

GUEST EDITORIAL

Wavefront Refraction and Correction

Galileo Galilei, the father of experimental science, taught that to understand nature, you must measure nature.¹ Galileo's contemporary, Christophoro Scheiner, explored the nature of eyes as optical instruments and discovered how to measure the eye's focusing distance simply by viewing a point of light through closely spaced pinholes in an opaque card.² Two centuries later, Thomas Young used Scheiner's principle to construct the first optometer capable of measuring ocular astigmatism as well as focusing errors of the eye.³

Another two centuries passed before Liang, Brimm, Goelz, and Bille elaborated Young's optometer to measure higher-order aberrations of the eye with a wavefront sensor.⁴ This development introduced the term *aberrometer* into our professional lexicon and expanded the scope of optometry far beyond measuring spherocylindrical refractive errors to include a plethora of optical flaws (e.g., spherical aberration, coma, trefoil).⁵ Aberrometers rapidly moved from the laboratory to the clinic in 2000, symbolically positioning aberrometry as the modern method of choice for measuring the optical characteristics of normal and clinically abnormal eyes.

At the same time, consensus was reached on a systematic scheme for mathematically decomposing the complex aberration structure of individual eyes into fundamental components and for measuring their strength in terms of Zernike coefficients.⁶ This consensus led to national (ANSI Z80.28) and international (ISO 24157) standards for reporting ocular aberrations in a clear and meaningful way.^{7,8}

This issue of *Optometry and Vision Science* features progress in the application of wavefront aberrometry to clinical optometry. The variety of topics examined and the geographic distribution of the authors clearly demonstrate the global deployment of aberrometry to examine clinically challenging optical problems as diverse as keratoconus, cataract, diabetic retinopathy, and refractive surgery.⁹⁻¹⁴

Changes in ocular aberrations, retinal image quality, and functional vision associated with aging, accommodation, myopia, spectacles, and peripheral vision are also being characterized with wavefront aberrometry.¹⁵⁻¹⁹

As we learn more about these diverse conditions, standards that will help guide clinical diagnosis and monitor treatment outcomes in the future are beginning to emerge.²⁰ Problems encountered when investigating clinical populations, in turn, prompt basic vision scientists to re-examine past assumptions and potential measurement artifacts associated with current aberrometry technology.^{21,22} Moreover, although lower-order aberrations vary little with pupil size, there is a growing awareness that higher-order aberration measurements depend critically on pupil size and shape,^{15,23} which

will vary with age, illumination, accommodation, eccentricity, and binocular vergence.

During the last decade, the primary clinical implementation of aberrometry has been within the refractive surgery arena, but research included in this feature issue highlights several other important developments and emerging clinical applications. It is now possible to use the same Zernike polynomial descriptions of the cornea and the whole eye, formally connecting the structural measurements of the cornea to their optical impact on refraction and vision. Also, aberrometry looks positioned to be the tool of choice in the design and evaluation of custom RGP lenses for highly aberrated eyes.

As clinical applications mature, there is a sense that we may be approaching a time when it is no longer necessary to ask the patient "which lens is better, #1 or #2?" Wavefront aberrometry, coupled with a powerful optical theory for quantifying the quality of the retinal image, provides reliable, objective, and comprehensive refractive measurements for guiding and monitoring optical correction. Reliable optical measurements will, in turn, allow the clinician to concentrate on other, equally important aspects of treatment like effectiveness, comfort, convenience, cost, and availability.

Measurement of the optical characteristics of the eye has progressed a long way since Scheiner and Young's pioneering discoveries. Application of these modern methods of wavefront refraction and correction offers important opportunities for better eye care in the future. Investigations using ocular wavefront aberrations continue to broaden our knowledge of the optical performance of the normal eye and, by comparison, the optical and visual consequence of abnormal ocular optics. As this knowledge grows, it provides a foundation for creating novel clinical diagnosis and treatment options. As these options increase, the clinical utility of the wavefront aberrometer becomes self-evident and, in the process, transforms the instrument into an essential tool in the modern practice of optometry.

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