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PACIFIC VISION INSTITUTE
Life in Focus

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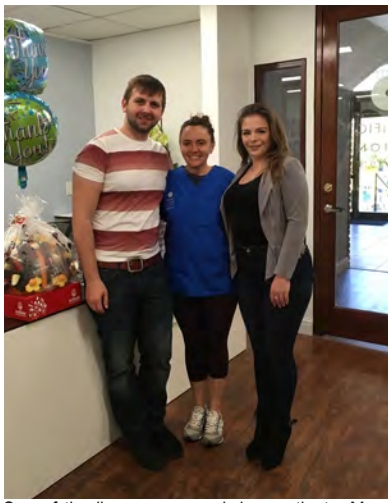
Bay Area optometrists observing topography-guided LASIK live surgery and topolyzer testing and analysis of patient's corneal higher order aberrations at Pacific Vision Institute

Topography-guided LASIK and PRK Workshops at Pacific Vision Institute

Topography-guided laser vision correction represents an evolution of both corneal imaging and laser technology to achieve precise LASIK and PRK outcomes. It combines exceptionally accurate measurements of lower and higher order corneal aberrations, sophisticated data analysis targeting the smoothest postoperative corneal shape, and the fastest lasers with the most precise eye trackers. To help primary eye care doctors incorporate discussion of topography-guided laser vision correction into their patient education process, Pacific Vision Institute conducted live surgery workshops, training both doctors and their staff. **These were the first workshops in the US to train optometrists in the fundamentals of topography-guided laser vision correction.**

The workshops were limited to less than 10 participants, allowing for hands on experience with topography mapping and direct observation of patients undergoing topography-guided LASIK in the operating suite at PVI. Patient selection criteria were discussed. Doctors learned how to assess the influence of corneal higher order aberrations on the power and orientation of refractive cylinder. They also learned how to determine who will benefit the most from topography-guided LASIK or PRK. A patient was then followed through the process - starting with the topolyzer mapping of lower and higher order corneal aberrations, vector analysis of whether the aberrations contribute to the power and orientation of the patient's refractive cylinder, analysis of correlation between the patient's line of sight vs. pupillary center, iris registration, information transfer to the laser, and the LASIK procedure itself. The doctors observed LASIK flap creation with the 5th generation iFS Intralase femtosecond laser followed by topography-guided corneal reshaping with Wavelight EX500 excimer laser. Postoperative topography-guided results were reviewed. The doctors had their own topolyzer topography maps performed. The contribution of their specific corneal higher order aberrations to their refractive cylinder was analyzed. At the conclusion of each workshop, the participants reported increased understanding of topography-guided LASIK. Each participant also received a certificate of completion. The experience proved useful in clinical practice, facilitating patient education process. ■



One of the live-surgery workshop patients, Max, and his girlfriend, Stacya at Max's follow up appointment. Stacya is a surgical assistant at PVI.

Three Types of Custom LASIK and PRK: Wavefront-guided, Wavefront-optimized, and Topography-guided

When wavefront-guided laser vision correction was introduced in the early 2000's, the word "custom" entered our vocabulary. It was used to describe LASIK and PRK performed using patient's optical data that included their higher order aberrations, such as coma, for example, in addition to their lower order aberrations - the sphere and the cylinder.

Initially, the optical data came from the map of the entire optical system of the eye - cornea, lens, and vitreous. This map was called a "wavefront map." It was subsequently discovered that **wavefront-guided (WG) corrections may result in inaccurate vision outcomes and the quality of vision may not be adequate**. There are several reasons for these findings.

Short-comings of wavefront-guided laser vision correction

1. Wavefront-guided laser vision correction attempts to treat aberrations of the entire optical system.

The internal optics of the eye - the lens and the vitreous - are dynamic. They change with accommodation (lens) and with age (lens and vitreous). If the treatment is done using wavefront data when a patient is 25 years old, for example, the patient's vision may deteriorate as they get older and their lens and vitreous change. Moreover, some optical aberrations have been proven to be useful in optimizing the quality of vision. Some higher order aberrations, for example, can increase depth of focus. Removing such aberrations may, in fact, cause vision to deteriorate.

2. Wavefront-guided treatments are centered on the pupil, not on patient's line of sight.

Many patients have at least some angle kappa (**Figure 1**). Their line of sight is not in the center of their pupil. In these patients, laser vision correction centered on their pupil will result in a decentered ablation overlying their line of sight. Such decentered ablation may cause induced astigmatism, decreased best corrected vision, glare and haloes, and reduced quality of vision.

3. Wavefront map couples the data for patient's higher order aberrations with the measurements of their sphere and cylinder.

The sphere and cylinder generated by wavefront aberrometry is similar to the sphere and cylinder generated by an autorefractor. Just as with autorefraction,

News at PVI

- Save this date: **16th Annual Cornea, Cataract, and Refractive Surgery Symposium** will be held on Sunday, January 27th, 2019 at the Four Seasons Hotel in San Francisco. New speakers, hands-on workshops, and Grand Rounds - style patient presentations will be featured.
- Dr. Faktorovich guest lectures at the American Society of Cataract and Refractive Surgery in Washington, DC, April 2018
- PVI becomes the first practice in San Francisco to perform topography-guided LASIK and PRK
- PVI is the first practice in the US to conduct topography-guided laser vision correction workshops for optometrists
- Reddit CEO and co-founder, Steve Huffman, describes his reasons for getting PRK at Pacific Vision Institute during his interview with the New Yorker magazine.

aberrometer-generated refraction does not take into account patient's subjective interpretation of their refractive error. Moreover, aberrometer-generated refraction can not be modified substantially to reflect patient's subjective refraction at the phoropter. As a result, operating on aberrometer-based refraction is similar to operating on autorefractor-based refraction, i.e. not as accurate as patients typically hope for.

4. Natural corneal asphericity is not maintained. This can result in glare and haloes.

5. High amount of corneal tissue is removed. By attempting to remove many higher order aberrations, wavefront-guided correction removes a significant amount of corneal tissue. Consequently, corneal integrity may be compromised. ■

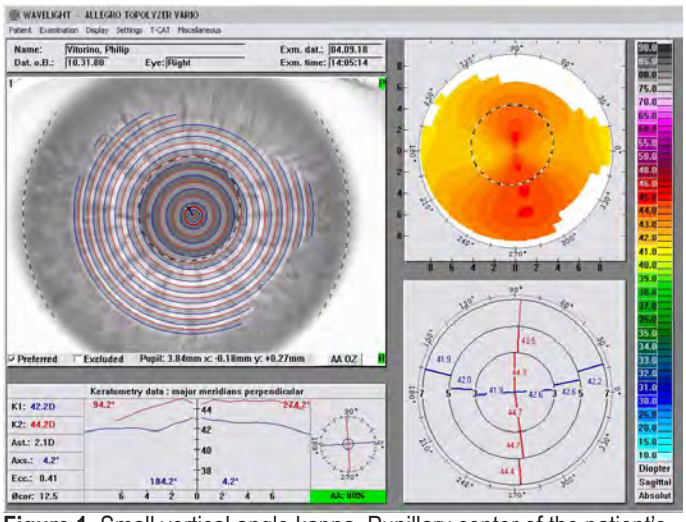


Figure 1. Small vertical angle kappa. Pupillary center of the patient's right eye is marked with x in the center of the dotted circle. Patient's line of sight is marked with the red circle inferiorly and slightly nasally to the center of the pupil.

Evolution of custom laser vision correction

As a result of the short-comings of wavefront-guided laser vision correction, customization of LASIK and PRK has evolved into wavefront-optimized and topography-guided corrections. Rather then targeting ocular aberrations, some of which are dynamic and change with time, wavefront-optimized and topography-guided corrections target corneal aberrations. Corneal aberrations are static. The effect of correcting such aberrations will likely remain permanent, whereas wavefront-guided correction that includes lenticular and vitreous aberrations may not result in a long-lasting outcome. In addition, both wavefront-optimized and topography-guided laser vision correction can be centered over the patient's line of sight, resulting in accurate centration of the ablation zone, even in patients with a significant angle kappa. Furthermore, patient's subjective refraction can be factored into the treatment plan. Natural corneal asphericity can be maintained. And, importantly, the amount of corneal tissue removed is not excessive.

Wavefront-optimized (WO) laser vision correction achieves customization by incorporating patient's corneal K-values into their treatment protocol. The laser software calculates the amount of spherical aberration and higher order astigmatism that would be induced if the patient's sphere and cylinder were ablated onto the cornea with the patient's K-values. The software then calculates an ablation profile that would compensate for the expected spherical aberration and higher oder astigmatism induction (Mrochen M, et al. Wavefront-optimized ablation profiles: theoretical background. *J Cataract Refract Surg.* 2004 Apr;30(4):775-85). As a result, the corrections are stable, and the quality of vision is good.

Topography-guided (TG) laser vision correction achieves customization by first measuring the patient's corneal astigmatism (including their K-values) and higher order aberrations with a devise called Vario Topolyzer. The surgeon then analyzes the data, determining whether the higher order aberrations contribute significantly to the patient's refraction. If the patient's higher order aberrations are minimal and don't contribute to their refraction, wavefront-optimized correction will be recommended to the patient. If the patient's aberrations are significant and contribute to their sphere and cylinder, the patient will be recommended topography-guided correction to achieve the most accurate outcome. ■

Topography-guided Laser Vision Correction Steps: Maria Valdez (Dr. Jeffrey Lem Optometry) undergoes LASIK at PVI

Step 1. Vario topolyzer

Step 2. Data acquisition & transfer

Step 3. LASIK

Step 4. Immediately after LASIK

Comparison table of 3 types of Custom LASIK and PRK

	Wavefront-Guided (WG)	Wavefront-Optimized (WO)	Topography-Guided (TG)
Laser	VISX Star S4 Wavelight EyeQ400 Wavelight EX500	Wavelight EyeQ400 Wavelight EX500	Wavelight EyeQ400 Wavelight EX500
Aberrations targeted	cornea+lens+vitreous HOAs	corneal K's	corneal K's and corneal HOA's
Treatment centration	pupil	pupil or line of sight	line of sight
Sphere & Cylinder adjustment	limited	unlimited	unlimited
Prolate cornea possible	No	Yes, population subset-specific	Yes, patient-specific
Amount of tissue removed	High	similar to conventional	slightly higher than conventional

Topography-modified Refraction: What is it and How Do We Use it to Refine Accuracy of Laser Vision Correction?

Higher order aberrations will refract as either sphere or cylinder at the phoropter. Spherical aberration, for example, will refract as sphere. Coma will refract as cylinder. The phoropter-generated refraction of such higher order aberrations, however, will not result in best-corrected visual acuity as clear as the phoropter refraction of lower order aberrations - the real sphere and cylinder. Patients who are trying to correct their higher order aberrations at the phoropher may appear to have either "soft refraction" or decreased best-corrected visual acuity. In the presence of normal conventional topography and normal exam of ocular structures, such findings may erroneously be attributed to amblyopia, subtle abnormalities in tear film, variable accommodation, or poor effort.

At Pacific Vision Institute, we analyze corneal aberrometry in each patient undergoing refractive surgery to determine whether their corneal higher order aberrations contribute to their sphere and cylinder refraction at the phoropter. If the measurements and calculations show that they do, in fact, contribute to the phoropter refraction, we perform topography-guided laser vision correction. This strategy addresses each source of the phoropter refraction, resulting in more precise vision outcomes. The laser beam targets specific location of the aberrations as well as delivers a symmetric ablation to correct the remaining spherocylinder. Without topography-guided capability, everything is treated as if it were all just a spherocylinder.

The following two examples of patients who underwent LASIK (D.B.) and PRK (T.J.) at PVI demonstrate how preoperative corneal aberrometry uncovered their vertical coma masquerading as refractive astigmatism.

According to a recent article by Zhou et al., vertical coma refracts as against-the-rule astigmatism at thephoropter (Zhou et al. Assessment of refractive astigmatism and simulated herapeutic refractive surgery strategies in

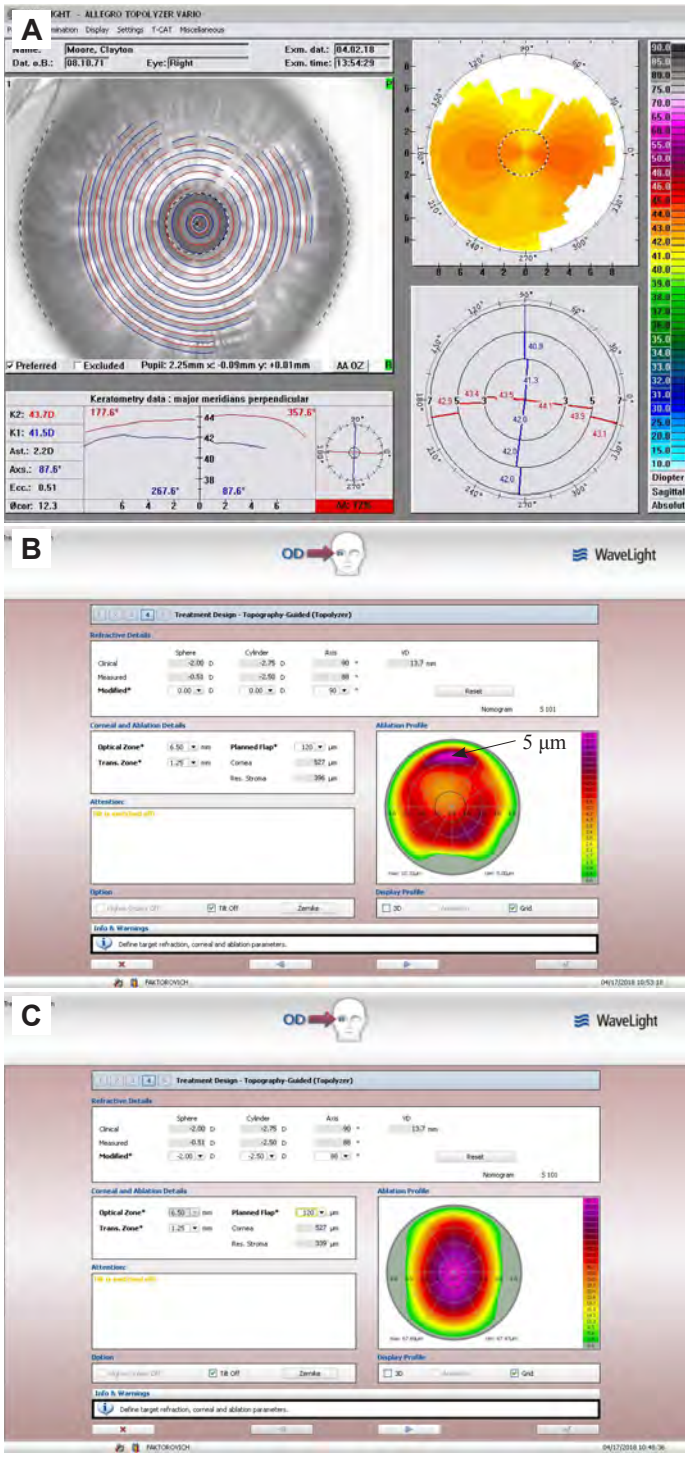


Figure 2. Patient T.J. refracts -2.75D axis 90. (A) Placedo disc topography demonstrates symmetric against-the-rule astigmatism. (B) Corneal aberrometry demonstrates vertical coma 5 microns high. (C) Topography-guided ablation delivers an ablation pattern that addresses the individual components of patient's refractive astigmatism.

coma-like-aberrations-dominant corneal optics. *Eye Vis (Lond)*.2016 May 12;3:13). Patient T.J. (**Figure 2**) refracted as symmetric, against-the-rule astigmatism, -2.75D axis 090. His best-corrected visual acuity was 20/20. Corneal aberrometry revealed vertical coma, 5 micron high. Based on the calculation that 16 micron laser reshaping results in approximately 1 diopter correction, 5 microns of vertical coma is equal to 0.31D. Patient's corneal cylinder measured with the topolyzer was -2.50D axis 090. His 0.31D of vertical coma refracted as an additional 0.25D of against-the-rule astigmatism, resulting in -2.75D refractive cylinder. Without topography-guided, -2.75D cylinder correction would have been programmed into the laser, indirectly treating the coma component and resulting in 20/20 best corrected visual acuity, just like his phoropter refraction. With topography-guided PRK, coma and cylinder components were addressed individually, delivering a more precise treatment pattern and resulting in improved best-corrected vision of 20/15.

Patient D.B. (**Figure 3**) refracted as slightly asymmetric with-the-rule astigmatism, -1.75 axis 001. His best-corrected visual acuity was 20/20-. His slight vertical asymmetry on placedo disc topography was attributed to a slight vertical angle kappa. Corneal aberrometry revealed 10 microns (=0.63D) of vertical coma. Corneal topolyzer measured his corneal cylinder at -2.30D axis 003. His vertical coma, refracting as against-the-rule astigmatism, reduced his corneal cylinder and resulted in him taking approximately 0.50D less of astigmatism at the phoropter. This patient could have also been corrected by simply programming his refractive astigmatism into the laser. His outcome would most likely been a "soft" 20/20. By undergoing topography-guided LASIK, however, each component of his refractive cylinder was identified, measured, and treated individually. His outcome was a crisp 20/20. ■

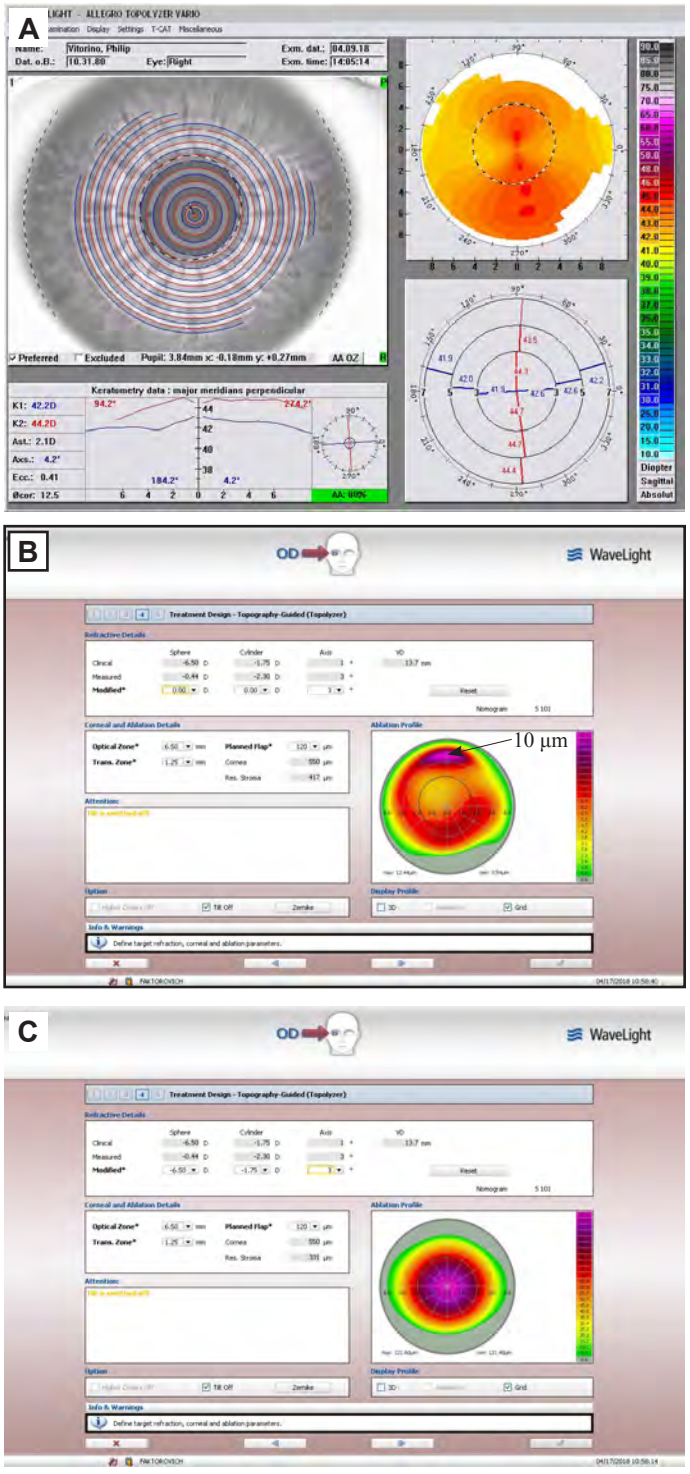


Figure 3. Patient D.B. refracts at -1.75D axis 001. (A) Placedo disc topography demonstrates slightly asymmetric with-the-rule astigmatism and a slight angle kappa. (B) Corneal aberrometry demonstrates vertical coma 10 microns high. (C) Topography-guided ablation delivers an ablation pattern that addresses the individual components of patient's refractive astigmatism.

Counselor's Corner

Q: Is there an extra fee for topography-guided LASIK?

A: No. All patients undergoing laser vision correction at Pacific Vision Institute, have their corneal higher order aberrations analyzed to determine their topography-modified refraction. If the data and the subsequent calculations reveal that some component of their refraction comes from higher order corneal aberrations, Dr. Faktorovich performs topography-guided laser vision correction. If corneal higher order aberrations are minimal and don't contribute to patient's refraction or quality of vision, Dr. Faktorovich performs wavefront-optimized laser vision correction.

Q: My patient is going for a consultation to multiple surgeons. How do I advise my patient where they should have their vision corrected?

A: The patient should be counseled to undergo surgery with the surgeon who achieves the best documented results for patients with similar prescriptions and similar age. The surgeon-specific results should be generated by an unbiased, independent third party data analysis. The patient should ask for the surgeon's 20/20 and better than 20/20 results during their consultation. They then need to compare such results and select the surgeon who achieves the best results in the highest percentage of patients. The surgeon's techniques, technology, experience, and their team all contribute to their results. But, by themselves, they mean nothing unless they result in the documented highest percentage of patients achieving 20/20 and better than 20/20 vision. If a patient says they are going to have their vision corrected where their friend went and had a good result, the patient needs to be counseled that their friend's prescription may have been different and the friend may have different vision demands. The only way to make an educated decision in medicine is to statistically compare post-treatment results.

Q: What is the enhancement policy for laser vision correction at Pacific Vision Institute?

A: Although less than 2 % of patients who undergo laser vision correction at PVI may need a touch up, the decision is up to the patient. If the patient feels that their vision could be improved and there is a small prescription that remains stable after the procedure, Dr. Faktorovich will do the touch up. Enhancements are free of charge to the patient regardless of patient's initial prescription, prescription after the procedure, visual acuity after the procedure, or the length of time that elapsed after the procedure. Some PVI patients who want a touch up may have other life plans they are attending to, such as moving, travel, work, family, and even though they would like a touch up, they don't have time for it until years after their procedure. We will do a touch up free of charge for these patients as well.

Q: What access do my patients have to Dr. Faktorovich after their surgery?

A: Co-managed patients are typically seen at PVI for their one-day postoperative visit. They are then examined by the co-managing doctor at their one-week, one-month, three-month, and six-month postoperatively, and then yearly for their annual exams. At 3 months after their procedure, the patients are also seen at PVI, where their refraction is performed. This data is used for tracking outcomes and nomogram update. If a co-managing doctor has any questions or would like the patient to be seen by Dr. Faktorovich, they can send the patient any time. Dr. Faktorovich is available to see the patient and help with any considerations that may arise in the care of the patient. ■

Q: When is Wavefront-guided laser vision correction performed?

A: Wavefront-guided laser vision correction is an older, less precise technique for LASIK and PRK. With the advent of the more accurate, corneal tissue-saving techniques such as wavefront-optimized and topography-guided laser vision correction, there is no medical reason to perform wavefront-guided correction. The only reason to do it is when a custom correction is planned but the surgeon has no access to wavefront-optimized or topography-guided technology.

Q: When do you perform Wavefront-optimized laser vision correction rather than Topography-guided?

A: Wavefront-optimized LASIK and PRK are performed when phoropter refraction is significantly different from topography-modified refraction, in patients with an uneven and/or variable tear film, and in patients with epithelial basement membrane dystrophy. During surgical planning, Dr. Faktorovich analyzes patient's total corneal power and higher order corneal aberrations. Total corneal power is calculated from tomography-generated data for anterior and posterior corneal curvature. Each value has a vector magnitude and direction. The vectors are added to generate the value and the vector for total corneal curvature. Each higher order order aberration is then analyzed and the vectors are added to each other. If the patient's subjective refraction closely matches the objective data derived from corneal analysis, topography-guided laser vision correction is performed. Some patients have undergone neuroadaptation during their development and their subjective interpretation of their ocular optics differs from their objective findings. When this is the case, wavefront-optimized correction is performed. During surgical planning, the patient's tear film is also analyzed extensively. Even when patients have normal appearing tear film, the quality of the tear film may vary slightly from blink to blink. Such patients will do best with wavefront-optimized laser vision correction.

Q: Does pupil size matter?

A: Multiple studies involving thousands of patients found no correlation between how widely the pupil dilates and the quality of vision after laser vision correction. There is a correlation, however, between postoperative corneal shape in the center of the corrected area and the quality of vision. This shape is called corneal asphericity. Ideally, postoperative asphericity should not be very different from the preoperative one. When they are very different, the brain may perceive glare and haloes, for example. When they are similar, perception of glare and haloes is reduced. ■

PVI Education Series

Thursday, June 14th, 2018: Live Surgery Topography-guided laser vision correction workshop for optometrists. Pacific Vision Institute, 505 Beach Street, San Francisco (3 CE hours).

Wednesday, June 20th, 2018: Live Surgery Topography-guided laser vision correction workshop for optometrists. Pacific Vision Institute, 505 Beach Street, San Francisco (3 CE hours)

Sunday, January 27th, 2019: 16th Annual San Francisco Cornea, Cataract, and Refractive Surgery Symposium. Four Seasons Hotel, San Francisco

***Ongoing:** Optometric Staff Training Workshops include live surgery observation - please contact us at comanagement@pacificvision.org for times and dates

*These workshops are limited to PVI Affiliated doctors only. Please contact us at comanagement@pacificvision.org for information on becoming a PVI affiliated doctor

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