Measuring Visual Performance and Quality of Vision

This information helps refractive surgeons optimize patients' outcomes.

BY SCOTT M. MACRAE, MD

High-quality vision consists of many elements. We refractive surgeons have become more sophisticated at manipulating optics with multifocal, pseudoaccommodating, or monovision IOLs; LASIK; and corneal inlays. We are learning what promotes the best visual function. Excellent diagnostic metrics and skills can produce superior outcomes and avoid visual complaints. This article discusses the tools for measuring visual performance and some of the ways in which we can optimize patients' quality of vision. An excellent review of the subject is summarized by Drum et al.[1]

MEASUREMENT

The classic metrics by which we measure visual performance are tests of visual acuity, contrast sensitivity, stereoacuity, and glare. Visual field loss can also contribute to performance problems. Johnson and Keltner found that binocular visual field loss to within 40° of eccentricity doubled the rate of driving accidents.[2]

In terms of driving, visual acuity testing measures people's ability to read the dashboard, distinguish road demarcations, and read road signs. Contrast sensitivity testing reveals how well they can drive in a fog. Stereoacuity testing demonstrates people's ability to discriminate depth, which allows them to stop before an intersection. Glare testing indicates how they handle light scatter.

> "Refractive (and wavefront) error, light scatter, binocular summation, illumination (pupillary size), and neuroadaptation [affect quality of vision]."

FACTORS AFFECTING QUALITY OF VISION

Overview

Several major areas affect quality of vision. They include refractive (and wavefront) error, light scatter, binocular summation, illumination (pupillary size), and neuroadaptation. Each plays a critical role in high-quality vision and affects vision in subtle and not-so-subtle ways.

Refractive and Wavefront Errors

When a patient has visual complaints, a manifest refraction, wavefront sensing, or corneal topography can aid us in ruling out irregular astigmatism. In refractory cases, a rigid diagnostic contact lens fitting can help us to pinpoint whether the problem relates to the lens or the cornea.

Corneal aberrometers and wavefront sensors can measure corneal and whole-eye aberrations, respectively. Whole-eye wavefront measurements allow us to predict the modulation transfer function. This objective measure of the optical system's quality can reliably evaluate contrast sensitivity.

We can calculate lenticular aberration by subtracting the corneal aberration from the whole-eye aberrations. Commercially available systems such as the iTrace (Tracey Technologies), Nidek OPD-Scan II (Nidek), and KR-1W Wavefront Analyzer (Topcon Medical Systems) allow us to measure whole-eye, corneal, and lenticular aberrations in order to identify which is the source of the problem.

Light Scatter

The ill effects of light scatter are additive. Commonly caused by cataract, light scatter can be aggravated by dry eye disease, anterior basement membrane dystrophy, and ocular surface disease, all of which further reduce visual function. Visual acuity and contrast sensitivity testing may not be good predictors of glare disability. Glare testing using the BAT Glare Test (Mentor) may be helpful. Forward light scatter can be tested more accurately with the Straylightmeter (Foundation for Eye Research), particularly when the patient has posterior capsular opacification. Under glare conditions, contrast sensitivity and low contrast acuity from the Pelli-Robson, Regan, and Berkeley tests provide reliable measurements of glare and image-quality reduction.

Binocularity

More than 1.50 D of anisometropia can inhibit binocular summation (2 eyes are better than 1) and cause binocular inhibition (2 eyes are worse than 1), prompting patients to close one eye when driving at night.[3]

There are ways to take advantage of binocularity. Geunyoung Yoon, PhD, and I have studied visual performance using binocular adaptive optics with modified monovision. We added a small amount of spherical aberration to patients' nondominant eye that was targeted for near monovision. This approach improved patients' binocular summation and stereoacuity and increased depth of field compared to traditional monovision.[4]

Likewise, at the annual meeting of the American Society of Cataract and Refractive Surgery, Graham Barrett, MD, presented a paper on using an extended depth of focus with a mild amount of spherical aberration and modest monovision (-1.25 D) for near.[5] He reported that these patients performed better at near than those with binocular distance correction and did not experience a significant decline in image quality or stereoacuity. Dan Reinstein, MD, has achieved comparable results using a similar strategy in patients undergoing mini monovision with LASIK. This promising area will be developed in the near future. Traditional stereoacuity testing is a reliable measurement of binocularity.

Illumination

Illumination and aperture diameter can be manipulated to enhance vision. The Kamra (Acufocus; not available in the United States) takes advantage of a modified pinhole technique. The implant increases depth of field by reducing the effective pupillary size. The retina receives less illumination, but this is well tolerated by patients. Combining the device with a modest amount of myopia (-0.75 D), as advocated by the group of Minoru Tomita, MD, PhD, gives patients good near vision without significantly disrupting their distance or night vision. The success of this approach depends, however, on binocular vision and good distance vision in the eye without the implant.

Neuroadaptation

There is growing evidence that neuroadaptation can play a significant role in improving visual performance. Durrie and McMinn evaluated a group of low myopes and a separate group of patients with early presbyopia during neural training with Gabor patches; the investigators noted a 2.2-line gain at distance and near, respectively.[6]

Pesudovs studied 26 patients who underwent low myopic LASIK treatment and found that, on average, they did not adapt to surgically induced astigmatism until 10 weeks after surgery.[7]

Further research on how to optimize neuroadaptation to improve visual performance is warranted.

CONCLUSION

By better understanding the tests that measure visual performance and diagnostics such as wavefront sensing and glare testing, we refractive surgeons can optimize patients' outcomes and their visual performance. ■

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1. Drum B, Calogero, Rorer E. Assessment of visual performance in the evaluation of new medical products. *Drug Discovery Today: Technologies*. 2007;4(2):55-61. http://www.fda.gov/downloads/ScienceResearch/SpecialTopics/CriticalPathInitiative/ArticlesandPresentations/ucm089354.pdf. Accessed June 23, 2014.
2. Johnson CA, Keltner JL. Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. *Arch Ophthalmol*. 1983;101(3):371-375.
3. Campbell FW, Green DG. Monocular versus binocular visual acuity. *Nature*. 1965;208(5006):191-192.
4. Zheleznyak L, Sabesan R, Oh JS, et al. Modified monovision with spherical aberration to improve presbyopic through-focus visual performance. *Invest Ophthalmol Vis Sci*. 2013;54(5):3157-3165.
5. Barrett GD. Extended depth of focus IOL and modest monovision. Paper presented at: ASCRS/ASOS Symposium and Congress; April 25-29, 2014; Boston, MA.
6. Durrie D, McMinn PS. Computer-based primary visual cortex training for treatment of low myopia and early presbyopia. *Trans Am Ophthalmol Soc*. 2007;105:132-138; discussion 138-140.
7. Pesudovs K. Involvement of neural adaptation in the recovery of vision after laser refractive surgery. *J Refract Surg*. 2005;21(2):144-147.