

April 2023



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# Fundamentals of Small-Aperture Optics for Presbyopic Patients

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MODERNOPTOMETRY

# Fundamentals of Small-Aperture Optics for Presbyopic Patients

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## Content Source

This continuing education (CE/CME) activity captures content from two roundtables.

## Activity Description

This supplement summarizes a discussion on small-aperture optics fundamentals.

## Target Audience

This certified CE/CME activity is designed for cataract/refractive specialists, general ophthalmologists, and optometrists.

## Learning Objectives

Upon completion of this activity, the participant should be able to:

- **Review** the optical correlation between pupil size and depth of focus/range of vision and other visual outcomes
- **Understand** how to customize pupil-size goals to the presbyopia patient's visual needs and expectations
- **Identify** pupil sizes to expect in patients with various small-aperture and pharmacological presbyopia treatments
- **Review** case studies of patients who greatly benefit from a customized pupil size

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Course # 83862-GO  
Activity # 125782

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## PRETEST QUESTIONS

Please complete prior to accessing the material and submit with Posttest/Activity Evaluation/Satisfaction Measures for credit.

1. Please rate your confidence in your ability to understand the fundamentals of small-aperture optics (based on a scale of 1 to 5, with 1 being not at all confident and 5 being extremely confident).
  - a. 1
  - b. 2
  - c. 3
  - d. 4
  - e. 5
2. Which technology has NOT been used to measure pupil size?
  - a. Automated pupilometers
  - b. Pachymetry
  - c. Wavefront devices
  - d. Automated refractors
3. Which of the following could possibly impact pupil diameter during the measurement?
  - a. Patient reading during the measurement
  - b. Intraocular pressure
  - c. Ocular surface disease
  - d. Room temperature
4. Which of the following is TRUE regarding small-aperture technology?
  - a. Autorefractometry can help doctors understand its impact in a specific patient
  - b. It is not associated with dysphotopsia
  - c. It is not impacted by central dry eye
  - d. None of the above
5. When do patients initially notice the signs of presbyopia?
  - a. Varying times
  - b. Age 40
  - c. Age 50
  - d. Age 55
6. What may NOT impact patients' first signs of presbyopia?
  - a. Refractive error
  - b. Current vision correction method
  - c. Residual accommodation
  - d. Use of artificial tears
7. In clinical trials, what was the target refraction for the small-aperture IOL?
  - a. Plano
  - b. -0.25 D to -0.50 D
  - c. -0.50 D to -0.75 D
  - d. -0.75 D to -1.00 D
8. Which part of the small-aperture IOL corrects the patient's refraction?
  - a. Aperture
  - b. Base power
  - c. Toricity
  - d. None of the above
9. What do panelists recommend to patients to help with dimming from presbyopia-correcting eye drops?
  - a. Lubricating drops
  - b. Blinking
  - c. Consistent use
  - d. Additional light
10. Which of the following is a red flag for presbyopia-correcting drops?
  - a. Unrealistic expectations
  - b. Slight hyperopia
  - c. Slight myopia
  - d. Monovision use
11. In patients receiving a small-aperture IOL in one eye, what type of IOL is used in the fellow eye?
  - a. Extended depth of focus
  - b. Small aperture
  - c. Standard monofocal
  - d. Accommodating IOL

## Defining Aperture Size

New small-aperture technologies expand interest in greater capabilities of presbyopia correction.

**W**ith advances in pharmacologic and IOL technologies that utilize small-aperture optics to deliver a greater range of vision in patients with presbyopia, clinicians are taking steps to better understand the correlation between aperture size and visual outcomes.

"This is a newer thought process of considering accommodation and using it for near vision and aperture size for presbyopia correction," said Elizabeth Yeu, MD.

### MEASUREMENT OPTIONS

A variety of technologies have been used to measure pupil size, including automated refractors, automated pupilometers, and wavefront devices, according to Karolinne M. Rocha, MD, PhD. However, she does not believe there is a current standard for measuring pupil size.

Clinicians also may use a near vision card to estimate the pupil size in their practices.

"With presbyopia drops coming out, it may be time to educate ourselves on the best ways to measure the pupil and the most appropriate patients for certain technologies," said Josh Johnston, OD, FAAO.

Pupil size is light dependent and dynamic, and if the patient is trying to read, the pupil may shift nasally, Dr. Rocha said.

"If you want to check the pupil size, you may need to adjust the lighting and check patients in the same room every single time," she said.<sup>1,2</sup>

### IMPACT OF PUPIL SIZE ON SURGERY AND SURGICAL OUTCOMES

Many doctors do not measure pupil diameter during an examination. "At one point we did in refractive surgery because we wanted to see how large the pupils were and if it would cause dysphotopsias and problems in different environments," said Douglas K. Devries, OD.

"Even if pupils are measured, practitioners often don't measure them in a systematic, reproducible manner," said Sumit "Sam" Garg, MD.

Jacob Lang, OD, FAAO, Dipl ABO, believes the focus may be shifting to pupil function, the dynamic change that occurs with light and dark and accommodation, and the ideal pupil size and pupil range. "As we start to think about a pupil size as being dynamic, can we modify how the pupil changes and its dynamic range?" he said. "Is there part of this patient's dynamic range that is not ideal for his visual function in his environment? We have not measured pupil size in a way that shows dynamic range in visual functional situations. I think that is where this is going."



*"Are you trying to improve quality of vision at distance and decrease higher-order aberrations or are you trying to give patients the largest independent range of vision for the longest period of time in all light levels?"*

— Cathleen M. McCabe, MD

Pupil assessment can be important before cataract surgery. "It is a red flag if the two pupils are dissimilar in size or if there is an afferent pupillary defect," said John A. Hovanesian, MD. "If we are seeing a cataract patient, the one thing we often care about is how well the pupil dilates because we want to know if surgery is going to be challenging. We want to know if there's a marker for intraoperative floppy iris syndrome or pseudoexfoliation."<sup>3,4</sup>

According to Dr. Hovanesian, when researchers looked at variables that provided the best accommodation and range of vision with early accommodative IOLs, they found that undilated pupil size made the most difference. "Patients who had tiny pupils had greater depth of focus," he said. "Of course, that's true with any lens implant."

In general, Dr. Yeu said, with a smaller pupil, the patient will have pseudoaccommodation. "You're going to get some level of greater depth of focus," she said. However, Dr. Yeu explained that vision and contrast degrade if the pupil size is too small.

"If the pupils are too small and you are considering a diffractive lens, you miss some of the benefit of that diffractive lens because now you are just looking at the central optic," Dr. Garg said. "These patients usually get good range of vision because their pupil is so small, so they have the pinhole effect and they think the lens is working for them, but you're not really using the optics of the lens. You're using the optics of the pinhole!"

"Patients with a central cataract obviously are not going to do well with a much smaller pupil," Dr. Hovanesian said. "We also have to think about ocular surface disease."

"Aperture size also is important for patients with less than healthy eyes or patients who may have compromised optic nerves and we want to maximize the light that is coming in," said Cathleen M. McCabe, MD.

In summary, Dr. Rocha said the impact of small-aperture optics can be affected by diffraction, defocus, refraction, lower-order aberrations if the patient is a latent hyperope, contrast sensitivity, retinal luminance, pseudoaccommodation, higher-order aberrations, and corneal asphericity.

Dr. Rocha explained that Xu et al studied pupil size as it relates to photopic, mesopic, and scotopic conditions.<sup>5,6</sup> They found that the smaller the pupil size, the better reading vision will be, but

if the pupil is too small, the patient starts to lose contrast and lines of vision at distance. The researchers reported that there is a sweet spot, which is about a 30% miosis from the patient's natural pupil size.

Diagnostic tools such as ray-tracing aberrometry can help clinicians understand the potential clinical impact of small-aperture optics and also help educate patients. For example, Dr. Rocha explained that Xu et al looked at metrics of contrast sensitivity, such as the visually weighted Strehl ratio determined from the optical transfer function and visual acuity. These devices can simulate the effect of a small aperture by simulating the ideal pupil size that can increase the depth of focus without compromising the distance vision and contrast, she said.

### PUPIL DIAMETER AND PRESBYOPIA DROPS

The effectiveness of presbyopic eye drops varies among patients, said William F. Wiley, MD. "Some people might take a drop and have a 2.5-mm pupil and some might have less than a 1-mm pupil and have very different effects from the same medication. With an IOL, it is going to be the same aperture size for every patient."

When prescribing currently available presbyopic eye drops, Jaclyn Garlich, OD, FAAO, learns about the patient's visual needs. "It's important to find out the visual scenario that the patient wants to improve. Do they want better near vision in dim light?" she said. "Do they want to work on the computer all day without reading glasses? Knowing this will help set realistic expectations."

"It is important to discuss possible dimming of vision with the patient prior to them trying the presbyopia-correcting drop to avoid the patient's being alarmed," added Dr. Garg.

There is currently only one miotic that is FDA approved for presbyopia correction (pilocarpine 1.25%), but Dr. Hovanesian explained that different formulations in the pipeline may provide different degrees of miosis and work for different lengths of time,

which may allow individualization of dosing. Clinicians may need to identify the right medication for the right patient.

To choose the right treatment, clinicians will need to know the desired outcome for each patient, Dr. McCabe added. "What are you trying to do? Are you trying to improve quality of vision at distance and decrease higher-order aberrations or are you trying to give patients the largest independent range of vision for the longest period of time in all light levels?" she said.

"What if you had a drop that only lasts for a certain number of hours?" said April Jasper, OD, FAAO. "At nighttime, patients have different needs for vision than they do during the day. Patients who are driving all day have different needs than others. If we understood this better, could we help them with different options?"

"There are plenty of anecdotal reports now that miotics improve quality of vision for patients with glare and halos from multifocal lenses or complex corneas from prior radial keratotomy or refractive surgery and the loss of best corrected vision," Dr. Hovanesian said. "If you refine the entrance aperture so that it uses more of the central cornea, you avoid a lot of aberrations."

"It is interesting that patients with very aberrated corneas sometimes ask for 'pinhole' glasses when they notice the improvement in vision quality they get when using the diagnostic pinhole test in clinic," Dr. Garg added.

Dr. Johnston noted that future drugs may offer lower concentrations with less impact. He believes older patients with a very small pupil may not notice a significant change with currently available presbyopia drops, and patients with very large pupils may be among those who experience dimming vision.

"It will be interesting to see if we can change the higher concentration for a subset of patients versus a lower dose," Dr. Johnston said. "Future technologies probably will have that, and we can optimize pupil size with different concentrations." ■



*"If you refine the entrance aperture so that it uses more of the central cornea, you avoid a lot of aberrations."*

— John A. Hovanesian, MD

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## How Changes in Aperture Size Impact Vision

Aperture size impacts various aspects of vision.

Large and small aperture sizes impact vision in different ways. Smaller aperture sizes increase the depth of focus, provide more uniform and predictable vision, and reduce light transmission, whereas a larger aperture decreases the subjective depth of field.<sup>1,2</sup>

William F. Wiley, MD, explained that, according to an editorial by W. Neil Charman, depth of focus remains relatively the same as the pupil size shrinks from 8 mm to 4 mm, changes a bit at 3 mm, and continues to significantly increase with a diameter at or below 2.5 mm.<sup>3</sup>

However, patients with a posterior subcapsular cataract (PSC), with a central aberration along the visual axis, benefit from a larger pupil size because more energy enters the eye around the aberration, said Jacob Lang, OD, FAAO, Dipl ABO.

Douglas K. Devries, OD, agreed. “As the lenticular opacities increase, there is a benefit to a larger pupil and a disadvantage to a smaller pupil. Patients are adversely affected when they have PSC as the small pupil decreases vision,” he said. “Larger pupils can permit a lot more light around the PSC. Larger pupils can also expose higher-order aberrations. We have the pro and con within the same size, depending on the condition of the lens and the cornea.”

### ASSESSING PATIENT PERCEPTION

Patients’ individual visual experiences influence their

expectations of small-aperture presbyopia drops, according to Jaclyn Garlich, OD, FAAO. “This is exactly where the conversation with the patient has to start: What is it that she wants?” she said. “To satisfy a patient, you have to lay out the potential side effects and limitations of these drops, so it is not surprising if she experiences any of these things.”

“This is not much different than other conversations we have with patients about expectations in regards to surgery, choosing an IOL, or about multifocal contact lenses or glasses,” said Cecelia Koetting, OD, FAAO, Dipl ABO.

### ADVANCING UNDERSTANDING

“I think as we learn more about pupil size, age, and refractive error, we will have a better patient profile for these drops and different technologies,” said Josh Johnston, OD, FAAO.

Panelists believe they will be able to better customize treatment to individual patient needs as additional presbyopia drops are approved and enter the market.

Pilocarpine 1.25% has been FDA approved for presbyopia correction, and several other formulations are in various stages of development.

“We are going to be searching for answers by trying different formulations on different individuals to determine what works best on a blue eye versus a brown eye versus a hyperope versus a myope,” Dr. Devries said. “We have so many combinations and permutations of those variables, I think it will take time to sort out those details.” ■

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## Impact of Refractive Error and Residual Accommodation

Factors influence visual quality and reading vision outcomes.

Panelists explored the effect of refractive error and residual accommodation on the potential outcomes of small-aperture therapies.

### ASSESSING REFRACTIVE ERROR AND RESIDUAL ACCOMMODATION

Jacob Lang, OD, FAAO, Dipl ABO, asks all patients who are older than 40 about their near vision. As patients approach this age, he cautions them that their vision will change in the future.

According to Elizabeth Yeu, MD, when examining 40- to 45-year-old patients, clinicians need to perform a manifest refraction, as well as a dark room adaptation and cycloplegic examination. The patient’s expectations will need to be set properly for treatment outcomes.

Refractive error is relevant to expectations of efficacy, said Cathleen M. McCabe, MD. “When we prescribe miotics with the hope of expanding a patient’s range of vision, we need to know if the patient is a latent hyperope because we should be expecting less improvement in his near vision as a result,” she said.

Clinicians also need to know how much accommodative reserve patients have. “A younger patient who is a +2.00 D and sees well at distance but is starting to struggle at near may be maximizing her accommodative reserve to see well at distance,” Dr. McCabe said. “She doesn’t have a lot left, so you need to improve her near vision more by having a smaller pupil size. But if a patient is somewhat myopic or emmetropic and not using

her accommodative reserve, you may be able to get away with a bit less pupil constriction and still have improvement in range of vision and near performance.”

“I tend to lean toward the idea that a myopic patient with a larger pupil might be a better candidate, and a pupil that is too small might be a problem,” said Douglas K. Devries, OD. He also believes hyperopic patients may be a bit more challenging because the doctor does not know how much latent hyperopia is present.

In clinical trials, the target refraction for the small-aperture IOL was -0.75 D to -1.00 D,<sup>1</sup> said John A. Hovanesian, MD. “Because those patients would achieve improvement in their depth of focus on both the distance and near side, they achieve J2 or so up close and close to 20/20 VA at distance,” he said. “It’s important to remember small pupils extend range of vision on both sides, hyperopic and myopic. That’s why it’s important to know a patient’s baseline refractive error.”

The small aperture has a different impact on the myopic defocus versus the hyperopic defocus, said Karolanne M. Rocha, MD, PhD. “Myopic patients do better. The hyperopic patients do not appreciate that flattening as much, when the curve is broadened to the left of the defocus curve. Clinically, we see that with the latent hyperopes.”

“I would say current treatment options have some lenticular effect. They are going to induce some level of accommodation,” said Jacob Lang, OD, FAAO, Dipl ABO. When we induce accommodation, even to a small amount, it will reduce the aberrations in a hyperope and increase the aberrations in a myope. In addition, reducing the pupil size will increase the depth of focus in a myopic patient, but the potential lenticular accommodation is going to push them toward being more myopic, he explained. He believes hyperopic patients may have slightly more of an advantage with current treatment options. However, Dr. Lang thinks future products with a different mechanism of action are designed to have less effect on the ciliary body and to be more pupil specific.

The small-aperture IOL showed that visual outcomes with astigmatism between 1.00 D and 1.50 D had similar outcomes as astigmatism less than 1.00 D,<sup>1</sup> said William F. Wiley, MD. Dr. Wiley explained that the small aperture helps mitigate the blur that regular astigmatism typically causes. “Our hope would be that the same idea could translate to irregular astigmatism,” he said.



*“The small-aperture mechanism of action will allow us to approach presbyopia correction in a different way than our current diffractive IOLs.”*

— Sumit “Sam” Garg, MD

In contrast to pharmacologic technology, small-aperture IOL technology allows surgeons to perform a refractive correction for patients with myopia or hyperopia. Consequently, the base power of the IOL has the ability to correct patients’ refraction, and the aperture portion of the IOL can extend the depth of focus, thus mitigating presbyopia. It can also mitigate small amounts of astigmatism, Dr. Wiley explained.

According to Dr. Hovanesian, research performed outside the United States has shown positive experiences with a small-aperture IOL in post-radial keratotomy eyes and other complex corneas.<sup>2,3</sup> “I also think it will work for patients with lower astigmatism who might qualify for a toric IOL,” he said. Dr. Hovanesian explained that this IOL is easy to use because it can be placed on any axis to correct that degree of astigmatism.

“Small-aperture IOLs are a very exciting option for us now in the United States,” said Sumit “Sam” Garg, MD. “The small-aperture mechanism of action will allow us to approach presbyopia correction in a different way than our current diffractive IOLs. Additionally, visual quality will be improved as a function of the cataract removal. As was stated earlier, low amounts of regular astigmatism will also be managed with these IOLs. Lastly, I am very eager to see how these IOLs help us with complex corneas (post-LASIK, post-radial keratotomy, irregular astigmatism, keratoconus, etc).”

## CUSTOMIZING TREATMENT ACCORDING TO REFRACTIVE ERROR

According to Consensus Finding #1 (Figure 1), 92% of panelists believe it is essential, very important, or important to customize the treatment plan of a small-aperture patient based on the amount of refractive error in that patient.

Josh Johnston, OD, FAAO, explained that younger presbyopic myopic patients are not looking for solutions because their near vision is good. “The larger number of happy patients who are getting topical treatments are emmetropic and hyperopic patients who really would be more desiring of technology like that to test,” he said.

“In our IOL patients, when you have someone who is a -2.00 D or -3.00 D preoperatively, the conversation about what their near vision is going to be after surgery and how it is going to contrast with their preoperative vision is so important,” Dr. Hovanesian said. “No implant that gives decent distance vision is going to mimic what it is to be a -3.00 D myope at uncorrected near, so beware of taking away uncorrected near vision with any lens implant.”

## CUSTOMIZING TREATMENT BASED ON RESIDUAL ACCOMMODATION

According to Consensus Finding #2 (Figure 2), 92% of panelists believed it was essential, very important, or important to customize the treatment plan of a small-aperture patient based on the amount of residual accommodation in a patient.

Patients with significant residual accommodation may have accommodative spasm, which can affect their distance vision, Dr. Johnston said. “We have to educate patients about that, especially our younger patients,” he said.

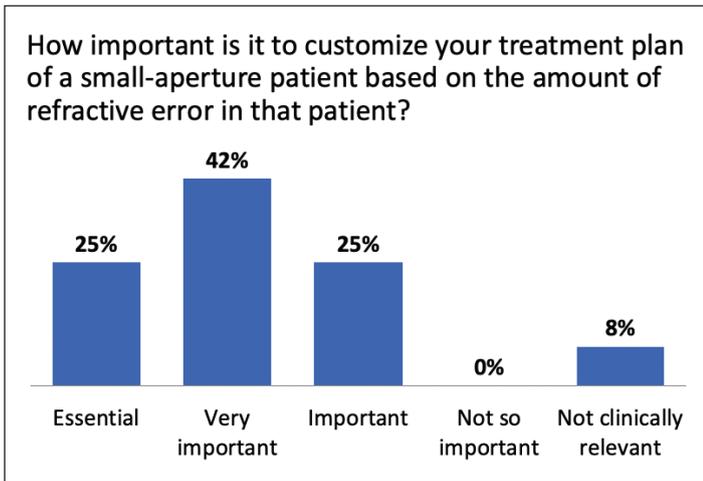


Figure 1. Consensus Finding #1.

Dr. Lang agreed that with the currently available topical medication, doctors need to recognize that there is still the potential for accommodative influence. “It will be interesting to see with future developments what concentrations have a role on accommodative influence and what different mechanisms of action have on accommodating influence,” Dr. Lang said.

A lower dose also may be useful in some patients. “That may also play into the recommendations for patients on how much

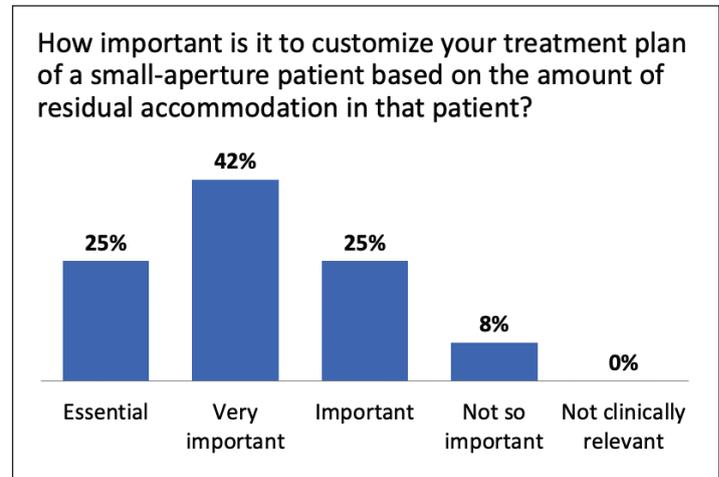


Figure 2. Consensus Finding #2.

depth of focus you are trying to achieve and where their working distance is,” Dr. Devries said.

Dr. Johnston explained that concentrations may be guided by patients’ age and visual goals, what they do at work, and other lifestyle factors. ■

1. Blecher MR, et al. One-year visual outcomes following monocular implantation with a small aperture IOL. Presented at American Academy of Ophthalmology, Chicago, 2022; September 30-October 3.  
 2. Quesada G, et al. European Society of Cataract and Refractive Surgery, poster, Milan, 2022; September 16-20.  
 3. Shajari M, Mackert MJ, Langer J, et al. Safety and efficacy of a small-aperture capsular bag-fixated intraocular lens in eyes with severe corneal irregularities. *J Cataract Refract Surg.* 2020;46(2):188-192.

## Preparing Ahead: Factors Impacting Patient Satisfaction With Small-Aperture Technologies

Ocular surface disease and dimming may dampen patient satisfaction.

Clinicians and their patients need to be aware of certain factors that may decrease satisfaction with small-aperture technology.

### MANAGING THE OCULAR SURFACE

Jaelyn Garlich, OD, FAAO, stressed that the condition of the ocular surface is critical with small-aperture technology, as it is with all other treatments. “We all understand that a dry cornea will impact clarity, but this is even more significant if the corneal staining is central and we are trying to use small-aperture technology.”

“We all learned in residency, if you have a very rough cornea and you are trying to determine visual acuity, a pinhole does not improve vision much,” said John A. Hovanesian, MD. “When you have a lot of light scatter because of the rough surface, it is going to scatter through a small pupil just as it does through a large pupil, and the small aperture will not yield significant improvement. You always need to manage dry eye if you want to improve vision quality.”

“Tear film stability is so important for any of the presbyopia solutions,” said Karolinne M. Rocha, MD, PhD. “Patients read the 20/20 line in clinic, but they complain that their vision is blurry.” The objective scatter index from the double-pass system shows the blur and point spread function from the tear film, she said (Figure).<sup>1</sup>

“When eliciting a history from these patients, it is important to ask if their vision is affected all the time or sometimes. If it is



*“Tear film stability is so important for any of the presbyopia solutions.”*

— Karolinne M. Rocha, MD, PhD

sometimes (fluctuating vision), it is prudent to address any ocular surface disease before considering a surgical intervention,” added Sumit “Sam” Garg, MD.

Cecelia C. Koetting, OD, FAAO, Dipl ABO, explained that patients blink approximately 50% less when they are concentrating or straining to read, increasing the risk of ocular surface disease. Therefore, she wondered whether presbyopia eye drops may decrease eye strain and subsequently dryness in patients whose symptoms resulted from exposure with electronic device usage.

However, she will not prescribe a topical therapy if it may cause worsening of ocular surface disease. “I think it’s important to make sure that we are not adding to ocular surface disease,” Dr. Koetting said.

William F. Wiley, MD, added that in the study for the small-aperture IOL, a couple of patients with vitreous floaters and posterior vitreous detachments required vitrectomy to maximize the performance of the optics.<sup>2</sup> “Although the aperture optics help extend depth of focus, they can be an issue if there are opacities or media problems,” Dr. Wiley said.

Elizabeth Yeu, MD, agreed, stressing that vitreous opacities can have a dramatic effect on patients’ vision and can make them very unhappy.

## DIMMING

When using small-aperture technologies, some patients may report that their vision is dimmer.

Based on his own experience and anecdotal experiences of others, Jacob Lang, OD, FAAO, Dipl ABO, believes dimming with pharmaceutical drops may result from the initial dynamic shift in the pupil diameter. “Once we get used to having a new dynamic

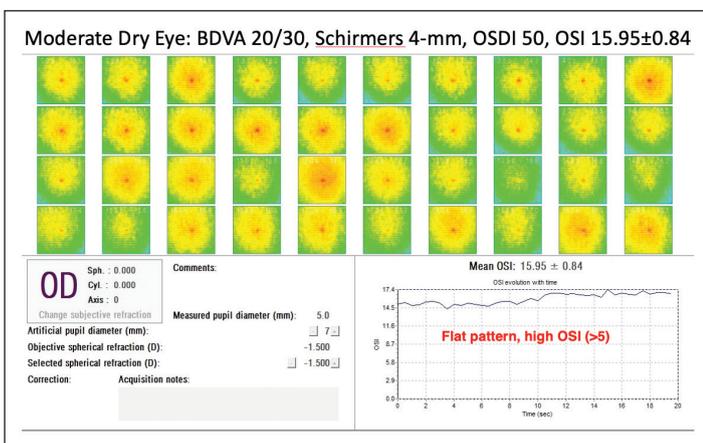


Figure. Ocular scatter index tear film analysis in patients with dry eye demonstrates that dry eyes can affect vision quality and visual function (tear film instability).



*“Although the aperture optics help extend depth of focus, they can be an issue if there are opacities or media problems.”*

– William F. Wiley, MD

range, dimming should be less of an issue after adaptation and adjustment to light requirements,” Dr. Lang said.

Panelists encourage patients to use the drops consistently, as directed. “One of the ways I explain it to patients is that it’s kind of like wearing a watch for the first time,” said April Jasper, OD, FAAO. After a few days, people do not notice it.

“Typically, my experience has been that they improve in 4 or 5 days,” Dr. Jasper said. She also found that patients with a larger pupil have more dimming as their pupil shrinks.

Dr. Koetting asks patients to try the drops every day for 2 weeks, so they have time to adapt and decide whether they can adjust to the change.

In the multicenter FDA clinical trial data for the small-aperture IOL, Dr. Hovanesian said, there were no significant differences regarding patient reports of dimming or changes in vision when the lighting conditions changed between the patients who received the small-aperture IOL compared with patients who had bilateral monofocal IOLs.<sup>2</sup> “Maybe it is because it is at the level of the implant. Maybe it is just because they do not have the on-and-off pharmacologic effect you get with drops,” he said. “These patients seemed to tolerate it, and all these patients received the lens in just one eye.”

In clinic, when using the pinhole occluder, Dr. Wiley has noticed that most patients initially respond that they see much better, but a subset respond regarding how dark it is. “Seemingly that could be at least a screening method that people who adapt to it quickly in the lane might more favorably tolerate any of the interventions,” he said. It is important to remind the patient that this is not an exact representation of what they would experience with the lens.

“One of the questions people commonly ask with regard to the small-aperture lens is whether it is possible to examine the retina,” Dr. Hovanesian said. “The answer is yes. We try to target patients who can dilate to about 6 mm so they can dilate outside of the area.”<sup>3</sup> ■

1. Gouvea L, Waring GO 4th, Brundrett A, Crouse M, Rocha KM. Objective assessment of optical quality in dry eye disease using a double-pass imaging system. *Clin Ophthalmol*. 2019;13:1991-1996.
2. Blecher MR, et al. One-year visual outcomes following monocular implantation with a small aperture IOL. Presented at American Academy of Ophthalmology, Chicago, 2022; September 30-October 3.
3. Srinivasan S, Khoo LW, Koshy Z. Posterior segment visualization in eyes with small-aperture intraocular lens. *J Refract Surg*. 2019;35(8):538-542.

# Evaluating Presbyopia Patients' Visual Needs and Expectations

Clinicians need to perform a comprehensive evaluation and ask the right questions to know which patients are candidates for small-aperture technologies.

**W**hen considering small-aperture technology, clinicians need to consider a range of factors.

## PRESBYOPIA EVALUATION

Patients initially notice the first signs of clinically significant diminished accommodation at different times.

Factors that impact patients' first signs of presbyopia include refractive error, how they correct their vision, and residual accommodation, among others. Therefore, patients will respond differently to the miotic drugs that are expected to become available.

According to April Jasper, OD, FAAO, patients need to have their pupils dilated as part of a comprehensive eye examination. "You need to know what they look like with their pupil large, what they look like with their pupil small. Otherwise, how can you solve their problems if you do not know what their eye looks like?" she said.

"Looking at the baseline pupil size, iris color, ocular surface, and the degree of presbyopia are good starting points when determining if a presbyopia drop will work well," said Jaclyn Garlich, OD, FAAO.

"Oftentimes, I look at patients' eyes before I check their refraction," said Cecelia Koetting, OD, FAAO. She wants to know before refraction whether the patient's problem is caused by the ocular surface, lens, or retina.

Cathleen M. McCabe, MD, emphasizes the importance of the patients' refractive status and accommodative reserve before an intervention, especially if they remain phakic. "Refractive status is critical, but I also want to know if they are using +1.00 D or +2.00 D readers? What are they doing to get by right now? That gives me an idea of what we are trying to achieve, if we are trying to replace the need for readers," she said.

## ASKING THE RIGHT QUESTIONS

"Expectations and goals almost fall into that extended depth of focus IOL category because we are expecting an improvement in functional vision—that full range from distance to intermediate," said Karolanne M. Rocha, MD, PhD. "So I think for these patients receiving small-aperture IOLs it is very important to manage expectations, like we do for all presbyopia-correction patients."

### EXAMINATION CHECKLIST FOR SMALL-APERTURE TECHNOLOGY

#### Goals and expectations:

- Questions about goals for vision
- Current near vision correction used
- Personality assessment
- Lifestyle and professional requirements

#### Comprehensive dilated examination:

- Refraction
- Residual accommodative reserve
- Baseline pupil size
- Comorbidities and pathology
- Ocular surface disease
- Posterior vitreous detachment status/retinal health
- Other abnormalities

"As we think of treating an early presbyope, the best patient to capture for [pharmaceutical treatment] is someone who is not quite used to reading glasses yet because it is so easy to put on reading glasses," said Elizabeth Yeu, MD. She explained that the ideal patient for presbyopia drops would probably be an emmetrope or someone who has mild hyperopia or myopia.

"It keeps them feeling like they are in that youthful vision part of their life," Dr. McCabe said. "It is a continuity of freedom from readers." Patients who had LASIK with monovision or multifocal contact lenses appreciate that, she said.

In addition to a list of several other questions, Dr. Jasper asks patients what their goals are today, comparing their answers with their other responses and their refraction to develop a plan.

Dr. Koetting does not prescribe topical presbyopia drops for patients who have high expectations and are not willing to compromise.

"Unrealistic expectations are a red flag," Dr. Garlich said. "If a patient tells me they want to be able to read the back of a medicine bottle in dim light, we discuss the limitations of these drops."

Specifically, it helps to know the near-vision activities patients engage in. For example, Dr. Koetting said, some patients play instruments and have specific visual needs to read music. "If you know what they are trying to read and what their demands are, it can help narrate the direction of where you are going," she said.

Success with presbyopia-correction options is very individual, Dr. McCabe said, depending on the patient's goals, ocular health, current refraction, accommodative reserve, and pupil size. "If you choose the perfect patient who is going to come into it exactly with those parameters that are ideally suited to what we have right now, they are going to have a great result," she said. "We do not have solutions that work for every patient."

"You have to have a dynamic pupil for the pharmaceutical therapies to be effective. But if that pupil is locked in place—whether it is due to age, accommodation, refractive error, medication—they are not going to have the 'wow' effect," said Josh Johnston, OD, FAAO. "So we need to achieve at least a 40% reduction in pupil size for the patient to notice any benefit."

## CONCLUSION: PRESBYOPIA DROPS

“We are just scratching the surface of the presbyopia drop treatment category,” Dr. Garlich said. “It’s wonderful to have a treatment option in our toolbox that does not involve glasses, contacts, or surgical intervention. As we learn what patients are best suited for these drops, it’s exciting to know there are other formulations in development that may provide even better targeted treatment for our presbyopes.”

The panelists all agreed that they look forward to an expansion of presbyopia drops. “We hope to have different formulations and concentrations of topical drops making pupil modulation, size, and all of these different variables more important because we will have ways to address all of the differences that we see,” Dr. Johnston said.

“I think we have to underpromise and overdeliver,” Dr. Koetting said. She asks patients to try the drops and use them consistently. Then they return to discuss their experience. If the drops do not work for them, she explains that there are potential alternatives in the pipeline.

“In a lot of ways this is the most natural option we have for treatment,” said William F. Wiley, MD. “Miosis is part of the accommodative system, so we are used to having miotic pupils. When we read, it is natural. Physiologically, humans have adapted to that response. This boosts that natural phenomenon that we have already been used to.” In theory, he said, people should be able to adapt relatively quickly, but there are a lot of things that need to stack up properly for it to function well.

“The nice thing about this category right now is that it fulfills a need that we have not had good options for in the past. We needed a bridge from that early presbyope to a more permanent surgical solution. This is a wonderful option that is not associated with dysphotopsias and is reversible, which is huge,” Dr. McCabe said.

“The beauty of presbyopia-correcting drops is that they give all eye care providers another option for helping patients navigate the challenges of presbyopia, taking into consideration their individual goals and needs,” Dr. Jasper said. “Not every option for presbyopia correction will be of interest or even effective in every patient, which is why patients expect and require a clinician who listens to them and is knowledgeable of the options available.”



*“As a clinical investigator during the FDA trial, I was very pleased with the level of full spectacle independence that patients experienced with the small-aperture IOL in one eye.”*

— Elizabeth Yeu, MD

“As we talk about some of the variables that we have—baseline pupil, refractive error, accommodative amplitude, residual accommodation—I hope that clinicians begin to recognize that there are variables. As they start to trial these drugs, they need to start looking at these variables within their patients and begin to formulate an algorithm of which drug works best for which patient,” said Douglas K. Devries, OD.

## CONCLUSION: SMALL-APERTURE IOLS

Small-aperture IOLs expand the presbyopia-correcting IOL options for cataract surgery, increasing the number of patients who are candidates for presbyopia-correcting IOLs.

In contrast to presbyopia eye drops, which are used in both eyes, small-aperture IOLs are used in one eye and a standard monofocal is used in the fellow eye. They can be used in patients who already have a standard monofocal IOL in one eye and desire a greater range of vision. Although presbyopia eye drops appear to be associated with variability regarding the effect, the same IOL will likely have a more universal effect across a wide range of patients, Dr. Wiley said.

“As a clinical investigator during the FDA trial, I was very pleased with the level of full spectacle independence that patients experienced with the small-aperture IOL in one eye,” Dr. Yeu said. “It is essential to really target and neutralize refractive error in the monofocal IOL in order to achieve great overall binocular satisfaction.”

“Monovision patients may be the best candidates if you are using a small-aperture IOL for the first time,” Dr. Rocha said. “I think having this category is fantastic because it offers great functional vision without dysphotopsias.”

While treating presbyopia, small-aperture IOLs enable correction of hyperopia and myopia, as well as small amounts of astigmatism. Dr. McCabe believes that the small-aperture lens could be helpful in cases where there’s concern that astigmatism could change significantly over the course of time. “It does not matter if there is a shift in axis over time because it is performing with the same mechanism,” she said. It may be a different, unique advantage to the small-aperture solution for low amounts of astigmatism.”

Research outside the United States has shown favorable results when a small-aperture IOL was implanted in post radial keratotomy eyes and eyes with other complex corneas.<sup>1,2</sup>

“Currently there are a lot of patients who are not ideal candidates for presbyopia-correcting IOLs due to their corneas being irregular. I have high hopes that small-aperture IOLs will allow for depth of focus in both regular and irregular corneas. This will allow surgeons to offer presbyopia correction to a large percentage of patients with greater confidence,” said Sumit “Sam” Garg, MD. ■

1. Quesada G, et al. European Society of Cataract and Refractive Surgery, poster, Milan, 2022; September 16-20

2. Shajari M, Mackert MJ, Langer J, et al. Safety and efficacy of a small-aperture capsular bag-fixated intraocular lens in eyes with severe corneal irregularities. *J Cataract Refract Surg.* 2020;46(2):188-192.

# Fundamentals of Small-Aperture Optics for Presbyopic Patients

Release Date: March 30, 2023

COPE/CME Expiration Date: March 30, 2024

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## DEMOGRAPHIC INFORMATION

Profession

\_\_\_ MD/DO

\_\_\_ OD

\_\_\_ NP

\_\_\_ Nurse/APN

\_\_\_ PA

\_\_\_ Other

Years in Practice

\_\_\_ >20

\_\_\_ 11-20

\_\_\_ 6-10

\_\_\_ 1-5

\_\_\_ <1

Patients Seen Per Week

(with the disease targeted  
in this educational activity)

\_\_\_ 0

\_\_\_ 1-15

\_\_\_ 16-30

\_\_\_ 31-50

\_\_\_ >50

Region

\_\_\_ Midwest

\_\_\_ Northeast

\_\_\_ Northwest

\_\_\_ Southeast

\_\_\_ Southwest

## LEARNING OBJECTIVES

Did the program meet the following educational objectives?

Agree

Neutral

Disagree

**Review** the optical correlation between pupil size and depth of focus/range of vision and other visual outcomes

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Understand** how to customize pupil-size goals to the presbyopia patient's visual needs and expectations

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Identify** pupil sizes to expect in patients with various small-aperture and pharmacological presbyopia treatments

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Review** case studies of patients who greatly benefit from a customized pupil size

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## POSTTEST QUESTIONS

Please complete at the conclusion of the program.

---

1. Based on this activity, please rate your confidence in your ability to understand the fundamentals of small-aperture optics (based on a scale of 1 to 5, with 1 being not at all confident and 5 being extremely confident).
  - a. 1
  - b. 2
  - c. 3
  - d. 4
  - e. 5
2. Which technology has NOT been used to measure pupil size?
  - a. Automated pupilometers
  - b. Pachymetry
  - c. Wavefront devices
  - d. Automated refractors
3. Which of the following could possibly impact pupil diameter during the measurement?
  - a. Patient reading during the measurement
  - b. Intraocular pressure
  - c. Ocular surface disease
  - d. Room temperature
4. Which of the following is TRUE regarding small-aperture technology?
  - a. Autorefractometry can help doctors understand its impact in a specific patient
  - b. It is not associated with dysphotopsia
  - c. It is not impacted by central dry eye
  - d. None of the above
5. When do patients initially notice the signs of presbyopia?
  - a. Varying times
  - b. Age 40
  - c. Age 50
  - d. Age 55
6. What may NOT impact patients' first signs of presbyopia?
  - a. Refractive error
  - b. Current vision correction method
  - c. Residual accommodation
  - d. Use of artificial tears
7. In clinical trials, what was the target refraction for the small-aperture IOL?
  - a. Plano
  - b. -0.25 D to -0.50 D
  - c. -0.50 D to -0.75 D
  - d. -0.75 D to -1.00 D
8. Which part of the small-aperture IOL corrects the patient's refraction?
  - a. Aperture
  - b. Base power
  - c. Toricity
  - d. None of the above
9. What do panelists recommend to patients to help with dimming from presbyopia-correcting eye drops?
  - a. Lubricating drops
  - b. Blinking
  - c. Consistent use
  - d. Additional light
10. Which of the following is a red flag for presbyopia-correcting drops?
  - a. Unrealistic expectations
  - b. Slight hyperopia
  - c. Slight myopia
  - d. Monovision use
11. In patients receiving a small-aperture IOL in one eye, what type of IOL is used in the fellow eye?
  - a. Extended depth of focus
  - b. Small aperture
  - c. Standard monofocal
  - d. Accommodating IOL

## ACTIVITY EVALUATION

Your responses to the questions below will help us evaluate this activity. They will provide us with evidence that improvements were made in patient care as a result of this activity.

---

Rate your knowledge/skill level prior to participating in this course: 5 = High, 1 = Low \_\_\_\_\_

Rate your knowledge/skill level after participating in this course: 5 = High, 1 = Low \_\_\_\_\_

This activity improved my competence in managing patients with this disease/condition/symptom. \_\_\_\_ Yes \_\_\_\_ No

Probability of changing practice behavior based on this activity: \_\_\_\_ High \_\_\_\_ Low \_\_\_\_ No change needed

If you plan to change your practice behavior, what type of changes do you plan to implement? (check all that apply)

Change in pharmaceutical therapy \_\_\_\_ Change in nonpharmaceutical therapy \_\_\_\_

Change in diagnostic testing \_\_\_\_ Choice of treatment/management approach \_\_\_\_

Change in current practice for referral \_\_\_\_ Change in differential diagnosis \_\_\_\_

My practice has been reinforced \_\_\_\_ I do not plan to implement any new changes in practice \_\_\_\_

Please identify any barriers to change (check all that apply):

\_\_\_\_ Cost \_\_\_\_ Lack of consensus or professional guidelines

\_\_\_\_ Lack of administrative support \_\_\_\_ Lack of experience

\_\_\_\_ Lack of time to assess/counsel patients \_\_\_\_ Lack of opportunity (patients)

\_\_\_\_ Reimbursement/insurance issues \_\_\_\_ Lack of resources (equipment)

\_\_\_\_ Patient compliance issues \_\_\_\_ No barriers

\_\_\_\_ Other. Please specify: \_\_\_\_\_

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The design of the program was effective for the content conveyed \_\_\_\_ Yes \_\_\_\_ No

The content supported the identified learning objectives \_\_\_\_ Yes \_\_\_\_ No

The content was free of commercial bias \_\_\_\_ Yes \_\_\_\_ No

The content was relative to your practice \_\_\_\_ Yes \_\_\_\_ No

The faculty was effective \_\_\_\_ Yes \_\_\_\_ No

You were satisfied overall with the activity \_\_\_\_ Yes \_\_\_\_ No

You would recommend this program to your colleagues \_\_\_\_ Yes \_\_\_\_ No

Please check the Core Competencies (as defined by the Accreditation Council for Graduate Medical Education) that were enhanced through your participation in this activity:

\_\_\_\_ Patient Care

\_\_\_\_ Practice-Based Learning and Improvement

\_\_\_\_ Professionalism

\_\_\_\_ Medical Knowledge

\_\_\_\_ Interpersonal and Communication Skills

\_\_\_\_ System-Based Practice

Additional comments:

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\_\_\_\_ I certify that I have participated in this entire activity.

This information will help evaluate this activity; may we contact you by email in 3 months to inquire if you have made changes to your practice based on this activity? If so, please provide your email address below.

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