Comparison of refractive error measurements in adults with Z-View aberrometer, Humphrey autorefractor, and subjective refraction

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Abstract

BACKGROUND: The aim of this study was to evaluate whether measurements obtained with the Ophthonix Z-View aberrometer (Vista, California) and a Humphrey autorefractor (Zeiss Humphrey, Dublin, California) correlate with standard subjective refraction measurements, based on visual acuity results.

METHODS: A retrospective data analysis was completed for 97 patients, age range 18 to 66 years, without evidence of systemic or ocular disease. All data were collected without dilation or cycloplegia. Refractive correction measurements (sphere, cylinder, axis) were converted to power vectors for analysis.

RESULTS: Differences-versus-means plots show generally excellent agreement between the results of each instrument and subjective refraction, all $r^2 > 0.77$, with the Z-View consistently exhibiting less variability than the autorefractor (AR). Nonetheless, the Z-View tends to undercorrect myopia, whereas the AR tends to overcorrect myopia, with statistically significant mean differences (±SD) in spherical equivalents with respect to subjective refraction of 0.118 (±0.311) and −0.193 (±0.474) diopters (D), respectively. Both instruments tend to overcorrect astigmatism of less than −1.25 and −0.75 D, respectively, in some cases by as much as −0.87 D. Both instruments also tend to err in cylinder axis measurement for low astigmatism, often by more than 10°.

CONCLUSIONS: The Ophthonix Z-View aberrometer is a useful objective clinical instrument that provides better accuracy than an AR, and its results can be used as a good starting point for a subjective refraction for most patients. It also measures higher-order aberrations not identified by other techniques. However, as with AR results, a spectacle prescription based solely on its measurements may not be appropriate for all patients.

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Most clinicians begin a subjective refraction with a patient-objective measure, such as retinoscopy, autorefraction, or lensometry. In many busy practices, either of the latter 2 procedures often is not performed by the clinician but by a technician. Previous studies have found that results from most commercially available infrared autorefractors (AR) provide a good starting point for the subjective manifest refraction (SR), but for many patients measurements are not accurate enough to prescribe from directly.[1-4]

Until recently, measurement and correction of refractive error has been limited to sphere and cylinder powers, also

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known as lower-order aberrations. With the advent of wavefront technology, both lower- and higher-order aberrations (HOAs) can be measured.[5,6] Early assumptions had been that HOAs are difficult to measure and correct and that they have little effect on vision.[7] However, several aberrometers have been developed for clinical use, and results from wavefront-guided laser in situ keratomileusis (LASIK) demonstrate that reducing HOAs can result in improved visual acuity (VA) and contrast sensitivity compared with conventional LASIK.[8,9] Similar to AR, an aberrometer can be used by a technician to provide objective data to the clinician.

Previous studies have compared measurements from various aberrometers with those of AR and SR.[7,10-15] Most of these studies demonstrate good repeatability for individual instruments and high correlations between methods for their study populations. However, many of these studies also show significant deviations for individual subjects, including instrument myopia and cylinder axis variability.

Ophthonix, Inc. (Vista, California) developed the Z-View® aberrometer to measure HOAs of the human eye[16] and likewise published studies favorably comparing its results with those of SR[17] and other aberrometers.[18] The Z-View specifically is designed to take measurements on nondilated, noncyclopleged eyes. However, Lai et al.[17] assessed only the root-mean-square of the Z-View results against the SR spherical equivalent for only 10 eyes.

Ophthonix claims that a spectacle lens manufactured based on data derived directly from Z-View measurements results in improved vision.[19,20] When we first used this system, we noted some discrepancies between findings on the Z-View and SR, in that some patients did not achieve the same visual success or comfort with their aberrometer-based prescriptions as with "traditional" prescriptions. This study compares patients' refractive corrections, as determined by their VAs, based on SR with those based on measurements made with the Z-View and a common AR used in our clinic.

We recognize that there is no perfect "gold standard" for refraction because many factors in addition to VA can be considered, including the patient's accommodative ability (especially for young patients and low hyperopes), blur interpretation, contrast sensitivity, cognitive ability, ambient and task lighting, and visual demands, among others. Clinically, though, subjective visual comfort is tantamount for most adult patients, as some may even relinquish a bit of VA for an improvement of overall "comfort." Consequently, SR, verified by trial framing, still is the best method of achieving this clinical goal for most typical patients.

Methods

Data from 100 consecutive patients examined in a private practice were considered for evaluation. This study was exempt from review by an institutional review board according to guidelines for retrospective clinical studies because all data were collected for the purpose of rendering clinical care. No identifying subject information is being reported, and all patients were provided written notice before examination that their data may be used in a future published research study.

Patient requirements for inclusion in the analysis were minimum age of 18 years, clear ocular media, no known ocular or systemic disease, no rigid contact lens wear for at least 1 year, and no prior refractive surgery. Soft contact lens wearers removed their lenses at least 30 minutes before testing. Patients were not cyclopleged or dilated for this part of the examination. Ninety-seven patients (56 women, 41 men) qualified for the study, ranging in age from 18 to 66 years. Results of the Student *t* test show that there is no significant difference in ages based on gender ($t[95] = 0.072$, $P = 0.943$). Overall mean (±SD) age was 36.7 (±12.7) years: 10 patients were 18 to 24 years of age, 50 were 25 to 34 years of age, 17 were 35 to 49 years of age, and 20 were 50 to 66 years of age. Only the measurements for the right eye of each patient were analyzed.

Each eye was measured once with a Humphrey 599 autorefractor keratometer (Zeiss Humphrey, Dublin, California) and automatically up to 3 times with the Z-View aberrometer, per the manufacturer's recommendations.[21] The Z-View measures were averaged by its software to provide a single set of results. The Z-View also measures the patient's actual pupil diameter and reports the pupil diameter used for HOA calculations. The Z-View software estimates the blur induced by trefoil, coma, spherical aberration, and all HOAs for the eye, but it does not report the individual Zernike coefficients. However, using a proprietary algorithm, it does determine whether the patient would be a good candidate for the Ophthonix iZon® (Ophthonix) custom prescription lens. We did not prescribe or order such custom lenses for our patients because that was not part of their clinical care. Thus, this retrospective study cannot assess such lenses or how our patients would have performed with them; this could be the goal of a future prospective study.

AR and Z-View measurements were conducted in random order by various trained technicians under normal room lighting, as is customary for each instrument. SR then was performed by a single experienced optometrist under mesopic lighting using a plus-cylinder phoropter and cross-cylinder lenses. VA was measured with a standard Snellen projected chart at 20 feet (6 m), using different lines of letters for the different corrections resulting from each refraction method to avoid memorization by the patient. Guessing by the patient was encouraged, but no extra or additional effort was used to elicit, coax, or coach the patient for any method.

The starting point for SR was the refractive correction recommended by Z-View. The endpoint was the lens power that resulted in the best VA and/or visual comfort. All measurements assumed a spectacle lens vertex distance of 14 mm.

For calculation purposes, Snellen acuities were converted to log minimum angle of resolution (logMAR)