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**Transforming patient outcomes with advanced refractive cataract technology**

*Sponsored by Johnson & Johnson Vision*

# Optimizing outcomes with extended range of vision IOLs: clinical, optical bench, and imaging testing

Chul Young Choi, MD, PhD

***Surgeons need to understand the capabilities of today's IOLs***

| Tecnis Symfony | | | |
|---|---|---|---|
| | Sphere | Cylinder | Spherical equivalent |
| Group 1 (visual acuity ≥ 1.0) | –0.46 | –0.52 | –0.71 |
| Group 2 (visual acuity = 0.8) | –0.69 | –0.57 | –1.05 |
| Group 3 (visual acuity = 0.63) | –0.71 | –1.06 | –1.25 |

| Tecnis ZCB00 (monofocal) | | | |
|---|---|---|---|
| | Sphere | Cylinder | Spherical equivalent |
| Group 1 (visual acuity ≥ 1.0) | –0.15 | –0.63 | –0.46 |
| Group 2 (visual acuity = 0.8) | –0.10 | –0.98 | –0.59 |
| Group 3 (visual acuity = 0.63) | –0.70 | –1.05 | –1.24 |
| Group 1: postop UCDVA < 0.0 (logMAR, 1.0 in decimal); Group 2: postop UCDVA = 0.1 (logMAR, 0.8 in decimal); Group 3: postop UCDVA = 0.2 (logMAR, 0.63 in decimal) | | | |

Figure 1. Correlations of uncorrected distance visual acuity and postoperative refractive errors

To obtain optimal results from the array of currently available premium IOLs, surgeons need to understand the technologies and know how to make the most of them.

There are inevitable factors that can impact patients' optical quality after surgery. For example, there are tolerance limits associated with dioptric power labeling by IOL manufacturers. If we implant a 20.0 D IOL, it may have +/–0.4 D error. When I tested a number of toric IOLs, there was a tilted axis resulting from the manufacturing process.

Outcomes also may be impacted by measurement errors, physiologic decentration and tilt of the IOL, and surgically induced astigmatism.[1,2] In addition, the dioptric changes of the IOL based on pupil size can impact results. Surgeons need to choose consistent, tolerant, steady lenses.

Before surgery, we ask patients what their real expectations are for presbyopic surgery. After surgery their expectations increase, but research has shown that J1 vision is not needed for functional near vision.[3] In my office, we do not have print smaller than J5.

The trend in South Korea is reduction of near add power to minimize glare and halos, enhanced intermediate vision, and trifocal and extended depth of focus (EDOF) technologies.

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*Technologic and surgical advances are changing the way cataract and refractive surgeons treat their patients and enabling them to optimize their refractive outcomes.*

*During the 2018 APACRS Annual Meeting in Chiang Mai, Thailand, leading experts from around the globe came together to discuss the impact of extended range of vision IOLs, toric IOLs, femtosecond laser-assisted cataract surgery, meibomian gland disease, and custom laser vision correction, optimized laser vision correction, and small incision lenticule extraction (SMILE) on surgical outcomes.*

*Chaired by **Ronald Yeoh, MD**, and **Hiroko Bissen-Miyajima, MD, PhD**, the symposium featured faculty members **Chul Young Choi, MD, PhD**, **Mahipal Sachdev, MD**, **Shinichiro Nakano, MD**, **Rohit Shetty, MD, PhD**, and **Edward Manche, MD**, who discussed how they use the latest innovations to optimize surgical outcomes.*

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## Clinical results

In a prospective bilateral consecutive study of presbyopia-correcting EDOF lenses (Tecnis Symfony, Johnson & Johnson Vision, Santa Ana, California) including 60 eyes in 30 patients with cataracts, monocular far and intermediate vision were excellent with the EDOF lens. The monocular near vision was J5 or better, and the binocular near vision was J4 or better.

These results are similar to those in a previous multicenter study of this EDOF lens led by Cochener.[4]

When we looked at binocular uncorrected near visual acuity, 93% had 0.5 near vision or better and 96% had binocular uncorrected intermediate visual acuity of 0.5 or better. When we considered binocular uncorrected distance visual acuity, 89% of patients could see better than 1.0. In contrast, when we look at trifocal IOL results reported by Cochener et al., less than 70% achieved a monocular corrected distance visual acuity of 0.00 logMAR.[5]

When I compared the Symfony EDOF and Tecnis monofocal lens to examine the tolerance for refractive error, the Symfony EDOF showed more tolerance to refractive error (Figure 1). I also found that if the refractive error is less than –0.5 D, we can expect much better visual acuity compared with monofocal IOLs (Figure 2).

> **"Surgeons need to choose consistent, tolerant, steady lenses."**
>
> **—Chul Young Choi, MD, PhD**

When I performed a bench test to determine the decentration tolerance of the Symfony EDOF and decentered the lens up to 0.75 mm, the Symfony lenses showed much better decentration tolerance than bifocal or trifocal IOLs.

## Imaging study

I also performed an imaging comparison of premium lenses. The scanning electron microscope showed a rough irregular shape on the surface of the PanOptix lens (Alcon, Fort Worth, Texas), with some large steps between the three diffractive focus areas. The anterior surface of the Symfony EDOF was much smoother and the posterior showed a very narrow regular striated pattern.

## Conclusion

To optimize outcomes from premium IOLs, it is important to manage the expectations of ourselves and for our patients. We also should choose a tolerant and forgiving IOL.


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*Dr. Choi is professor of ophthalmology, Sungkyunkwan University, School of Medicine, Kangbuk Samsung Medical Center, Seoul, South Korea. He can be contacted at sashimi0@naver.com. He has no financial interests related to this article.*

| Tecnis Symfony | | Tecnis ZCB00 (monofocal) | |
|---|---|---|---|
| | Uncorrected distance visual acuity (logMAR, decimal) | | Uncorrected distance visual acuity (logMAR, decimal) |
| Group A (SE ≤ –0.5) Mean = –0.32 | –0.013 (1.04) | Group A (SE ≤ –0.5) Mean = –0.36 | 0.028 (0.94) |
| Group B (–0.5 < SE ≤ –1.0) Mean = –0.79 | 0.004 (0.99) | Group B (–0.5 < SE ≤ –1.0) Mean = –0.74 | 0.048 (0.91) |
| Group C (SE > –1.0) Mean = –1.60 | 0.020 (0.96) | Group C (SE > –1.0) Mean = –1.30 | 0.083 (0.84) |
| Group A: postop UCDVA < 0.0 (logMAR, 1.0 in decimal); Group B: postop UCDVA = 0.1 (logMAR, 0.8 in decimal); Group C: postop UCDVA = 0.2 (logMAR, 0.63 in decimal) | | | |

Figure 2. Correlations of uncorrected distance visual acuity and postoperative refractive errors

# Optimizing lens extraction in challenging cataract cases

Mahipal Sachdev, MD

## *The femtosecond laser is a valuable tool in complicated cases*

The femtosecond laser provides numerous advantages in cataract surgery in terms of precision, accuracy, and repeatability. It is becoming a valuable tool in complex cases as it allows effective automated creation of incisions, capsulotomy, and lens fragmentation.

The capsulotomies created have a uniform size, shape, and position, which translates into an effective lens position.[1] Effective lens position is gaining importance with the increased use of premium IOLs, like multifocal, trifocal, and extended depth of focus IOLs. Secondly, laser-assisted lens fragmentation reduces the phacoemulsification time and energy used, thereby protecting the endothelium from ultrasound energy-induced damage. Thirdly, the technology creates multiplanar incisions for better stability and arcuate incisions to reduce astigmatism. We use arcuate incisions to reduce as much as 1.25 D of astigmatism.

When we first began using the femtosecond laser for capsulotomies, anterior capsulotomy perforations or tags were reported.[2,3] However, the liquid optic interface introduced later reduced these variations.[4]

## Surgical challenges

In complex cases, the femtosecond laser-assisted technique gains importance. For example, in patients with a white cataract, intralenticular pressure is increased, the capsule may be fibrosed, and the zonules may be weak (Figure 1). Creating a good capsulotomy is especially important in such cases. The femtosecond laser enhances safety and predictability when creating the capsulotomy. However, surgeons should be alert for tags.[5]

Despite the risk of capsulotomy-related complications with brunescent cataracts, the femtosecond laser helps by significantly reducing the effective phacoemulsification time.[6]

In eyes with posterior polar cataracts, use of intraoperative optical coherence tomography (OCT) to assess the polar opacity allows us to adjust the posterior safety zone to protect the posterior capsule. Furthermore, use of femtosecond laser-assisted pneumodelineation eliminates the need for hydrodissection or hydrodelineation and the laser enhances nuclear disassembly, allowing a safe epinuclear cushion during the nucleotomy.

With subluxated cataracts, weak zonules make the capsulorhexis challenging (Figure 2). In an eye with a subluxated cataract and small pupil, we may place a pupil expander like a Malyugin ring or iris hooks, then perform the capsulotomy and nucleotomy.

In a case with significant post-traumatic subluxation, with decentration, I use the scanned capsule center rather than the pupil center. With this approach, when you pull the lens the capsulotomy should shift. However, I did perform a case where in taking this approach, the laser was cutting the iris despite reducing the diameter. In such a situation, we

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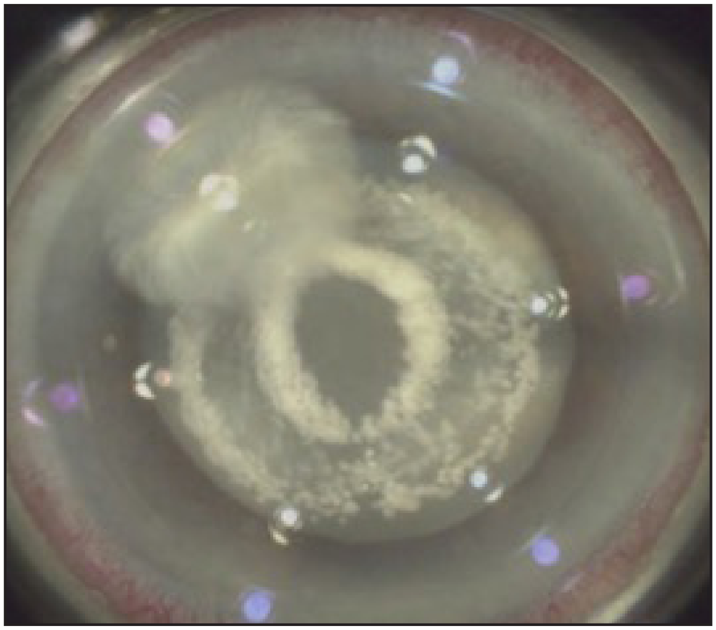

Figure 1. White cataracts present numerous surgical challenges.

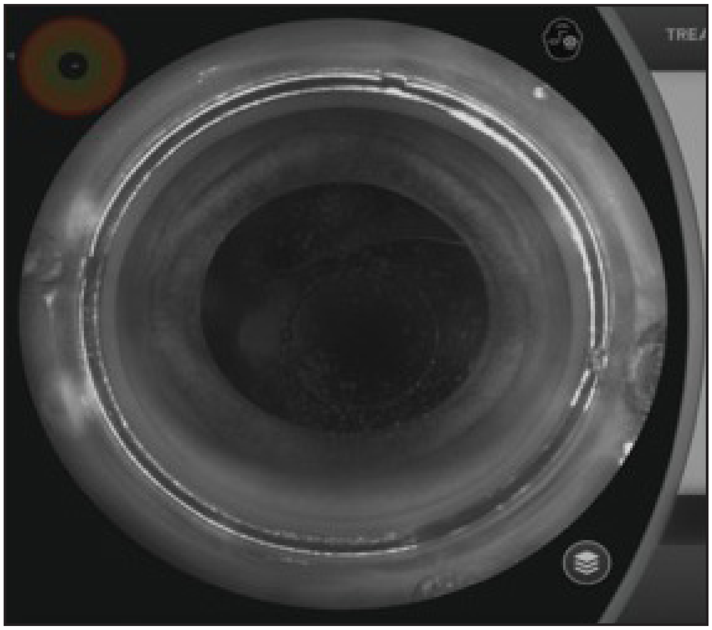

Figure 2. The femtosecond laser may help surgeons overcome some difficulties with subluxated cataracts.

# Keys for optimizing outcomes with toric intraocular lenses

Shinichiro Nakano, MD

## *Precision is essential at every stage of the process*

To achieve optimal outcomes from toric IOLs, we need to examine four aspects of the surgical process: preoperative diagnostics, intraoperative placement and axial alignment, rotational stability, and postoperative management.

### Preoperative evaluation

We first need to consider postoperative astigmatism. Although preoperative astigmatism consists of corneal plus lenticular astigmatism, postoperative astigmatism includes the corneal and surgically induced astigmatism minus the correction achieved by the toric IOL.

In addition, Koch et al. demonstrated that if we base calculations only on anterior corneal astigmatism, we may overcorrect eyes that have with-the-rule astigmatism and undercorrect eyes with against-the-rule astigmatism.[1,2]

Surgeons can measure posterior corneal astigmatism with optical coherence tomography or a compensation formula, such as the Barrett Toric Calculator (ascrs.org/barrett-toric-calculator).

> *"We should be sure the IOL unfolds fully because it will rotate as it unfolds."*
>
> —Shinichiro Nakano, MD

We also need to identify irregular astigmatism, which cannot be corrected with toric IOLs (Figure 1).

Hasegawa et al. showed that 1.0 D of with-the-rule or against-the-rule astigmatism reduces visual acuity.[3] Therefore, 1.0 D of astigmatism is a good threshold for using toric IOLs.

Research conducted at Optical Express centers studied 4,970 eyes of 2,585 patients undergoing refractive lens exchange with IOLs. Residual astigmatism of at least 1.0 D significantly reduced the likelihood of 20/20 vision and, as a result, patient satisfaction.

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successfully performed a manual capsulotomy, decentering it as much as possible. We used a posterior approach to remove the vitreous. We inserted a capsular tension ring, and the lens was centered. We performed a nucleotomy, and with bimanual aspiration, we completed the case and the postoperative results were good.

### Lens removal

With the femtosecond laser, lens fragmentation is automated. Femtosecond laser-assisted cataract surgery allows use of different patterns to fragment the lens, like a grid pattern and quadrants, and surgeons are free to choose the pattern depending on the type of cataract and their own comfort level. Real-time OCT helps in adjusting the posterior safety zone in cases such as polar or posterior subcapsular cataracts.

With advances in phacoemulsification, we are moving toward fluidics-driven lens removal, using a system that recognizes occlusion and adjusts vacuum before the occlusion breaks. In addition, we have simultaneous longitudinal and transverse ultrasound.

Furthermore, dual pump technology enables us to switch between venturi and peristaltic modes within the same case. The peristaltic mode provides good hold and venturi provides good followability.

### Conclusion

Advanced femtosecond laser-assisted cataract surgery technology has become a valuable tool in complex cases. When we push the limit in cataract cases, the femtosecond laser emerges as a winner.


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*Dr. Sachdev is chairman and medical director, Centre for Sight Group of Hospitals, New Delhi, India. He can be contacted at drmahipal@gmail.com. He has financial interests with Carl Zeiss Meditec (Jena, Germany), Johnson & Johnson Vision (Santa Ana, California), and Avedro (Waltham, Massachusetts).*

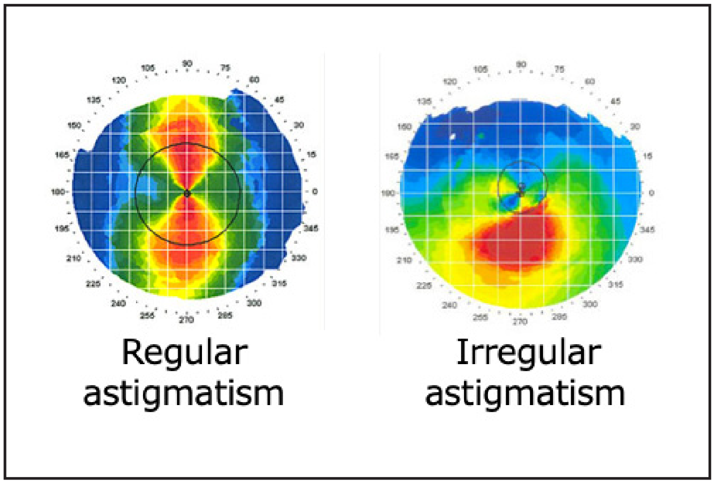


Figure 1. Regular and irregular astigmatism

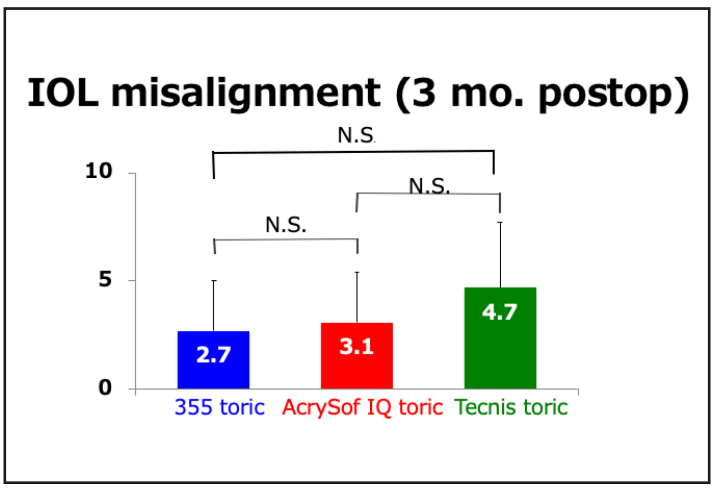


Figure 2. Comparison of the 3-month postoperative rotational errors among three different toric IOLs

## Intraoperative placement and alignment

Exact alignment of toric IOLs is key. One degree of rotation in patients with toric IOLs reduces the toric IOL effect by 3.3%, and 30 degrees of rotation reduces the toric effect by 100%. Therefore, precise marking of the incision site and toric axis are critical.

After inserting the IOL, we need to avoid rotation. We should be sure the IOL unfolds fully because it will rotate as it unfolds. The Tecnis toric IOL (Johnson & Johnson Vision, Santa Ana, California) unfolds a bit more slowly with cold balanced salt solution, but I preheat it with warm saline (approximately 30 degrees C) for 20 seconds, which dramatically shortens the unfolding time. We also need to remove as much OVD as possible before final positioning. Because OVD acts as a lubricant, the toric IOL will rotate if OVD remains in the bag.

Inoue et al. reported that most toric IOL axis misalignment occurs within 1 hour after surgery, so patients should avoid rapid head movement during that time.[4]

Dr. Inoue and I performed two comparative studies showing that there was no statistical difference in rotational error among several different toric IOLs. Figure 2 shows the actual data for 3-month postoperative rotational errors among three different toric IOLs.

## Residual cylinder

In patients with residual astigmatism, we need to repeat the manifest refraction several times to ensure the refraction is stable before making a treatment decision.

We should establish whether the postoperative error resulted from ocular surface disease, treat that if significant, and repeat the manifest refraction. We also must ensure that the toric IOL is aligned correctly.

The cause of residual astigmatism will guide postoperative treatment; options may include glasses or contact lenses, limbal relaxing or arcuate incisions, LASIK or PRK, IOL repositioning, or IOL exchange. Toric IOL repositioning should be considered if the patient has an off-axis IOL and is unhappy, there is no significant spherical error, and the posterior capsule is intact. However, the surgeon should wait 1 to 3 weeks after surgery to reposition the IOL. When we studied 6,431 eyes implanted with toric IOLs, the repositioning rate was only 0.65%.[5]

## Achieving optimal outcomes

To optimize outcomes when implanting toric IOLs, surgeons must precisely evaluate corneal astigmatism, develop a calculated preoperative plan, and reposition the IOL if there is excessive misalignment.

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*Dr. Nakano is chief of the Department of Ophthalmology, Ryugasaki Saiseikai Hospital, Ryugasaki, Japan. He can be contacted at nakanoryugasaki@yahoo.co.jp. He has financial interests with Johnson & Johnson Vision.*

# Meibomian gland disease in refractive surgery patients

Rohit Shetty, MD, PhD

***The tear film plays a significant role in postoperative patient satisfaction***

MGD is the leading cause of dry eye. → Long-term ocular surface rehabilitation requires functional meibomian glands.

Core mechanism of MGD: obstruction. → Treating dry eye means treating meibomian gland obstruction.

Early intervention is best. → Routine meibomian gland function/structure evaluation.

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Figure 1. Key points from meibomian gland disease research

| Medical treatments | Device/manual treatments |
| --- | --- |
| Hot compresses | Thermal pulsation |
| Antibiotic (azithromycin) and corticosteroid ointments (loteprednol) | Manual expression |
| Low-dose oral doxycycline for chronic or severe disease | Meibomian gland probes |
| Nutritional supplements | Pulsed light therapy plus manual expression |

Figure 2. Treatments for meibomian gland disease

Advanced technologies and techniques are enhancing cataract and refractive surgery, but ultimately patients' postoperative quality of life will differentiate outcomes.

Issues such as postoperative dry eye significantly impact patients' quality of life, and this condition has been associated with depression.[1] However, when diagnosing dry eye, there is a disconnect between signs and symptoms and pathologies drive tear film abnormalities.[2]

## Expanding diagnostics

We can no longer rely only on Schirmer's results or tear breakup time. Many other factors are involved. For example, the new classification of dry eye addresses neurosensory abnormalities.[3]

To determine what was driving the pain associated with dry eye, we began examining biomarkers, but we also need to consider confocal microscopy images. The combination will help us understand dry eye better and help pharmaceutical companies develop improved treatments.

Along with biometry, meibography and tear film diagnostics will play an important role in the future of cataract and refractive surgery. Although meibography enables us to classify the stage of meibomian gland disease, the assessment of meibomian gland function and tear film diagnostics also provide critical information. When we look at the biomarkers in patients with severe pain, we see that the balance is off between pro-nociception and anti-nociception markers.

What causes this is a compromise to the meibomian glands, the presence of inflammation, and other factors. Many patients have inflammation, with dendritic cells. If we perform cataract surgery or refractive surgery on these patients, they will be perpetually unhappy. However, we often do not check for inflammation because we do not see it on a slit lamp.

Figure 1 shares key findings from meibomian gland disease research.

## Emerging treatment options

Traditionally, treatment has focused on warm compresses, lid hygiene, doxycycline, and other measures, but challenges may arise and patients may not comply with treatment (Figure 2). Many new therapies are emerging, including office-based treatments to directly address meibomian gland stasis. Thermal pulsation has been shown in multiple peer-reviewed reports to significantly improve meibomian gland function and reduce dry eye symptoms.[4]

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# Review of study data comparing safety and efficacy of today's corneal refractive options

Edward Manche, MD

***Research compares custom laser vision correction, optimized laser vision correction, and SMILE***

Wavefront-guided (WFG) and wavefront-optimized (WFO) laser technology have become the technologies of choice for excimer laser vision correction, with approximately equal numbers performed each year in the United States.[1]

However, we need to consider whether there are significant differences in outcomes between the two technologies.

## WFG vs. WFO surgical results

A number of studies comparing WFG and WFO procedures have shown excellent outcomes in both groups, but a greater percentage of patients achieved 20/16 and 20/12.5 vision with WFG treatment.[2–4]

We recently conducted a large prospective, randomized, eye-to-eye study, which included 200 eyes (100 patients) randomly chosen to have WFG treatment while the fellow eye had WFO treatment.

Twelve months after surgery, both platforms were equally effective in reducing spherical equivalent. Patients treated with WFO had a mean manifest spherical equivalent of –0.19 D compared with –0.08 D for WFG treatment. Efficacy was excellent, as shown in Figure 1. A greater percentage of eyes treated with WFG had 20/12.5 and 20/10 vision, although it was not statistically significant.

> ***"Multiple peer-reviewed papers show advantages of WFG vs. WFO LASIK, especially at higher levels of visual acuity."***
>
> ***—Edward Manche, MD***

Best corrected contrast visual acuity at 5% and 25% was approximately equivalent up to 20/50. Regarding 25% best corrected contrast acuity, at 20/40 and 20/32 there was a statistically significant advantage of WFG compared with WFO treatment.

## SMILE vs. LASIK outcomes

LASIK is the gold standard for laser vision correction, but small incision lenticule extraction (SMILE) is becoming more widely adopted.

SMILE was approved by the U.S. Food and Drug Administration in 2016 to correct spherical myopia, with 99.7%

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Clinicians often perform thermal pulsation when dry eye and meibomian gland dysfunction are diagnosed postoperatively, but we wanted to determine its efficacy before surgery. We performed thermal pulsation preoperatively in patients with meibomian gland dysfunction, moderate dry eye, tear breakup time less than 5 seconds, and contact lens intolerance. Three months after treatment, patients' tear breakup time and ocular comfort index improved. If we wait until after surgery to perform thermal pulsation, however, the cascade of cytokines has begun and treatment may not be immediately effective.

However, the question remained as to why some patients' symptoms and gland function improved even when their downstream tear film metrics did not. Therefore, we again looked at the cytokines. Thermal pulsation heat reduced the nociceptor cytokines, so we speculated that increased heat can change the balance of the cytokine axis and the cytokine axis can reduce patients' symptoms. There may not be a change in tear breakup time or Schirmer's because it is a completely different pathway.

## Conclusion

Patient selection for cataract and refractive surgery is very important. When diagnosing dry eye, we need to keep in mind that symptoms are more important than signs, and we must treat meibomian gland dysfunction and dry eye before cataract or refractive surgery.

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*Dr. Shetty is vice chairman, Narayana Nethralaya Eye Institute, Bangalore, India. He can be contacted at drrohitshetty@yahoo.com. He has financial interests with Carl Zeiss Meditec (Jena, Germany), Alcon (Fort Worth, Texas), and Johnson & Johnson Vision (Santa Ana, California).*

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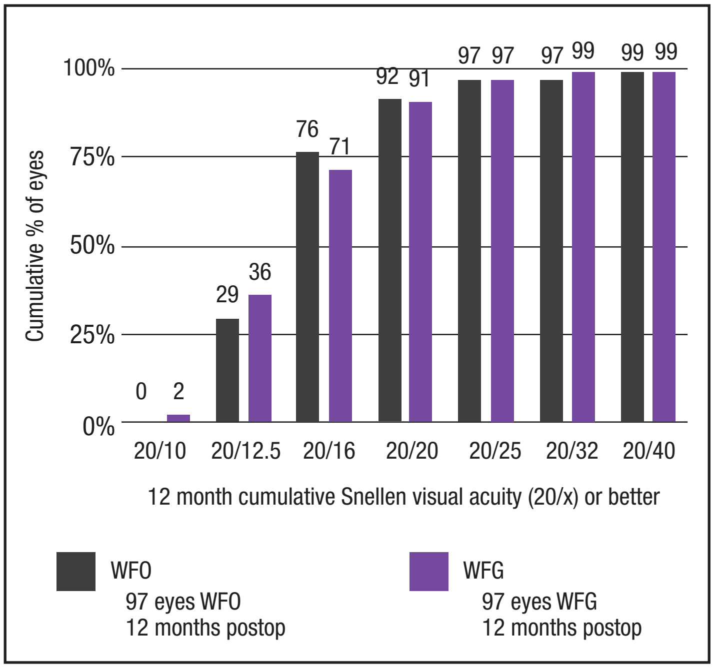


Figure 1. 12-month uncorrected distance visual acuity after WFG vs. WFO LASIK

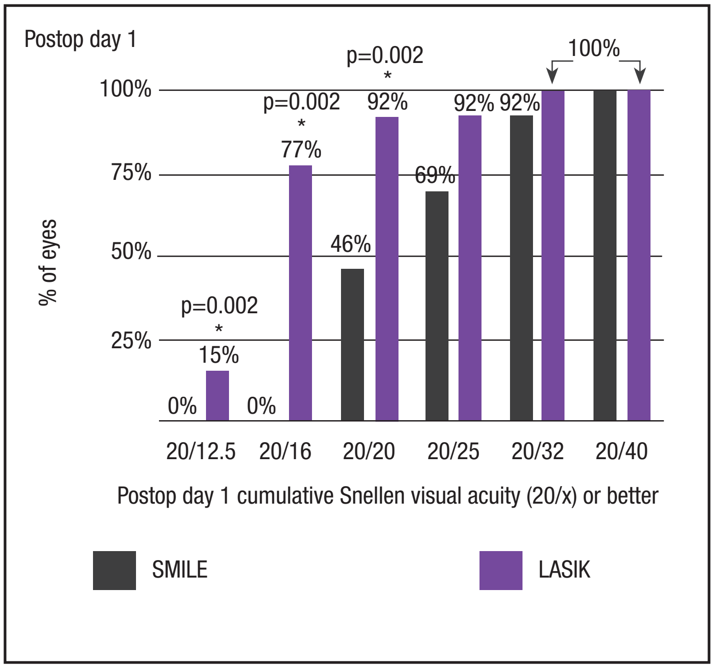


Figure 2. Postoperative day 1 uncorrected distance visual acuity after WFG LASIK vs. SMILE

of eyes having 20/40 vision or better and 88% of eyes at 20/20 or better 6 months after surgery.[5] It recently received approval for myopia with astigmatism.

Most studies show that outcomes are similar between LASIK and SMILE.[6]

Khalifa et al. reported that 100% of eyes treated with WFG LASIK and SMILE had at least 20/40 vision or better 6 months after surgery.[7] However, 35.3% of the LASIK-treated eyes achieved 20/16 vision compared with 10.2% of the SMILE-treated eyes.

Comparing topography-guided LASIK with SMILE, Kanellopoulos reported improved results for topography-guided LASIK (86.4% of LASIK-treated eyes vs. 68.2% of SMILE-treated eyes achieved uncorrected distance vision of 20/20; 59.1% of LASIK-treated eyes and 31.8% of SMILE-treated eyes achieved uncorrected distance vision of 20/16).[8]

In an ongoing study at Stanford, each patient is receiving WFG LASIK in one eye and the fellow eye is receiving SMILE.

Six months after surgery, both platforms were equally effective in reducing spherical equivalent. On postoperative day 1, 100% of eyes in both groups had 20/40 vision or better, but LASIK had a significant advantage at 20/20, 20/16, and 20/12.5 (Figure 2). One month after surgery, 92% of both groups had 20/20 vision or better and LASIK had the advantage at 20/16 and 20/12.5.

## Assessing the research

WFG and WFO LASIK and SMILE provide excellent outcomes with outstanding safety. However, multiple peer-reviewed papers show advantages of WFG vs. WFO LASIK, especially at higher levels of visual acuity.

LASIK and SMILE have similar outcomes in most published papers, but more recent reports suggest WFG and topography-guided LASIK may yield better outcomes compared with the current SMILE surgery when looking at uncorrected visual acuities of 20/16 or better.

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*Dr. Manche is professor of ophthalmology, Byers Eye Institute, Stanford University School of Medicine, Stanford, California. He can be contacted at edward.manche@stanford.edu. He has financial interests with Allergan (Dublin, Ireland), Alcon (Fort Worth, Texas), Avedro (Waltham, Massachusetts), Carl Zeiss Meditec (Jena, Germany), Johnson & Johnson Vision (Santa Ana, California), Shire (Lexington, Massachusetts), RxSight (Aliso Viejo, California), Seros Medical (Palo Alto, California), Ocular Therapeutix (Bedford, Massachusetts), and Presbia (Dublin, Ireland).*