When measuring quality of vision - scatter matters

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ABERROMETRY provides at best a theory of how well a patient can see, but a better way to measure quality of vision may be to use double-pass retinal imaging, says Spanish researcher Pablo Artal PhD. Wavefront sensing devices measure only the lower range of optical aberrations and in most eyes that is adequate. However, in some eyes an additional factor not measured by aberrometry, light scatter, can also degrade the retinal image, he told a session of the 7th ESCRS Winter Refractive Surgery Meeting.

In a series of eyes Dr Artal and his associates compared the modulation transfer function (MTF) of the retinal image of a point source using a double-pass image technique with the MTF predicted by aberrometry. They found that there was little difference between the two measurements in normal eyes. However, in eyes with mild to severe light scatter, such as those with the early-stage cataracts, there was a two to three-fold difference in the MTF obtained with the two techniques.

"In a patient's eye with mild to severe amount of scatter, wavefront sensors might overestimate image quality while the double-pass technique produces a more accurate description of the optical quality," he explained. Dr Artal noted that light scatter is what happens when light passes through a turbulent medium, like fog or frosted glass. In the human eye light scatter can arise from any imperfection in the optical system, whether it is on a refractive surface or within the various ocular media.

Light scatter therefore comprises extremely small distortions in the wavefront and of an order up to thousands or even millions of Zernike terms, which no aberrometer will ever be able to measure.

"Scatter is microscopic and of such a super, super high order that you cannot capture it with aberrometry even if you have thousands of tiny microlenses. The only way it would be possible would be if you had zero diameter microlenses and that is why we need different approaches in the assessment of vision," Dr Artal said.

To obtain retinal images, the Spanish investigators used a double-pass instrument (OQAS, Visiometrics SL) which records images of a point source in near infrared light after reflection in the retina and double-pass through the ocular media.

They measured aberrations over a 5.0mm pupil using a prototype of near-infrared Hartmann-Shack wavefront sensor with a high dynamic range and more than 220 microlenses. From the wavefront measurements, they calculated the point spread function (PSF) and from this they obtained the modulation transfer function. The MTF was also obtained from the double-pass images.

"The good thing about the double-pass approach is that we get good information about everything going on in the retina, both median high order aberrations and light scatter. The aberrometer we use is much better than any commercially available instrument; it has more microlenses than most and as we developed it ourselves we

have total control over its inner workings. Moreover, its high dynamics means that it can be used to measure highly aberrated eyes," Dr Artal said.

Dr Artal noted that in a separate investigation using a different technique and instrumentation he and his associates have been able to demonstrate that scatter increases with age and that LASIK can add years to a patient's scatter quotient.

In their study they used double-pass polarimeter which they developed to measure the way light scatter affects the polarisation of beams as they pass through the ocular media. They compared the degree of scatter in eight normal eyes of people between 20 to 70 years of age and seven post-LASIK eyes in patients who ranged in age from 23 to 37 years. They found that scatter increased with age.

They also determined that while those undergoing LASIK for less than -2.5 D of myopia had a moderate increase in scatter, those who underwent the procedure for -4.5 D or more of myopia had the same amount of scatter as in the untreated normal eyes of people 60 to 70 years old. "We knew that LASIK induces higher order aberration and on the basis of our findings we believe that LASIK also induces extra light scatter that is real and measurable.

Therefore, even if you have a system that reduces the amount of induced aberrations it will probably not reduce the amount of induced scatter. We don't know how this comes about but somehow after LASIK the cornea becomes a more turbulent medium," Dr Artal said. He added that while double-pass imaging systems are unlikely ever to be used to guide LASIK ablations, they could be useful in determining the cause of poor vision in patients where aberrometry cannot explain it.

In the future, double-pass imaging systems may also find application in the grading of visual disability due to cataract. "That's one of the most interesting paths this technology could take. The system allows us to really detect and quantify in a more objective way the level of scatter.

By finding out how that correlates with the different levels of cataract, a similar system could be used for determining how much of their vision they might regain through treatment," Dr Artal said