Tools & techniques
Why objective measurement of visual quality and optical scatter is critical in surgical planning and decision making

by Jay S. Pepose, MD, PhD

Decision making and planning for cataract and refractive surgeries calls for a thorough preoperative assessment of retinal image quality. Until recently, obtaining a comprehensive, objective assessment of baseline and interblink optical quality was problematic in the clinical setting, particularly when attempting to gauge scattered light. But thanks to the recent developments, we now have the power to quickly and objectively measure the combined impact of optical scatter and higher-order aberrations on retinal image quality using a single device.

The need to preoperatively assess retinal image quality in surgical planning and decision making

With the convergence of lens and corneal-based refractive surgery, patients' expectations have increased markedly. Our case is a patient who had LASIK at age 40, and then presented at age 57 with complaints of decreased vision requesting a LASIK enhancement. The patient's complaints were mostly related to decreased vision at dusk and nighttime, increasing difficulty in night driving, and some fluctuation in vision throughout the day at work. Examination revealed well-healed LASIK flaps, trace nuclear sclerosis and uncorrected vision of 20/25 refracting to 20/20 with +0.5 D sphere. Slit lamp examination revealed anterior segment findings based on the back scatter of light. In contrast, the patient's complaints related predominantly to forward scatter of light (i.e., light moving in the direction of the retina), and there can be some discordance between these assessments. The scatter of light can be caused by an unstable tear film, from the LASIK flap interface and from the crystalline lens. Changes in scatter over time are generally caused by an unstable tear film, and it would be beneficial and more physiological to assess this temporal fluctuation in scatter without...
Pepose, MD, PhD, reviews his experience with the Visiometrics HD Analyzer. This tool has aided him in the sometimes challenging art of decision making for the kerato-and lenticular refractive patient. As we see more of these patients in the future, and remove lenses at an earlier and earlier point in their cataractous development, we'll need all the help we can get to assess and treat these patients appropriately.

Richard Hoffman, MD, Tools & techniques editor

perturbing the tear film with fluorescein or other drops commonly employed in tear break-up time measurement. An objective measure of retinal image quality as well as its stability over time, along with comparison to age-matched normative values, would be an important tool in the ophthalmologist's armamentarium for surgical decision making, as illustrated by this case. A LASIK enhancement in someone with considerable intraocular scatter may not produce the desired results or alleviation of symptoms, which would likely worsen with further progression of lenticular opacity and increased aberrations and scatter. On the other hand, a patient with low aberrations and low optical scatter might do quite well with a laser vision enhancement for years to come.

The impact of optical scatter and higher-order aberrations in degrading retinal image quality

Relying on patients' subjective complaints, high and low contrast vision, and biomicroscopy alone may not give a full picture of the factors that may conspire to degrade the retinal image quality. Hartman-Schack aberrometry may overestimate retinal image quality, especially in eyes that are more highly aberrated or have considerable optical scatter. The accurate interpolation of the eye's wavefront and its decomposition into specific aberrations are limited by several underlying causes, including the density of the lenslet array. This often leads to artifactual dampening of highly aberrated wavefronts as well as total insensitivity to the effects of ocular scatter. While the wavefront aberrometer has proven to be an important clinical tool to measure and identify higher-order and lower-order aberrations and the eye's optical performance in monochromatic light, it is encumbered by these limitations and especially by the inability to directly measure light scatter. Since both optical scatter and wavefront aberrations increase with age, reliance on wavefront aberrometry alone to assess the impact of these factors on retinal image quality can be suboptimal and at times misleading.

Benefits of the HD Analyzer

Fortunately, technological developments were able to overcome these limitations. The HD Analyzer (Visiometrics, Terrassa, Spain) is the next generation of the Optical Quality Analysis System (OQAS).

It assesses optical quality objectively, with excellent repeatability, including light scatter measurement, among other metrics. The device is objective in that it does not rely on the description of suboptimal vision by patients or their subjective assessment of stray light. Rather, it measures and records the retinal point spread from the double pass images and from this the ocular modulation transfer function (MTF) is determined. The MTF incorporates all of the relevant effects of diffraction, higher-order aberrations and scatter in degrading the retinal image quality. The double pass images are the total summation of the disturbances in light's path through the ocular media, whether it is due to tear film instability, corneal disease causing higher-order aberrations, cataract, posterior capsular opacity, or a multifocal pseudophakos. It also enables multiple other assessments of visual quality, including the Strehl ratio, MTF, MTF cutoff, normalized MTF values of optical quality at 100%, 20% and 9% contrast and an optical scatter equivalent of a tear break-up time—all with a single instrument. With such technology, we can better understand what the patient is experiencing and its root cause. You get a total composite analysis of the retinal point spread, which is representative of what is projected onto the patient's retina (without the retinal and neural processing) and provides a direct measurement of the optical quality. Devices such as wavefront aberrometers are based on the spacing of the centroids compared with a perfect grid, and by Fourier
transformation derive the shape of the wave, which can be decomposed into specific Zernike polynomials—this is an interpolation of data, rather than a direct measurement of the quality of the retinal image.

**Form**

The technology is based on the double-pass technique. A point source of near infrared light is imaged and recorded after reflection off of the retina and double pass through the ocular media, after which the device measures the size and shape of the light spot and the intensity of the light at the periphery versus the center of the retinal point spread image. These measurements objectively produce data on visual quality and optical scatter. The objective scatter index is the only parameter that enables the objective quantification of intraocular scatter light and is useful in a multitude of clinical scenarios, e.g., cataract surgery, refractive surgery, dry eye syndrome management. A step up from its predecessor, OQAS, it offers faster acquisition and computation, a more compact design with a much smaller footprint and a more elegant display of data. Everything is quickly available on one printout, and the entire workflow is sped up as a result of these improvements.

**Function**

The HD Analyzer provides unique information that is otherwise unavailable. When trying to assess a patient's cataract, relying solely on slit lamp microscopy and high contrast vision for disability assessment, many pieces of the puzzle will remain missing. The objective measurement of light scatter can help in the early detection of cataracts and is also useful in cases of identified cataracts where it can help determine the degree of severity and impact on retinal image quality. Research has shown that the Ocular Scatter Index (OSI) and the derived MTF correlate with visual acuity in patients with all forms of cataract. The OSI correlates closely with the LOCS III grading of cataract, but has the advantage of providing an objective rather than subjective assessment, with less risk of interobserver variability. The various objective metrics produced by the HD Analyzer can be factored in as an adjunct to the patient's symptoms and visual acuity, helping the surgeon decide when to perform cataract surgery, LASIK surgery or enhancement, or consider alternative treatments or observation. In phakic or pseudophakic patients, we can use the technology to help measure the amplitude of accommodation or depth of focus and determine the effect of accommodation on the quality of the retinal image.

We have numerous ways of testing for dry eye disease, e.g., tear osmolarity, questionnaire providing an index of symptoms, performing vital dye staining or Schirmer testing, but it is only with a device capable of objectively determining light scatter that we can look at serial measurements of scatter over time; this allows us to essentially see an automated tear break-up time without having to instill fluorescein or other drops into the eye, which could change the entire tear dynamics. Thus, we can get a clearer idea of the patient's tear break-up without perturbing the tear film. The device can even be used to test visual quality over time comparing different contact lenses. As dry eye can impact patients' visual outcome, this clear assessment of tear break-up is very significant in our pre-surgical planning. It might prompt the surgeon to treat a patient's dry eye more aggressively before he/she proceeds with surgery. Dry eye could also affect the stability or fidelity of measurements for cataract or refractive surgery, making this assessment even more important.

Objective light scatter measurement can also prove useful in less straightforward cases. In our case, the application of the HD Analyzer...
revealed a marked increase in optical scatter between blinks (Figure 1), consistent with an unstable tear film and low tear break-up time. After instilling a drop of artificial tears to negate the effect of the dry ocular surface, additional measurements with the HD Analyzer revealed an optical scatter index of 2.5, consistent with an early cataract, and other metrics (MTF cutoff, MTF) consistent with reasonably high optical quality (Figure 2). Punctal plugs were placed and additional dry eye treatment was initiated. On repeat measurement a few weeks later, the optical scatter over time showed a decrease in temporal variation, but the overall optical scatter index remained elevated. Quantifying the severity of the patient's cataract according to the objective scatter index and other metrics allowed us to conclude that a LASIK enhancement might produce a short-lived result, as there was already considerable optical scatter. If we were to go ahead with the LASIK enhancement, based only on slit lamp and wavefront analyses, there was a chance that the patient would be dissatisfied with the quality of vision because of a problem that could have been identified with light scatter measurements.

From the patient's perspective, undergoing assessment with the HD Analyzer is similar to sitting down in front of an autorefractor, and the near infrared wavelength ensures that patient comfort is not compromised. In our practice, the device is in a central location so that it is easily accessible, and we try to use it early in the intake; we want these assessments to be one of the first tests that we do, before we start to perturb the ocular surface and before any surgical decisions are made. The unique diagnostic benefits of this instrument, combined with its compact design, ease of use, convolved images to enhance patient education, make this next-generation objective light scatter and retinal image quality measurement technology an essential tool for eyecare professionals. In my experience, the multitude of capabilities of objective light scatter and visual quality measurement as applied in so many areas of eyecare are key to a more accurate understanding of our patients' conditions and in the management of their care.

References

Objective optical assessment of tear-film quality dynamics in normal and mildly symptomatic dry eyes.

Editors' note: Dr. Pepose has financial interests with Visiometrics.

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