

- A. Monofocal IOL set for distance
- B. High-add multifocal IOL
- C. Low-add multifocal IOL
- D. Extended depth of focus IOL

4. Which of the following is not a good option for Stage 2 DLS?

- a. Refractive lens exchange (RLE)
- b. Blended/monovision
- c. Corneal inlays
- d. Observation without surgery

5. A 64-year-old patient presents with cataract and 1.75 D of against-the-rule astigmatism and hopes to become more independent of spectacles for distance and near after cataract surgery. Which of the following is NOT a satisfactory option?

- A. Low-power multifocal IOL
- B. Extended depth of focus IOL with toric
- C. Accommodating toric IOL
- D. Multifocal with postoperative laser vision correction

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