

*The impact of refractive error on outcomes and patient satisfaction: Data-driven pathways to target outcomes and reduce refractive surprises*

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**Today's options and opportunities: What is the "new bar" for presbyopia correction?**

by John Vukich, MD



John Vukich, MD

**Advances in technology and techniques are making new refractive outcomes possible**

**T**raditionally, ophthalmologists have considered presbyopia to be an age-related alteration in the ability of the human lens to change its refractive

power. This concept now has expanded to include pseudophakic loss of near vision with implantation of distance-corrected monofocal intraocular lenses (IOLs).

To effectively take presbyopia correction to new levels, we need to examine how we can use the latest technology to correct a patient's refractive error and restore uncorrected vision at all ranges.

The options for correcting presbyopia include progressive or bifocal spectacles; multifocal contact lenses; monovision with contact lenses, LASIK, or IOLs; corneal inlays; and presbyopia-correcting IOLs. Specific visual needs and preferences, ocular anatomy, concomitant disease, and other factors must be taken into consideration in determining which approach is best suited for a given patient.

When pursuing any surgical solution to presbyopia, refractive targeting must be precise. The ideal refractive target may be a slightly myopic or hyperopic one, rather than plano.

**“Satisfaction drops significantly if patients have more than 0.5 D of error in either direction.”**

**—John Vukich, MD**

**Targeting inlay outcomes**

It is recommended, for example, that the small aperture corneal inlay be implanted monocularly in an eye with  $-0.75$  D myopia (and a plano fellow eye). This refractive target can provide a depth of focus of up to 2.75 D and near visual acuity of J1 or better. A plano to hyperopic refraction in an eye implanted with this style of inlay will result in poorer near and distance vision (Figure 1). As visual acuity—and especially near acuity—decline, patient

satisfaction drops off dramatically (Figure 2). This mirrors what we have seen in previous studies of patient satisfaction with multifocal IOLs as well.

**Surgical monovision**

Monovision results in a loss of binocularity, depth perception, and image summation and may not be tolerated by some patients. Although  $-2.0$  D is the practical

*continued on page 2*

**This monograph is part of a year-long curriculum focused on treatment of presbyopia and management.**

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**Educational Objectives**

Ophthalmologists who participate in this activity will:

- Implement a lower threshold for acceptable pseudophakic refractive errors in presbyopia-corrected patients
- Identify steps to mitigate refractive surprises and other key variables to increase postoperative success

**Designation Statement**

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continued from page 1

limit that most patients can tolerate, a monovision target of -1.50 to -1.75 D is more commonly used to minimize the visual compromises. This range provides good intermediate vision but will typically not provide sufficient near vision for pseudophakes or for phakic patients in their 50s and beyond.

Corneal inlays are implanted monocularly but may in some cases offer a different fundamental mechanism for reestablishing near visual acuity. The small aperture inlay, for example, relies on pinhole optics to extend the depth of focus and provide near acuity.

Unlike monovision, which requires patients to suppress distance vision when reading near, there is no need to suppress distance because it remains in focus. Patients with small aperture inlays are binocular under all conditions except near focus.

### Presbyopia-correcting IOLs

When performing refractive lens surgery with a multifocal IOL, a plano target is ideal. The current standard has been to achieve results within  $\pm 0.5$  D of a plano correction. However, many practices are now reporting even tighter refractive accuracy, within  $\pm 0.25$  D, thanks to improvements in technology to measure axial length and formulas used to calculate IOL powers.

Patients with better uncorrected acuity are more satisfied with their outcomes. Satisfaction drops significantly if patients have more than 0.5 D of error in either direction. Patients who are 0.5 D hyperopic are significantly less satisfied than those who are 0.5 D myopic.

Newer, low add multifocal IOLs, extended depth of focus IOLs, and extended range of vision IOLs may benefit from a slightly myopic micro-monovision target in the nondominant eye and may also prove to be more tolerant of minor amounts of residual refractive error.

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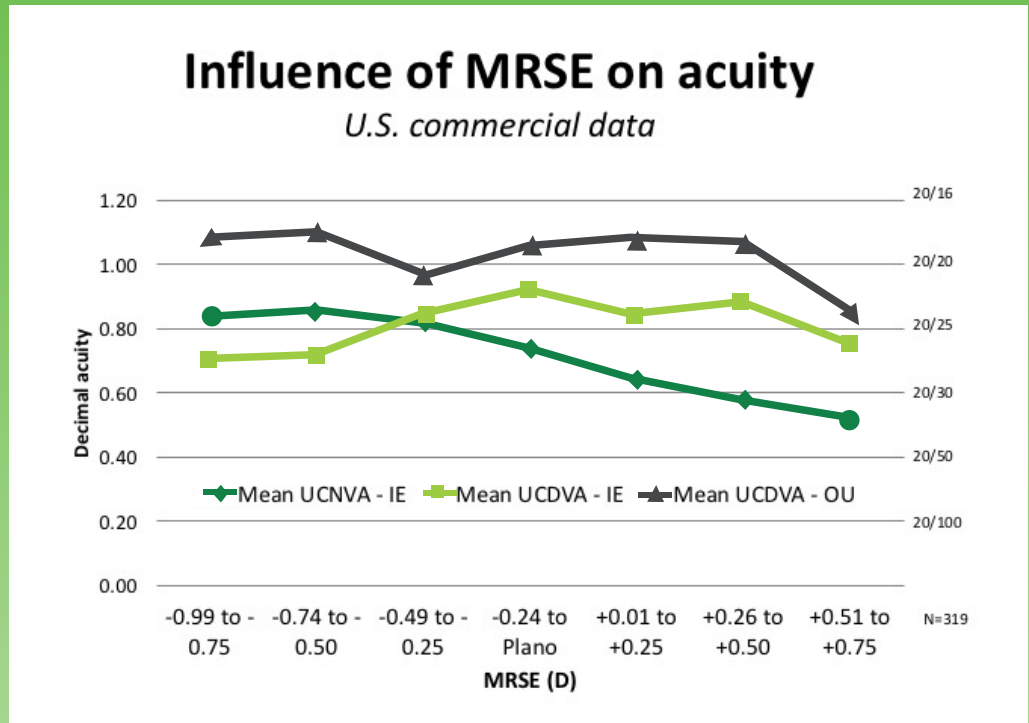


Figure 1. In U.S. commercial implantations of the KAMRA small aperture inlay (AcuFocus), the best near and distance vision results were achieved when the MRSE was -0.25 D or more myopic.



Figure 2. The most satisfied patients achieved good UCNVA and UCDVA (20/25 or better) in the inlay eye. Decline in near vision resulted in a bigger reduction in satisfaction than decline in distance vision.

# Presbyopia stages and the role of refractive error

by Steven Dell, MD



Steven Dell, MD

## Customization based on presbyopia stage and patient's visual goals is key in presbyopia correction

To provide the range of vision that today's presbyopic patients expect, we need to match our surgical strategies and technology to their stage of presbyopia and their visual goals and requirements.

In addition to staging the progression of presbyopia and the status of the lens, in my practice we customize treatment to the patient's current refraction, with different choices for emmetropes, hyperopes, and myopes.

For example, I would typically treat a myopic early presbyope with laser vision correction, using a bit of defocus in the nondominant eye. Monovision is best suited for patients who wear contact lenses for monovision. In patients without monovision experience, we may perform a contact lens trial before surgery.

Presbyopic emmetropes are among the most difficult patients to satisfy. Anything we do to correct presbyopia affects their excellent uncorrected distance vision. Some plano patients do well with refractive lens exchange with a multifocal IOL or accommodating IOL, which usually is implanted in the nondominant

eye. However, patients must be motivated to achieve spectacle independence at near.

In hyperopes with early presbyopia, I rely on refractive lens exchange with an accommodating or multifocal IOL. If they need spectacles for distance, we perform bilateral refractive lens exchange.

The lower add power multifocal IOLs (e.g., +3.25, +2.75 D, or +2.50 D) have been a game changer, providing higher patient satisfaction and better visual quality while allowing patients to read close up.

At the later stages of presbyopia or if patients require cataract extraction, lens surgery would be preferred, and we would select the option that best meets the patient's visual goals. Possibilities include monovision, multifocal IOLs, accommodating IOLs, or a mix-and-match approach.

## Astigmatic considerations and new IOLs

For cataract surgery or refractive lens exchange in astigmatic patients, the choice of a toric or multifocal IOL depends on the degree of astigmatism and the patient's desire for presbyopia correction.

We can treat very small degrees of corneal astigmatism with arcuate corneal incisions, but when astigmatism is between 1.0 and 1.5 D, most surgeons

transition to an astigmatism-correcting IOL. The only IOL available to treat both presbyopia and astigmatism is the Trulign IOL (Bausch + Lomb).

I think extended range of vision sphere and toric IOLs, when they become available, will significantly change our practice pattern.

During a multicenter study with 3-month follow-up, patients with bilaterally implanted extended range of vision (EROV) IOLs (Tecnis Symphony, Abbott Medical Optics) had 20/20 or better mean uncorrected distance vision, 20/20 or better mean distance-corrected intermediate vision, and a 2-line improvement in distance-corrected near over control. There was not a significant difference in glare or halos compared with monofocal IOLs. A toric version of this lens is also available outside the U.S.

## Visual satisfaction

The degree of tolerable postoperative refractive error depends on the technology we choose. We need to achieve spot-on refractive outcomes with multifocal IOLs. Even 0.5 D of astigmatism, hyperopia, or myopia can affect the intended function of these lenses.

EROV lenses may tolerate defocus better. Investigators have recently begun to test the effects of micro-monovision in patients implanted with EROV lenses and have found that a  $-0.75$  D target can further improve near

with minimal impact on distance vision (Table 1). More research needs to be done to understand the ideal refractive targets with these new IOLs.

We need to bear in mind that patients' expectations and visual requirements often depend on their occupations, pastimes, and personalities. During preoperative counseling, I listen carefully to patients' visual goals. Based on the exam and their requirements, I offer a definitive recommendation rather than several choices, which may confuse patients.

When troubleshooting residual error, our first step is to determine the cause. Some patients may require ocular surface treatment, but others may need laser vision correction, astigmatic keratotomy, or limbal relaxing incisions. In more extreme cases, we may need to perform a refractive lens exchange or implant a piggyback IOL.

To determine whether we have helped our patients achieve their goals, we ask them to complete short surveys.

By customizing treatments to meet presbyopic patients' visual goals and needs and assessing their satisfaction, we can achieve better outcomes and build our practices.

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	Mean visual acuity (logMAR)		
	Far	Intermediate	Near
Uncorrected	-0.048	0.028	0.207
Distance-corrected	-0.112	-0.031	0.195
0.50 D monovision	-0.049	-0.015	0.130
0.75 D monovision	0.011	-0.049	0.071
1.00 D monovision	0.049	-0.078	0.022

Table 1: Monovision of  $-0.75$  D resulted in 0.12 logMAR reduction from distance-corrected VA at far, no significant difference at intermediate, and 0.12 logMAR improvement at near, Encore Study

## Avoiding refractive surprises with presbyopia-correcting IOLs

by Elizabeth Yeu, MD



Elizabeth Yeu, MD

**To optimize results, surgeons need to address astigmatism and focus on quality care every step of the way**

**P**atients have high hopes when they invest in pseudophakic presbyopia-correcting surgery, but their expectations may promptly deflate if refractive error remains untreated.

In my clinical experience, in patients with multifocal IOLs, which are exquisitely sensitive, visual acuity declines by 1 line per 0.25 D of astigmatism. Patients will be dissatisfied if surgeons do not nail the spherical equivalent.

The good news is that surgeons can achieve their targeted outcomes in most patients, but it requires a strong commitment to refractive cataract surgery.

Before beginning to implant presbyopia-correcting IOLs, surgeons should consider whether they have the necessary surgical skills and plans in place to be successful (see box). In striving for improved refractive outcomes, for example, we need to know our surgically induced astigmatism (SIA) and the expected outcome of limbal relaxing incisions. Surgeons can calculate their personal SIA using an online calculator ([sia-calculator.com](http://sia-calculator.com)).

### A closer look at corneal astigmatism

Advanced preoperative diagnostics are also essential. In my experience, the i-Optics Cassini device with the Total Corneal Astigmatism (TCA) software, along with corneal topography, is particularly helpful in avoiding postoperative refractive surprises.

In a retrospective review of my own toric IOL results (n=50 eyes), the TCA software has increased the accuracy of my results, demonstrating a 0.50-D residual refractive astigmatism in 94% of eyes, compared with 84% using the Barrett Toric Calculator and 76% with the Baylor nomogram. Posterior corneal astigmatism plays an important role in refractive astigmatism management, and our data suggest that it is actually aligned with the rule posteriorly in ~75% of eyes, which may be less than we thought previously. Moreover, oblique astigmatism was seen in more than 22% of corneal astigmatism cases that I was treating, and these eyes behave very differently posteriorly than eyes that have vertically or horizontally oriented anterior corneal astigmatism. About half of these eyes have TCA that is less than that seen anteriorly, whereas the other half of oblique eyes have TCA that is greater than the anterior corneal astigmatism.

Another way to better understand the total corneal

**“Surgeons may choose to bundle options to make it simpler for patients to understand and to deliver a seamless spectrum of care.”**

**—Elizabeth Yeu, MD**

astigmatism would be to use intraoperative aberrometry; it is not necessary to initially invest heavily in expensive capital equipment to be an effective refractive cataract surgeon. However, these devices can be very valuable in further mitigating refractive surprises.

### Excluding dry eye

Patient selection for refractive cataract surgery or refractive lens exchange is a key component in achieving successful outcomes. Surgeons need to carefully examine the ocular surface of any patient who is considering these procedures. More than 60% of our cataract surgery patients have at least mild to moderate dry eye disease that is clinically seen on the slit lamp even if they are not necessarily symptomatic.<sup>1</sup> However, according to the 2015 ASCRS

Clinical Survey, 57% of surgeons think ocular surface dysfunction occurs in less than 20% of their cataract patients. When ocular surface problems go unnoted and untreated, we are much more likely to see refractive surprises because of poor image capture or incorrect IOL selection.

In addition, if suboptimal, fluctuating, or blurred vision results from dry eye that has not been treated, patients will be dissatisfied with their outcomes. We also need to emphasize the importance of continuing dry eye treatments after surgery to maintain optimal visual outcomes.

### Refractive packages

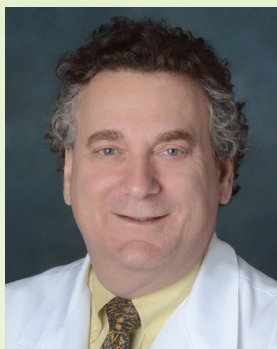
Surgeons should have a plan for correcting refractive error when a surprise occurs. In my practice, refractive packages that include preoperative assessments and

## Presbyopia-correcting IOL surgery requirements

- Select appropriate candidates
- Master surgical skills and IOL power calculation
- Optimize ocular surface
- Manage astigmatism
- Use good marking technique
- Know your SIA
- Plan for refractive enhancement if necessary

# Maneuvers to mitigate refractive surprises

by Richard Tipperman, MD



Richard Tipperman, MD

***With excellent strategies, surgeons can ultimately satisfy patients even when the initial outcome is less than optimal***

**D**espite our best efforts, refractive surprises occasionally occur after pseudophakic presbyopia-correcting surgery. To achieve optimal outcomes from enhancements, surgeons

need to weigh the strengths of available technologies in light of each patient's needs.

Laser vision correction (LVC) is one of our best tools for fine-tuning refractions very effectively and predictably.

I prefer to use LASIK for these procedures. Although some surgeons choose PRK for enhancements to avoid flap-related complications, PRK recovery is much more uncomfortable. Furthermore, LASIK offers a faster visual recovery.

If the residual error is 4.00–5.00 D or a patient has a thin cornea, I usually perform a lens exchange or implant a piggyback lens rather than performing LVC (Figure 3).

Conversely, if a patient has weak zonules or a compromised capsule, a corneal refractive procedure is more appropriate than a lens exchange.

Limbal relaxing incisions are useful to address 0.50 to 0.75 D of residual astigmatism when the patient's spherical equivalent is close to plano. We can perform them easily in the office, and they are minimally invasive (Figure 4).

## Managing the technicalities

If we are meticulous in our preoperative measurements and surgical techniques, most patients will be pleased with their pseudophakic presbyopia-correction outcomes and will not require touchups. However, how can cataract surgeons who provide advanced technology IOLs but not LVC satisfy their patients if refractive surprises occur?

One option is to offer patients who sign up for these procedures a voucher for a discounted LVC touchup with a colleague. Patients who do not require an enhancement can transfer the certificate to a friend or relative for a discounted LVC procedure.

This can be a win-win-win situation—for patients, who are pleased with their discount; for cataract surgeons, who can count on a colleague to perform occasional LVC enhancements; and for refractive surgeons, who gain additional patients.

If a patient has 1.5 D or more of residual astigmatism or the spherical equivalent is not plano, we use LVC to correct the astigmatism rather than a lens exchange.

## Weighing technologies

Because residual refractive errors after cataract surgery usually are very small, it is less important

*continued on page 6*

continued from page 4

postoperative enhancements have been an important tool in ensuring that patients ultimately get the outcome they want.

Packages can be customized to be all-inclusive (covering the total cost of enhancements) or offer discounted refractive touchups. A potential disadvantage of packages, however, is that patients may have even higher expectations.

In contrast, some practices provide a more detailed list of à la carte options. However, in my experience, the more exhaustive lists can confuse patients.

Surgeons need to present options clearly so patients can readily understand them.

We keep it relatively simple, and I think many practices are taking this approach. We offer two basic packages, based on patients' visual goals. Patients may opt for distance-only correction or a range of distance and near correction.

However, your practice setting should guide your choices. Surgeons in a medical retina practice that also performs cataract surgery are less likely to have patients who qualify

for presbyopia-correcting IOLs. Therefore, à la carte choices may be more appropriate.

Packages must also make sense in terms of profitability and costs. For example, surgeons with a high enhancement rate should factor that into the equation.

By committing to exceptional treatment, surgeons can deliver the visual results presbyopic patients expect. Surgeons may choose to bundle options to make it simpler for patients to understand and to deliver a seamless spectrum of care.

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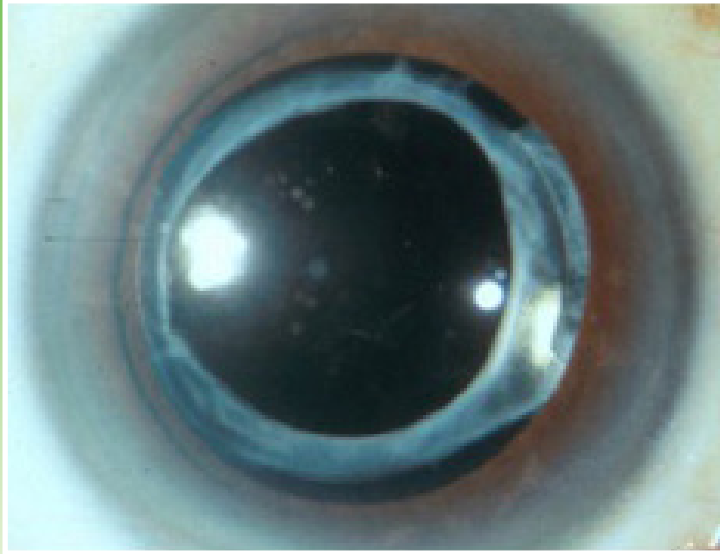


Figure 3. A large capsulorhexis may make IOL removal for exchange easier.

whether we use wavefront-optimized, wavefront-guided, or topography-guided systems. Most surgeons use the system with which they are most comfortable.

In my experience, the femtosecond laser is advantageous in creating LASIK flaps. The incidence of flap complications is greater with a mechanical microkeratome compared with a femtosecond laser.<sup>1,2</sup>

Arcuate incisions created with a femtosecond laser are exquisitely accurate and controlled, but they rely on a coupling effect and the patient's tissue response. Therefore, there is still variability in those nomograms.

Bladed arcuate incisions are very low tech and low cost, and surgeons do not need to pay disposable or interface costs.

Both techniques and technologies work well. It is up to surgeons to choose what works best in their hands.

### Before the enhancement

Before a touchup with LVC or a lens exchange in presbyopic

patients, a contact lens trial is beneficial, simulating the final result. Patients can see that they will give up some near focus if we treat myopic residual refractive error, and they can decide whether additional surgery would be worthwhile.

Additionally, it is important to wait until the patient's refraction is stable before performing a touchup. If there is any sign of capsular opacification, we treat that and wait for the refraction to stabilize before performing the enhancement.

### Going the distance

Because patients are already disappointed if a refractive surprise occurs, I prefer to perform LASIK with a femtosecond laser, if possible. I want to use my best procedure to satisfy the patient as efficiently as possible, with the lowest risk of complications. Although I absorb that cost, I think it is in their best interest. They achieve good results and are usually extremely appreciative,



Figure 4. This "stubby" limbal relaxing incision knife has a short length that makes it easier to use at the slit lamp.

***“I want to use my best procedure to satisfy the patient as efficiently as possible, with the lowest risk of complications.”***

**—Richard Tipperman, MD**

knowing that we have gone the extra distance to achieve a good result.

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# Strategies to raise the bar in presbyopic correction: An interview with Douglas Koch, MD



Douglas Koch, MD

## *Meticulous preoperative planning and surgical strategies can help ophthalmologists optimize visual quality when correcting presbyopia*

Perhaps surprisingly, most ophthalmic surgeons achieve refractive outcomes within 0.5 D of their target refraction in only 60–70% of their pseudophakic presbyopia-correcting procedures. The good news is they can take their results much higher, said **Douglas Koch, MD**, professor and Allen, Mosbacher and Law chair in ophthalmology, Cullen Eye Institute, Baylor College of Medicine, Houston.

The 2015 ASCRS Clinical Survey showed that 62% of respondents think 0.75 D of astigmatism is acceptable (Figure 5), and 41% think 0.75 D of spherical error is acceptable.

However, Dr. Koch has higher aspirations. “We really want to be at 90% and above,” he said.

There are a number of ways that surgeons can lower their thresholds for acceptable refractive error levels after presbyopia-correcting surgery, Dr. Koch said.

### Increased accuracy

“You have to become very accurate to become the surgeon that people want to go to—not only for cataract surgery but for refractive lens exchange,” he said. Not only do surgeons need to establish preoperative and postoperative strategies, but they need to know how to manage postoperative refractive errors using various options. “These may include relaxing incisions, laser corneal surgery, or in some instances, even IOL exchange,” he said.

During preoperative planning, he suggests obtaining 2 or 3 measurements from different devices, including a biometer and topographer. If a significant discrepancy is found, the measurements should be repeated.

“Part of that whole process is looking at the ocular surface when a patient first presents,” Dr. Koch said. “We look at the mires of the Placido topographer, and if the mires are not pristine, then we go ahead and treat the patient with artificial tears, at a minimum, and bring them back to remeasure them,” he said.

He prefers the LENSTAR Optical Biometer (Haag-Streit) and IOLMaster 700 (Carl Zeiss Meditec) as his automated keratometers for astigmatism planning.

His favorite formulas are the Holladay 1, the Barrett Universal II formula, and **Warren Hill, MD**'s new RBF formula. For long eyes, Dr. Koch still gets the best accuracy with the Holladay 1 with the Wang-Koch axial length modification. For short eyes, he adds the Olsen formula to the other 3 and looks for an average of the 4 calculated values.

The simplest solution to determine the posterior astigmatism is Barrett's formula, he said, but he still relies heavily on the Baylor nomogram. “In addition, **Adi Abulafia, MD**, and I have developed another formula, and I now use this routinely; some manufacturers are going to

Acceptable amount of residual cylinder before there is an impact on visual quality and patient satisfaction

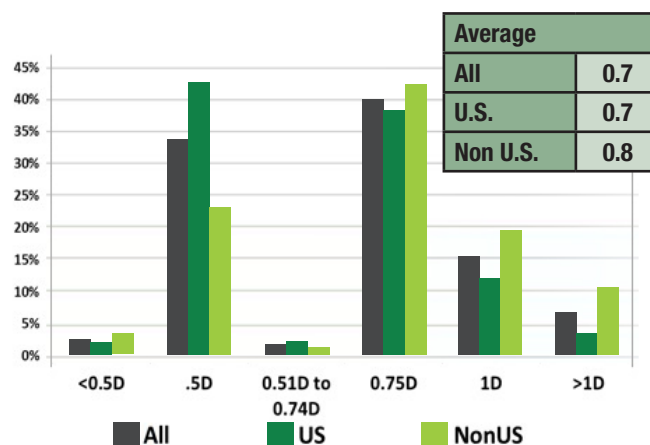


Figure 5. Results of the ASCRS Clinical Survey regarding residual astigmatism after implantation of a presbyopia-correcting IOL

incorporate that into their toric calculators,” Dr. Koch said.

The literature has not shown that any device can accurately measure posterior corneal astigmatism on a patient-by-patient basis, but Scheimpflug devices and LED reflection technology are bringing surgeons closer to that point, Dr. Koch said. Researchers also are investigating optical coherence tomography to determine posterior corneal astigmatism.

“The idea would be to have a technology in our hands sometime in the next year or 2 that would give us true corneal power measurements, both in terms of front and back power and also front and back astigmatism, and I think that we would see a huge step up in the accuracy of our lens calculations,” he said.

### Surgical options

Dr. Koch thinks surgeons can achieve successful outcomes without a femtosecond laser. “I think we are still looking for clear data that show there might be an advantage in terms of refractive surgery,” he said. “I think that will

come as these lasers become more refined and as we develop lens implants that might more clearly attach to the anterior capsule so the precision of the capsulotomy might be critical.”

Additionally, Dr. Koch thinks the literature has not demonstrated greater benefits in creating relaxing incisions with the femtosecond laser compared with diamond knife incisions. “But I have no doubt that over time, as we refine it, this will take place,” he said.

### Conclusion

To optimize outcomes from presbyopia-correcting surgery, surgeons need to master precise planning and surgical techniques and successfully manage postoperative refractive errors. “It requires a broad skill set so that you can take good care of your patients from inception to the final outcome,” Dr. Koch said.

Dr. Koch can be contacted at [dkoch@bcm.edu](mailto:dkoch@bcm.edu).

## The impact of refractive error on outcomes and patient satisfaction

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### CME questions (circle the correct answer)

1. Dr. Yeung explained that visual acuity declines by 1 line per \_\_\_\_\_ of residual astigmatism.
  - a. 0.25 D
  - b. 0.50 D
  - c. 0.75 D
  - d. 1.00 D
  
2. According to Dr. Koch, surgeons achieve refractive outcomes within 0.5 D of their target refraction in \_\_\_\_\_ of their pseudophakic presbyopia-correcting procedures.
  - a. 25–35%
  - b. 30–40%
  - c. 40–50%
  - d. 60–70%
  
3. If patients have residual error of 4.0 or 5.0 D, Dr. Tipperman usually performs \_\_\_\_\_.
  - a. LASIK
  - b. PRK
  - c. A lens exchange or implants a piggyback lens
  - d. Arcuate incisions
  
4. Dr. Dell generally uses \_\_\_\_\_ in hyperopes with early presbyopia.
  - a. LASIK
  - b. Refractive lens exchange
  - c. PRK
  - d. Small aperture inlay
  
5. If you are implanting a small aperture corneal inlay or EROV lenses, what should your refractive target be for the nondominant eye?
  - a. Emmetropia
  - b. Slight myopia (–0.50 to –0.75 D)
  - c. Monovision ( $\geq 1.00$  D)
  - d. Slight hyperopia (0.25 to 0.50)

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