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Accuracy of a Smartphone-Based Autorefractor Compared to Gold-Standard Refraction

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Abstract

Significance.—Uncorrected refractive error is a prevalent problem throughout the world especially among the low-income population who have limited access to professional eye care and cannot afford eyeglasses.

Purpose.—To evaluate the accuracy and usability of a low-cost, portable, smartphone-based autorefractor (Netra, EyeNetra Inc, Sommerville, MA) in adults.

Methods.—A cross-sectional study was conducted to compare the portable refractor with subjective (manifest and cycloplegic) refraction for sequential adult participants with best-corrected visual acuity 20/40. For each method of refraction, the spherical equivalent was calculated. Differences between methods were tested with linear mixed regression models. A validated usability questionnaire was administered regarding ease of use (100-point scale, higher scores better) for the portable autorefractor.

Results.—87 subjects (152 eyes) were studied (age range: 20 – 90 years; mean $\pm$ standard deviation, 51.9 ± 18.3 years). Mean spherical equivalent by the portable device was -2.76 Diopters (range -14.75 to 3.63) compared to -2.49 Diopters (range -15.25 to 4.25) by manifest refraction. The mean relative difference in spherical equivalent between methods was -0.27 Diopters ($P = .001$, significantly different than zero Diopters). The mean absolute difference between methods was 0.69 Diopters ($P < .001$, significantly different than 0.5 Diopters absolute difference). Similar results were found when comparing spherical equivalent between Netra and cycloplegic refraction methods. Subjects reported average ease of use for the Netra of 75.4 ± 19.8 .

Conclusions.—The portable autorefractor had small, but clinically significant differences from subjective refraction. The device's scores on the usability scale indicate good overall patient acceptance. The device may be valuable for use where there is limited access to a trained refractionist.

Keywords

autorefractor; ametropia; refractive error; refraction; smartphone

Uncorrected refractive error is the largest cause of preventable blindness, and one of the primary causes of visual impairment noted by the World Health Organization and the National Academy of Medicine.^{1, 2} As of 2015, approximately 625 million persons worldwide and 8.4 million persons in the United States are visually impaired because of uncorrected refractive errors with significant visual morbidity and cost.^{3–7} Adults with visual impairment have diminished quality of life and productivity, reduced general and visual function, and increased rates of depression.^{1, 3} The number of people with uncorrected refractive error is growing and is expected to double by 2050.⁴

Given the prevalence of and likely growth of uncorrected refractive errors, new strategies to screen for refractive errors and provide eyeglass prescriptions may provide value in resource-limited settings. A new commercially-available, portable, low-cost autorefraction device came on the market in 2015 (Netra, EyeNetra Inc, Sommerville, MA). The device has a one-time cost of \$1099. Currently, other portable refraction devices cost between \$7000 and \$11,400, and table-top auto-refractors start at \$8500; however, more devices are becoming available. Some publications about this device exist, but not in the peer-reviewed literature (Pamplona VF, et al. IOVS 2015;56:ARVO E-Abstract 2211; Pamplona VF, et al. IOVS 2014;55:ARVO E-Abstract 2723).^{9–10} The aim of our study was to evaluate the accuracy of the Netra for calculating refractive error in adults compared to subjective refraction, with the intent to use in low-resource settings.

METHODS

This study was reviewed and approved by the institutional review board at the University of Michigan, adhered to the Tenets of the Declaration of Helsinki, and complied with the Health Insurance Portability and Accountability Act. Following informed consent, participants with best-corrected visual acuity 20/40 were recruited from the refractive, comprehensive, and cornea clinics of a tertiary-care eye hospital (Kellogg Eye Center, University of Michigan) from June to December 2016. Participants were excluded if they were younger than 18 years old, had amblyopia, had physical disabilities resulting in inability to use technology, or had refractive error outside the bounds of the device specifications. Experienced ophthalmic technicians performed subjective manifest refraction without cycloplegia and, when appropriate during clinical care, cycloplegic refraction, on all recruited participants. Participants then performed ‘self-refraction’ using the portable device. The manifest refraction, cycloplegic refraction, and portable device refractions were entered into the phoropter and the best-corrected visual acuity for each was recorded.

The portable device consists of a plastic frame attached to a dedicated smartphone with Bluetooth, WiFi and processing capabilities (Appendix Figure A1, available at <http://links.lww.com/OPX/A364>). The device has a binocular fixation system with optic lenses, centration and alignment interfaces, and a software application on a smartphone (Gaiser H, et al. IOVS 2013;54:ARVO E-Abstract 2340). The refractometer couples Scheiner principles with Shack-Hartmann techniques to approximate refractive error from multiple light rays reflected from different parts of the cornea and lens.⁵ Practically, the participant aligns the red and green lights using an interface. The device fits the measurements from eight axes per eye to compute the refractive error and to calculate inter-pupillary distance (range 52 to 72

millimeters) (Pamplona V, et al. IOVS 2015;56:ARVO E-Abstract 2211). The device measures sphere in the range from -12 to $+5.5$ diopters, in 0.25 diopter increments, cylinder in the range from -7 to 0 diopters, in 0.25 diopter increments, and axis to one degree (Pasala V, et al. IOVS 2011;52:ARVO E-Abstract 2852).¹⁰ The device is typically performed with a paraprofessional assisting the patient. The device provides verbal instructions to the patient. Literacy is not required. There is not a letter chart inside the device, but parallel images to be aligned. The device is available in many languages.

The device also provides confidence scores for the reliability of the final refraction. During the course of the study, two different sets of confidence codes existed due to software updates. Initially, confidence scores were reported as “great”, “good”, “poor” and “lousy” and subsequently replaced by ‘warnings’ (no warning, yellow triangle, or red triangle). For analyses, we combined “Lousy” and “Poor” confidence scores with the red triangle warning into a low confidence group, “Good” confidence scores were combined with the yellow triangle warning into a medium confidence group, and “Great” confidence scores were combined with no warning into a high confidence group.

After initial device testing, the study team had concerns that older patients had difficulty using the device. An established usability survey (System Usability Scale) was administered to a subset of study participants ($n=50$) after they used the device, with deliberate over-sampling of older patients (<https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html>).^{11–12} The survey assessed ease of use by agreement with ten statements, each graded on a 5-point Likert scale from strongly disagree (1) to strongly agree (5). Five items are stated in a positive direction and five are stated in a negative direction. The final item scores were re-scaled from 0 to 4 and reversed, when applicable, to calculate an overall System Usability Scale score as the sum of the final item scores scaled to 100. Higher scores indicated greater agreement with questions on the ease of use for the device.

Statistical Analysis

Demographics of the sample were summarized and reported using means and standard deviations for continuous measures, and frequencies and percentages for categorical measures. Logarithm of the Minimum Angle of Resolution (logMAR) was converted to best-corrected visual acuity. Spherical equivalent, sphere, cylinder, and axis measurements obtained from the device were compared to those from manifest refraction and cycloplegic refraction. Relative difference in these measures between refraction methods was tested for significant deviations from zero (no difference) with linear mixed regression models. These models accounted for the correlation of measurements between eyes of a subject. The absolute difference in spherical equivalent measurement between the device and other refraction methods was tested for significant deviations from 0.5 diopters with linear mixed regression models, as has been performed in related work.¹³ The effects of age (continuous, dichotomized at <45 years versus ≥ 45 years as an indicator of possible presbyopia, and dichotomized at <65 years versus ≥ 65 as an indicator of possible difficulty with using technology), device confidence value (low, medium, or high), and an indicator of myopia versus hyperopia were evaluated for significant associations with absolute difference in

spherical equivalent between refraction methods using linear mixed regression models. The association between device confidence values (eye-based) and subject age (<65 years versus ≥65) were evaluated with a chi-square test, after aggregating confidence to the subject-level by taking the lowest confidence between eyes of a subject. The association between device confidence values and probability of best corrected visual acuity ≥20/20 from device refraction was evaluated with repeated measures logistic regression with generalized estimating equations methodology.¹⁴ This model also accounts for the correlation of measurements between eyes of a subject. Odds ratios and 95% confidence intervals are reported.

Best corrected visual acuity attained by each refraction method was categorized to evaluate the distribution of eyes ≥20/20, ≥20/25, or ≥20/40. McNemar's tests were used to evaluate significant imbalance in the distribution of these best corrected visual acuity categories between refraction methods. Survey results for ease of use of the device were summarized with means and standard deviations for each individual item of the scale as well as the overall System Usability Scale score. Comparison of survey item responses and overall System Usability Scale score between younger (<65 years) and older (≥65 years) participants were tested with two-sample Wilcoxon tests. Statistical analyses were performed with the software package SAS, version 9.4 (SAS Institute, Cary, NC).

RESULTS

A total of 152 eyes of 87 participants were included in the study for analysis (65 contributed both eyes, 22 contributed a single eye). All eyes underwent device and manifest refraction, and 75 eyes of 41 subjects also had cycloplegic refraction (34 contributed both eyes, 7 contributed a single eye). The mean ± standard deviation for age of subjects was 51.9 years ± 18.3 years (range 20–90 years), with 71% of subjects <65 years old (n=62). Forty-eight percent of the sample was female (n=42). The racial distribution was 79.4% Caucasian (n=69), 6.9% African American (n=6), 5.7% Asian (n=5), 6.9% other race (n=6), and 1.1% (n=1) with no race reported.

Scatterplots of the relationship between refraction methods for the measurement of spherical equivalent show a strong, positive linear relationship, although differences >±0.5 diopters are noted (Figure 1). Measures obtained from device, manifest refraction, and cycloplegic refraction are summarized for the sample in Table 1. Spherical equivalent, sphere, and best corrected visual acuity all showed significant differences between device refraction and the other two refraction methods. Spherical equivalent and sphere were, on average, more myopic when measured by the device compared to manifest refraction (Spherical equivalent: −2.76 diopters versus −2.49 diopters, respectively, $P = .001$; Sphere: −2.34 diopters versus −2.02 diopters, respectively, $P < .001$). Similarly, spherical equivalent and sphere were, on average, more myopic when measured by the device compared to cycloplegic refraction (Spherical equivalent: −4.21 diopters versus −3.76 diopters, respectively, $P < .001$; Sphere: −3.77 diopters versus −3.19 diopters, respectively, $P < .001$). Cylinder was, on average, greater from the device compared to cycloplegic refraction with a difference of 0.21 diopters ($p = .02$) but not significantly different between the device and the manifest refraction ($p = .08$). Axis values were not significantly different between the device and manifest ($p = .21$)

or cycloplegic ($p = .87$) refraction. Best corrected visual acuity was, on average, slightly, but significantly worse when obtained from device refraction (logMAR best corrected visual acuity=0.14, Snellen vision 20/27, Standard Deviation (SD) = 0.22) compared to manifest refraction (logMAR best corrected visual acuity=-0.01, Snellen vision 20/20, SD=0.10; $P < .001$) and compared to cycloplegic refraction (logMAR best corrected visual acuity=-0.03, Snellen vision 20/20, SD=0.08; $P < .001$). There were no significant differences noted between eyes from younger or older subjects (<65 years and 65 years or <45 years and 45 years) with respect to the absolute difference in spherical equivalent measurement between refraction methods ($P = .18$ and $P = .28$, respectively, for absolute difference in spherical equivalent between the device and manifest refraction; $P = .98$ and $P = .81$, respectively, for absolute difference in spherical equivalent between the device and cycloplegic refraction). Further, no significant difference between myopic eyes and hyperopic eyes (as determined by manifest or cycloplegic refraction) were found with respect to absolute difference in spherical equivalent between device and manifest refraction ($P = .43$) or device and cycloplegic refraction ($P = .07$).

We then analyzed absolute differences between refraction methods. When comparing spherical equivalent measured between the device and manifest refraction, 62% of eyes had an absolute difference of >0.5 diopters between methods with an average absolute difference of 0.69 diopters (significantly greater than 0.5 diopters, $P < .001$). (Table 2) Similarly, 60% of eyes showed an absolute difference in spherical equivalent measurement of >0.5 diopters between the device and cycloplegic refraction, with an average absolute difference of 0.74 diopters (significantly greater than 0.5 diopters, $P = .01$). Cylinder measurements were 1.0 diopter different between the device and manifest refraction in 20% of eyes ($n=30$), with an average absolute difference of 0.50 diopters (not significantly different from 0.5 diopters, $P = .91$). Cylinder measurements were 1.0 diopter different between the device and cycloplegic refraction in 14% of eyes ($n=10$, with an average absolute difference of 0.45 diopters (not significantly different from 0.5 diopters, $P = .37$)).

In Appendix Table A1 (available at <http://links.lww.com/OPX/A365>), we report the number of eyes that did (or did not) achieve a specific level of vision monocularly with the tested device against the manifest and cycloplegic refraction methods. Device refraction resulted in fewer eyes with best corrected visual acuity 20/20 compared to manifest refraction and cycloplegic refraction (Figure 2; Appendix Table A1, available at <http://links.lww.com/OPX/A365>). Best corrected visual acuity was 20/20 as measured by both the device and manifest refraction in 43.4% of eyes. However, 37.5% of eyes had best corrected visual acuity 20/20 by manifest refraction that was measured as < 20/20 by device refraction. Alternatively, only 1.3% had best corrected visual acuity <20/20 by manifest refraction that was measured as 20/20 by device refraction ($P < .0001$). The remaining 17.8% of eyes had best corrected visual acuity measured as < 20/20 by both methods of refraction. Best corrected visual acuity was 20/40 by both the device and manifest refraction in 86.8% of eyes. Similar differences existed when comparing best corrected visual acuity correction between device refraction and cycloplegic refraction monocular vision results (Appendix Table A1, available at <http://links.lww.com/OPX/A365>).

The confidence ratings generated by the device were high for 57.6% of eyes (n=80), medium in 28.1% of eyes (n=39), and low in 14.4% of eyes (n=20). No significant association was found between the age of a subject and confidence in the device results ($P = .71$). Confidence ratings in device results were significantly associated with the probability of best corrected visual acuity of 20/20 by device refraction. Specifically, eyes with high confidence had significantly increased odds of best corrected visual acuity 20/20 compared to eyes with low confidence (odds ratio=6.77, 95% confidence interval = 1.80–25.4, $P < .01$). However, eyes with medium confidence in device results were not significantly different from eyes with low confidence ($P = 0.06$) or high confidence ($P = .15$) with respect to the probability of best corrected visual acuity 20/20.

Results for subject-reported ease of use of the device are summarized in Table 3. On average, subjects reported agreement with ease of use of the device (mean System Usability Scale score=75.4, standard deviation=19.8 with a score of 100 being the best possible score). The strongest agreement was noted for the statements: “Most people would learn to use this device very quickly.” and “This device was easy to use” (mean=4.2 for both on original scale of 1–5). The strongest disagreement was noted for the negative statements: “I found this device was unnecessarily complex” and “I needed to learn a lot of things before I could get going with this device” (means = 1.7 and 1.8, respectively). No significant differences in overall System Usability Scale score or individual survey item scores were noted between age groups (<65 years and ≥65 years, all $P > .05$, data not shown) or on overall System Usability Scale between subjects whose eyes were both myopic versus both hyperopic ($P = .52$). Subjects that participated in the usability survey were compared to those who did not complete the survey with respect to subject-based characteristics (age, gender) and an eye-based characteristic (manifest VA). There were no differences in gender ($P = .42$, Chi-square test). Subjects who participated in the survey were older than those who did not participate in the survey (mean ± SD, 61.5±16.7 years versus 44.0 ± 15.4 years, respectively; $P < .0001$, 2-sample t-test). Further, subjects who participated in the survey had eyes with significantly worse logMAR visual acuity than eyes of subjects who did not participate in the usability survey (manifest logMAR visual acuity 0.03±0.09 versus −0.03±0.10, respectively, $P = .0017$ linear mixed regression model for the effect of participating in the survey).

DISCUSSION

This study examined the accuracy and ease of use of a portable refractive device. Spherical equivalent refraction from the device was strongly correlated with manifest refraction in our study. The mean relative difference in spherical equivalent between the device and manifest refraction was −0.27 diopters. However, absolute differences in spherical equivalent of more than 0.5 diopters occurred in approximately 60% of eyes. Absolute differences in cylinder of more than 1.0 diopters occurred in 20% of eyes. Best corrected visual acuity relative difference between device and manifest refraction was, on average logMAR 0.15, or 1 to 2 lines on the Snellen chart. A lower percentage of eyes achieved best corrected visual acuity of 20/20 Snellen vision with the device. These differences are similar to those reported from studies investigating other autorefractors. Previous published studies comparing measurement of spherical equivalent between alternate autorefractors with manifest

refraction showed average mean differences of -0.11 diopters (Carl Zeiss i.Profiler, Oberkochen, Germany),¹⁵ -0.03 diopters (Nidek ARK-700A, Fremont, CA),¹³ -0.50 diopters (SVOne, Smart Vision Labs, New York),¹⁶ 0.03 diopters (Canon RK-F2, Tokyo, Japan),¹⁴ and -1.00 to $+0.11$ diopters (Topcon KR-8000, Paramus, NJ).^{13,17} The device accuracy is reasonable, but alternative methods or devices rely on different optical principles to measure refraction. Certainly, advances in technology have the promise of improving the use of all portable refraction devices.

Participants reported agreement with the ease of use of the device (mean System Usability Scale score= 75.4 , standard deviation= 19.8), regardless of the age of the patient. There was a significant association between device obtained best corrected visual acuity and the device confidence scores, with better best corrected visual acuity observed when confidence was higher. Although all participants were first time users of the device, some participants reported high confidence with the device, despite their inexperience. Despite the fact that participants who took the survey were older and had worse vision than the entire cohort, they still reported good usability with the device.

Although differences in spherical equivalent and best corrected visually acuity was statistically significant; the results may or may not be considered clinically significant. The results should be interpreted in the context of the eye care providers' intended use of the device. Different interest groups will interpret the results of this study differently. In robust health care settings, this difference may be unacceptable. In a resource poor settings with limited access to a trained refractionist, the ultimate visual acuity could be compared to the patient's uncorrected refractive error, a likely alternative. We chose to study the device as a one-time use of the device (versus multiple "chances" to get comfortable with the device and optimize results) which may influence results. Considering the low cost, portability, and user-directed interface, this technology could be useful in countries with high prevalence of uncorrected refractive error and barriers to traditional eye care.¹⁸ Outreach programs should balance the cost of this device, or similar devices, supported by a paraprofessional and likely less accurate results versus the cost of recruiting, training, and retaining a high-quality refractionist.

The specific target was adult patients. We deliberately sampled older adults because we had specific concerns that older adults may have difficulty using the device. Vision and usability results were similar for younger and older populations. When resources are limited, accurate distance refractive error measurements are critical and presbyopia is often estimated. While not an ideal approach, it is practical in low resource settings. Also, older patients should have ocular health checks. We envision a comprehensive approach to address refractive needs and disease screening. Given that uncorrected refractive error is the largest source of visual disability, the eyeglass services likely garner a large volume of need.

Limitations should be noted. First, although the device is registered with the United States regulatory process (Food and Drug Administration), its adoption would be difficult in some care settings. Refraction using a portable device with a non-licensed eye care provider is subject to legal restrictions in some states.¹⁹ Secondly, the device only measures refractive error and does not detect vision disorders. In our study, we selected patients with best

corrected visual acuity 20/40 vision, effectively screening out visually significant ocular pathology. Third, the device may have different accuracy for people who need extra time and assistance with the technology. This was not explored in our study. Lastly, we did not test reliability of the device and thus cannot claim validity of the instrument. Future work should investigate the reliability of repeat measurement of refractive error by the device.

This portable, low-cost device provides a reasonable, but not perfect measure of subjective refraction. Participants reported agreement with ease of use of the device. The device has potential to be used in settings with minimal access to eye care providers or a trained refractionist.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Scatterplots and Bland-Altman plots comparing spherical equivalent measurement between Netra refraction and Manifest refraction (upper panels), Netra refraction and Cycloplegic refraction (lower panels). Reference lines denote no difference (solid black line) and differences >0.5 diopters (dashed gray lines). BCVA = Best-Corrected Visual Acuity.

Figure 2. Bar charts comparing best-corrected visual acuity obtained between Netra refraction and Manifest refraction (left panel), Netra refraction and Cycloplegic refraction (right panel).

Table 1.

Comparison of measures obtained from Netra refraction to those obtained with manifest and cycloplegic refraction

Variable	Manifest Refraction (n=152 eyes)			Netra Refraction (n=152 eyes)			Difference (n=152 eyes)			P*
	Mean (SD)	Min, Max	Median	Mean (SD)	Min, Max	Median	Mean (SD)	Min, Max	Median	
SE (D)	-2.49 (3.58)	-15.25, 4.25	-2.00	-2.76 (3.54)	-14.75, 3.63	-2.13	-0.27 (0.83)	-2.38, 3.00	-0.25	.001
Sphere (D)	-2.02 (3.56)	-15.00, 4.75	-1.50	-2.34 (3.54)	-14.75, 4.75	-1.75	-0.32 (0.93)	-2.75, 3.50	-0.50	< .001
Cylinder (D)	-0.94 (0.83)	-4.50, 0.00	-0.75	-0.83 (0.76)	-4.00, 0.00	-0.75	0.11 (0.71)	-2.00, 2.50	0.00	.08
Axis	95 (54)	1, 180	95	88 (56)	0, 180	90	-6 (59)	-154, 167	0	.21
logmar BCVA	-0.01 (0.10)	-0.12, 0.48	0.00	0.14 (0.22)	-0.12, 1.10	0.10	0.15 (0.19)	-0.20, 1.00	0.12	< .001

Variable	Cycloplegic Refraction (n=68-75 eyes)			Netra Refraction (n=68-75 eyes)			Difference (n=68-75 eyes)			P*
	Mean (SD)	Min, Max	Median	Mean (SD)	Min, Max	Median	Mean (SD)	Min, Max	Median	
SE (D)	-3.76 (3.37)	-12.75, 2.75	-3.00	-4.21 (3.19)	12.50, 2.13	-3.63	-0.45 (0.78)	-2.25, 1.25	-0.38	< .001
Sphere (D)	-3.19 (3.30)	-11.25, 2.75	-2.25	-3.77 (3.11)	-11.0, 2.5	-3.25	-0.56 (0.82)	-2.25, 1.25	-0.50	< .001
Cylinder (D)	-1.13 (0.91)	-4.00, 0.00	-1.00	-0.92 (0.83)	-4.00, 0.00	-0.75	0.21 (0.61)	-1.25, 2.50	0.00	.018
Axis	102 (55)	0, 180	90	100 (51)	0, 180	90	-1 (45)	-105, 107	0	.87
logmar BCVA	-0.03 (0.08)	-0.12, 0.18	0.00	0.09 (0.17)	-0.12, 0.80	0.05	0.12 (0.15)	-0.12, 0.70	0.10	< .001

SD=Standard Deviation, SE=Spherical Equivalent, D=Diopters, BCVA=Best-Corrected Visual Acuity

* P-value from a linear mixed regression modeling testing if the measured refraction is significantly different between methods

Table 2.

Descriptive statistics for the absolute difference in spherical equivalent between refraction methods, overall and stratified by subject age.

Absolute difference in SE	Mean (SD)	Min, Max	Median	% eyes > 0.5D IDiff	P*
Manifest vs. Netra (n=152 eyes)	0.69 (0.53)	0.00, 3.00	0.63	61.8	<.001
Cycloplegic vs. Netra (n=73 eyes)	0.74 (0.54)	0.00, 2.25	0.50	60.3	.01
Eyes from Subjects < 65 years					
Manifest vs. Netra (n=110 eyes)	0.65 (0.47)	0.00, 2.38	0.50	59.1	<.01
Cycloplegic vs. Netra (n=67 eyes)	0.72 (0.55)	0.00, 2.25	0.50	59.7	.01
Eyes from Subjects 65 years					
Manifest vs. Netra (n=42 eyes)	0.80 (0.66)	0.00, 3.00	0.69	69.1	.02
Cycloplegic vs. Netra (n=6 eyes)	0.73 (0.50)	0.12, 1.50	0.69	66.7	.5

SE=Spherical Equivalent, SD=Standard Deviation, D=Diopters

*

p-value from a linear mixed regression model testing for the absolute difference in SE between methods of 0.5 D

The absolute difference in SE between manifest refraction and Netra refraction was not significantly different in eyes from young patients (mean=0.65 D) versus older patient (mean=0.80 D), $P_{\text{value}} = 0.18$

The absolute difference in SE between cycloplegic refraction and Netra refraction was not significantly different in eyes from young patients (mean=0.72 D) versus older patient (mean=0.73 D), $P_{\text{value}}=0$.

Table 3.

Descriptive statistics for reported agreement with ease of use for the Netra device (n=50 subjects).

Ease of Use Survey Item	Mean [*]	SD	Min	Max	Median	P ^{**}
I think that I would like to use this device frequently	3.42	1.18	1	5	3.0	.60
I found this device was unnecessarily complex	1.70	1.16	1	5	1.0	.80
I thought this device was easy to use	4.22	1.23	1	5	5.0	.44
I think that I would need the support of a technical person to be able to use this device	2.34	1.36	1	5	2.0	.81
I found the various functions in this device were well integrated	4.00	1.16	1	5	4.0	.70
I thought there was too much inconsistency in this device	2.00	1.28	1	5	1.0	.25
I would imagine that most people would learn to use this device very quickly	4.22	0.97	1	5	4.0	.19
I found this device very cumbersome to use	2.04	1.18	1	5	2.0	.16
I felt very confident using this device	4.12	1.06	1	5	4.0	.33
I needed to learn a lot of things before I could get going with this device	1.76	1.20	1	5	1.0	.81
Netra SUS Score	75.35	19.83	15	100	80.0	.78

SD = Standard Deviation; SUS = System Usability Scale

* Mean (and other descriptive statistics) response for the 10 ease of use survey items based on the original Likert scale: strongly disagree (1) to strongly agree (5)

** Two-sample Wilcoxon test to compare Netra scores between subjects <65 years old and ≥ 65 years old