

Investigation of the Accuracy of a Low-Cost, Portable Autorefractor to Provide Well-Tolerated Eyeglass Prescriptions

A Randomized Crossover Trial

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Purpose: To compare patient preferences for eyeglasses prescribed using a low-cost, portable wavefront autorefractor versus standard subjective refraction (SR).

Design: Randomized, cross-over clinical trial.

Participants: Patients aged 18 to 40 years presenting with refractive errors (REs) to a tertiary eye hospital in Southern India.

Methods: Participants underwent SR followed by autorefraction (AR) using the monocular version of the QuickSee device (PlenOptika Inc). An independent optician, masked to the refraction approach, prepared eyeglasses based on each refraction approach. Participants (masked to refraction source) were randomly assigned to use SR- or AR-based eyeglasses first, followed by the other pair, for 1 week each. At the end of each week, participants had their vision checked and were interviewed about their experience with the eyeglasses.

Main Outcome Measures: Patients preferring eyeglasses were chosen using AR and SR.

Results: The 400 participants enrolled between March 26, 2018, and August 2, 2019, had a mean (standard deviation) age of 28.4 (6.6) years, and 68.8% were women. There was a strong correlation between spherical equivalents using SR and AR ($r = 0.97$, $P < 0.001$) with a mean difference of -0.07 diopters (D) (95% limits of agreement [LoA], -0.68 to 0.83). Of the 301 patients (75.2%) who completed both follow-up visits, 50.5% ($n = 152$) and 49.5% ($n = 149$) preferred glasses prescribed using SR and AR, respectively (95% CI, 45.7–56.3; $P = 0.86$). There were no differences in demographic or vision characteristics between participants with different preferences ($P > 0.05$ for all).

Conclusions: We observed a strong agreement between the prescriptions from SR and AR, and eyeglasses prescribed using SR and AR were equally preferred by patients. Wider use of prescribing based on AR alone in resource-limited settings is supported by these findings. *Ophthalmology* 2021;128:1672-1680 © 2021 by the American Academy of Ophthalmology. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).



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Globally, 2.2 billion people are estimated to have vision impairment (VI) or blindness, of whom 1 billion have VI that could have been prevented or treated.¹ More than 38 million individuals worldwide are estimated to be blind at present, and this will increase to approximately 115 million by 2050.² Refractive error causes more than half of the VI in persons globally¹ and is the second most common cause of blindness.^{3,4} Uncorrected refractive error (RE) has a substantial negative impact on productivity,⁵ resulting in an annual economic loss of \$269 billion worldwide.⁶ Improved strategies to increase screening and correction for REs could have a substantial impact on reducing the global burden of VI and associated socioeconomic losses.

Of the 2.2 billion people (28.6% of the world's population⁷) with eye care needs, an estimated 42% (0.92 billion) would benefit from eyeglasses,⁴ an easy and economic treatment. However, lack of easy access to refractive services and limited numbers of trained professionals remain key challenges for the uptake of eyeglasses in poorer regions of the world.⁸ Eyeglass coverage is directly proportional to the gross domestic product, with low- and middle-income countries having the least coverage.⁹ Refractive error care currently relies on highly trained personnel such as ophthalmic technicians or optometrists to conduct refractions and provide prescriptions. They are not available in many settings, and where they are, using

them adds substantially to the cost of care.¹⁰ The capacity to provide refraction services is essentially determined by this cadre of skilled professionals. Autorefractors operated by non—eye care health workers^{11,12} can provide accurate refractions.¹³ However, current autorefractors are expensive and often bulky and thus not widely used in low-resource settings. An accurate, lightweight, easily portable, and low-cost autorefractor would reduce the overall cost of providing eyeglasses by providing eyeglass prescriptions without the need to rely on highly trained personnel. Furthermore, wider availability of such devices could help make RE correction universal.

Autorefractors provide good agreement with subjective refraction (SR) in a range of settings.^{14–16} Autorefractors and wavefront aberrometers that meet portability requirements typically do not perform well enough to replace SR under cycloplegic-free conditions, although such devices have been used successfully for vision screening.^{17,18}

QuickSee (PlenOptika Inc) is a portable autorefractor marketed at relatively low cost compared with existing devices. The accuracy of this device has been established in both high- and low-resource settings.^{19–21} The aim of the current randomized clinical trial was to compare patient acceptance of eyeglasses with prescriptions based on autorefraction (AR) derived from this with those derived from SR, the current standard.

Methods

The protocol for this study was approved by the Institutional Review Boards of Aravind Eye Hospital (AEH), Madurai, India, and the Johns Hopkins Medical Institution, Baltimore, Maryland. Informed written consent was obtained from all study participants before study implementation, and the principles of the Declaration of Helsinki were followed. The study protocol is registered under [ClinicalTrials.org](https://clinicaltrials.org) (registration number: NCT03615612).

Design and Participants

This was a randomized, controlled, cross-over clinical trial conducted at AEH, Madurai, India, from March 26, 2018, to August 2, 2019. Patients aged 18 to 40 years presenting with REs to the general ophthalmology clinic at AEH who had not had a new pair of glasses in the previous 2 years were included in the study. We limited our study participants to the 18- to 40-year age group because accommodation is overactive in individuals aged < 18 years, and those aged more than 40 years might require bifocals, which would have added complexity to spectacle prescribing. We excluded patients with (1) REs outside the detection range of the device (−10 to +10 diopters [D]); (2) cylindrical power greater than 3 D (when high astigmatism is fully corrected, patients tend to have poor adoption of eyeglasses); (3) travel distances beyond 10 km from the hospital (to enhance compliance to the additional visits required for the study); (4) speech or hearing impairment; and (5) those unwilling to purchase eyeglasses from the AEH.

Sample Size

We arrived at a sample size of 167 in each group assuming an expected difference of 15% in patients' preference between spectacles prescribed using SR and AR, with a 5% alpha error and 80% power. Considering approximately 20% loss to follow-up, we recruited 200 participants in each group.

Study Procedures

The study was conducted following standard patient care at the general ophthalmology unit of AEH. After patients went through the usual preliminary workflow at the clinic, they were recruited for the study based on the inclusion and exclusion criteria described in [Figure S1](#) (available at www.aaojournal.org).

Subjective Refraction

Streak retinoscopy and SR were performed for all participants by 1 of 3 trained study refractionists. The refractionists were standardized by comparing their refractions with the refractions from an expert refractionist on the same 10 patients before the start of the study. Each refractionist had to agree with the expert refractionist within ± 0.75 D spherical equivalent for at least 8 of 10 patients.

Autorefraction

The QuickSee is a portable open-view wavefront aberrometer capable of conducting binocular AR. This study used a monocular model of the QuickSee, commercially available under the brand name “QuickSee Flip” or “e-see” depending on geography, specifically designed to be sold at a lower price to increase accessibility in low- and middle-income countries. The participants were asked to look through the eye piece of the autorefractor at a fixation target located 6 m away. To ensure that the subject's eye was correctly aligned with the eye piece, the device was adjusted or the subject was requested to adjust his line of sight. A trained study coordinator (based on a training protocol) guided the subjects in the use of the autorefractor. The device illuminates the eye using a low-power laser diode through the pupil, and the light captured by the inbuilt wavefront sensor provides an estimate of the magnitude of various aberrations in the subject's eye. An approximately 10-second video of the captured light is recorded for each eye. This information is then used by the device to estimate the subject's refraction and generate the spectacle prescription.

Randomization and Masking

All participants underwent AR followed by SR. The measurements from both SR and AR were input into the study database with a different random number code used to differentiate the 2 prescriptions for analysis. The random number codes were computer generated for each patient by the study statistician at the clinical trial unit of AEH. Separate prescriptions were generated for each refraction by an independent, masked optician who prepared 2 pairs of eyeglasses in identical frames of the patient's choice, based on the results of the 2 separate measurements. The patients, providers of eyeglasses, and final evaluators were all masked to the source of the prescription.

Provision of Eyeglasses and Follow-up

Patients' selected frames and the inner arm of the eyeglasses were marked with the random number code associated with the source of the refraction (SR or AR). Patients were randomized to wear 1 pair of eyeglasses for 1 week, after which they returned for a follow-up visit to AEH. At this first visit, their visual acuity was evaluated and responded to a questionnaire of 10 questions on difficulty in performing various activities and 2 additional questions on concerns due to wearing the glasses ([Appendix](#), available at www.aaojournal.org). The patients returned the first pair of glasses and were given the other pair for 1 week to use before returning for the second follow-up visit. Patients were reminded via phone call to wear the glasses and return for the follow-up interviews.

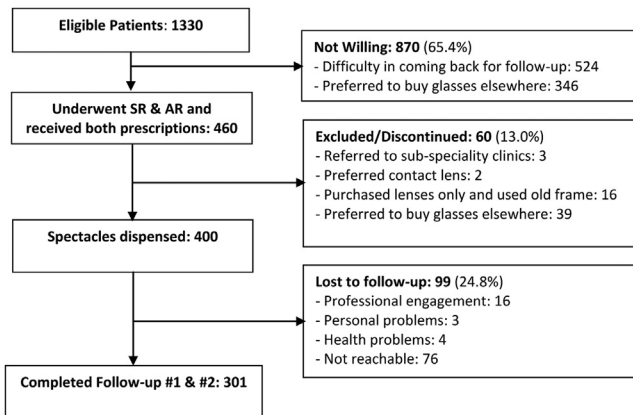


Figure 1. Flowchart for study enrollment. AR = autorefraction; SR = subjective refraction.

At the second follow-up, visual acuity testing and the questionnaire were readministered for the second pair of glasses. At the second visit, patients were asked to wear both pairs of glasses and indicate their preference (forced choice protocol), which was given to them. Patients who completed both follow-up visits were paid a sum of Indian Rupees (INR) 500 (~US \$7) as a contribution toward the cost of making 2 additional visits and their time. The cost of eyeglasses ranged from INR 430 to INR 2300 with an average of INR 1243.

Outcome Measures

The primary outcome measure for the study was the difference in the proportions of patients preferring eyeglasses issued using AR or SR. This was measured at the end of the second follow-up visit. The secondary outcomes were the level of agreement of the eyeglass prescription using AR with that using SR and the difference in participants' experience of wearing the 2 pairs of

eyeglasses. At the time of each follow-up visit, visual acuity was assessed with the patient wearing the provided eyeglasses. Patients were also interviewed using a structured questionnaire to capture their feedback on the experience of wearing the eyeglasses.

Safety Check

To avoid providing patients with improper eyeglasses, we had planned to discontinue participants with visual acuity (tested with trial frames) worse than 6/12 using prescription or a difference of more than 1 line between the 2 prescriptions in either eye. However, none of the patients met either criterion requiring exclusion.

Statistical Analysis

For statistical comparison, prescriptions were converted to power vector parameters²² of spherical equivalent (M), vertical Jackson cross cylinder (J_0), and oblique Jackson cross cylinder (J_{45}) for SR (M_{SR} , $J_{0,SR}$, $J_{45,SR}$) and AR (M_{AR} , $J_{0,AR}$, $J_{45,AR}$). Pearson coefficients (r), Bland–Altman plots, and intraclass coefficients (ICCs) were used to analyze the correlation and agreement, respectively, between SR and AR measurements both overall and by RE subcategories. The RE subcategories were defined as low myopia (myopia > -3 D), high myopia (myopia ≤ -3 D), low hyperopia (hyperopia $< +1$ D), high hyperopia (hyperopia $\geq +1$ D), low astigmatism (astigmatism < 1 D), and high astigmatism (astigmatism ≥ 1 D). Study participant–reported difficulties while using the glasses issued using SR and AR were compared as a dichotomous variable using the McNemar's chi-square test. Visual acuity was measured using a Snellen chart at a 6-m testing distance, and all visual acuity measurements were converted to logarithm of the minimum angle of resolution units for statistical comparisons. We analyzed the refraction measurements for the right and left eyes separately and report the results based on the right eye because results were largely similar. Significance level was set at $P \leq 0.05$, and STATA 14.0 (StataCorp LLC) was used to perform all statistical analyses.

Results

Participants

Among 1330 eligible participants invited to the study, 870 (65.4%) declined to participate (Fig 1). Of the remaining, 460 participants (enrolled between March 26, 2018, and August 2, 2019) underwent AR- and SR-based refraction and received respective eyeglass prescriptions. Of these, 60 participants (13.0%) were excluded or discontinued for various reasons, mainly preferring to buy glasses elsewhere or preferring to keep habitual frames and only purchase lenses (55/60; 92%). The 400 patients who continued in the study received 2 pairs of eyeglasses, each based on 1 of the 2 refractions, and wore them one after the other, with an interval of at least 1 week. A total of 99 patients (24.8%) were lost to follow-up, and 301 patients (75.3%) were included in the final analysis examining patient preference for eyeglasses. The 400 patients included in the preliminary analysis had a mean (standard deviation) age of 28.4 (6.6) years, and 68.8% were women. The mean (standard deviation) presenting visual acuity was 0.53 (0.38) logMAR. There were no differences in demographic or vision characteristics between participants who were and were not lost to follow-up (Table 1).

Prescription Agreement

The SR and AR were strongly correlated (Pearson correlation coefficients of $r = 0.97$, $r = 0.94$, and $r = 0.78$, for M , J_0 , and J_{45} ,

Table 1. Demographic and Vision Characteristics of Participants Who Were and Were Not Lost to Follow-up (N = 400) in a Randomized Trial of Spectacle Provision

Patient Characteristics	Completed Study N = 301 (75.2%)	Lost to Follow-Up N = 99 (24.8%)
Age, mean (SD)	28.4 (6.6)	28.9 (6.2)
Female, N (%)	207 (68.8%)	61 (61.6%)
RE Presenting logMAR, mean (SD)	0.52 (0.38)	0.56 (0.38)
SR RE Spherical Equivalent, mean (SD)	−1.66 (1.69)	−1.85 (1.60)
SR RE J_0 vector, mean (SD)	−0.01 (0.58)	−0.11 (0.42)
SR RE J_{45} vector, mean (SD)	−0.04 (0.28)	−0.02 (0.23)
SE difference, mean (SD)	−0.10 (0.38)	0.001 (0.40)
J_0 difference, mean (SD)	−0.02 (0.20)	−0.07 (0.18)
J_{45} difference, mean (SD)	−0.03 (0.19)	−0.02 (0.13)
SR BCVA logMAR, mean (SD)	0.01 (0.04)	0.01 (0.05)
AR BCVA logMAR, mean (SD)	0.02 (0.06)	0.02 (0.06)
Subjective Cylinder $< -0.75^*$, N (%)	100 (50.5)	25 (41.7)

AR = autorefraction; BCVA = best-corrected visual acuity; J_0 = vertical Jackson cross cylinder; J_{45} = oblique Jackson cross cylinder; logMAR = logarithm of the minimum angle of resolution; RE = refractive error; SD = standard deviation; SE = spherical equivalent; SR = subjective refraction.
*Median cylindrical correction.

Table 2. Comparison of Subjective Refraction and Autorefraction (N = 400)

Type of Refractive Error	Refractive Parameter	Subjective Mean (SD)	Autorefraction Mean (SD)	Mean Difference	95% LOA	r
All N = 400	M	-1.71 (1.67)	-1.62 (1.70)	-0.07 (0.39)	0.68–0.83	0.97
	J_0	-0.04 (0.55)	-0.002 (0.45)	-0.03 (0.19)	0.34–0.41	0.94
	J_{45}	-0.04 (0.27)	0.004 (0.24)	-0.03 (0.18)	0.32–0.38	0.78
Low Myopia Myopia > -3 D N = 192	M	-1.55 (0.75)	-1.29 (0.77)	-0.27 (0.54)	0.79–1.52	0.74
	J_0	-0.08 (0.54)	-0.68 (0.45)	-0.01 (0.21)	0.40–0.42	0.93
	J_{45}	-0.07 (0.29)	-0.07 (0.31)	-0.001 (0.17)	0.33–0.33	0.85
High Myopia Myopia ≤ -3 D N = 67	M	-4.67 (1.36)	-4.30 (1.20)	-0.38 (0.53)	0.66–1.42	0.92
	J_0	0.22 (0.41)	0.23 (0.39)	-0.01 (0.18)	0.34–0.36	0.90
	J_{45}	-0.004 (0.25)	0.10 (0.22)	-0.11 (0.15)	0.18–0.40	0.82
Low Hyperopia Hyperopia < +1 D N = 3	M	0.83 (0.14)	0.75 (0.25)	0.08 (0.14)	0.30–0.19	0.87
	J_0	0.43 (0.43)	0.25 (0.25)	-	-	-
	J_{45}	-	-	-	-	-
High Hyperopia Hyperopia ≥ +1 D N = 3	M	2.67 (2.89)	2.58 (3.62)	0.08 (0.76)	1.37–1.41	0.99
	J_0	-	-	-	-	-
	J_{45}	-	-	-	-	-
Low Astigmatism Astigmatism < 1 D N = 93	J_0	-0.05 (0.27)	-0.02 (0.27)	-0.02 (0.14)	0.25–0.29	0.87
	J_{45}	-0.01 (0.14)	0.01 (0.16)	-0.02 (0.12)	0.21–0.26	0.67
High Astigmatism Hyperopia ≥ +1 D N = 93	J_0	-0.02 (0.74)	0.02 (0.65)	-0.04 (0.24)	0.43–0.51	0.95
	J_{45}	-0.06 (0.35)	-0.03 (0.34)	-0.03 (0.22)	0.40–0.46	0.80

A = limit of agreement; D = diopters; J_{45} = oblique Jackson cross cylinder; J_0 = vertical Jackson cross cylinder; LOA = limits of agreement; M = spherical equivalent; r = correlation coefficient; SD = standard deviation.

respectively), and the mean differences in diopters were -0.07 (95% limits of agreement [LoA], 0.68 to -0.83), 0.03 (95% LoA, 0.34 to -0.41), and 0.03 (95% LoA, 0.32 to -0.38), respectively (Table 2, Fig 2). The intraclass correlation coefficients (ICCs) also showed a high level of agreement with ICC = 0.96 (95% CI, 0.95–0.97), ICC = 0.96 (95% CI, 0.95–0.97), and ICC = 0.87 (95% CI, 0.84–0.90) for M, J_0 , and J_{45} , respectively (Table S1, available at www.aaojournal.org). In subanalyses using RE categories, the correlation remained strong for myopia and astigmatism with the correlation coefficient, r ranging from 0.80 to 0.95 with the exception of M for low myopia ($r = 0.74$) and J_{45} for low astigmatism ($r = 0.67$). The mean differences were similar to those of the overall analysis. The ICC values also supplement the high levels of agreement between the SR and AR in the RE subcategories with ICC ranging from 0.79 to 0.97. There were only 6 cases of hyperopia in total with 3 each in the low and high categories; thus, the correlation analyses did not yield meaningful results.

Prescription Preference

Of the 301 patients (75.2%) who completed both follow-up visits, 50.5% (152) and 49.5% (149) preferred glasses prescribed using SR and AR (forced choice), respectively (95% CI, 45.7–56.3; $P = 0.86$). There were no differences in demographic or vision characteristics between patients who preferred glasses using SR and AR (Table 3). The magnitude of RE also did not have a predictive effect on preference. Of the 301 participants who completed the study, 47% (142/301) were given SR-based eyeglasses and the remaining (53%) were given AR-based glasses as their first allocation ($P = 0.17$). Among those who preferred SR or AR, 58.6% (89/152) and 64% (96/149), respectively, were found to have preferred the eyeglasses allotted to them first. Of the 99 participants who were lost to follow-up, 55% ($n = 54$) had received SR-based eyeglasses and the remaining 45% ($n = 45$) had received

AR-based glasses as their first allocation, and this difference was not statistically significant ($P = 0.20$).

At the time of the first and second follow-up visits, when patients were interviewed about their experience wearing each set of eyeglasses, no differences were noted relating to various activities or concerns when using eyeglasses prescribed by SR or AR ($P > 0.05$ for all; Table 4).

Discussion

Patients had a similar preference for eyeglasses based on AR or SR performed by a trained refractionist. The final refraction measurements obtained were similar using the 2 methods. Furthermore, there was no difference in the self-reported patient experience when wearing the glasses prescribed using the 2 refractions. The lack of patient preference for one approach over the other lends strong support to wider use of the QuickSee Flip/e-see in resource-limited settings and possibly in other locations as well.

This study is novel in its assessment of patients' experience and their preference of eyeglasses prescribed using an autorefractor operated by a nonrefractionist compared with SR performed by an expert refractionist in a low-resource setting. Most studies^{15,16,20,21} comparing AR with SR have relied solely on objective measures such as agreement of the refractions or resultant visual acuity. A recent study conducted in the same setting compared patients' preferences of refractive correction using trial lenses based on an early research prototype version of the QuickSee to SR²³ and found that more than half had no preference or preferred eyeglasses prescribed by QuickSee.²³ The current study provides additional evidence

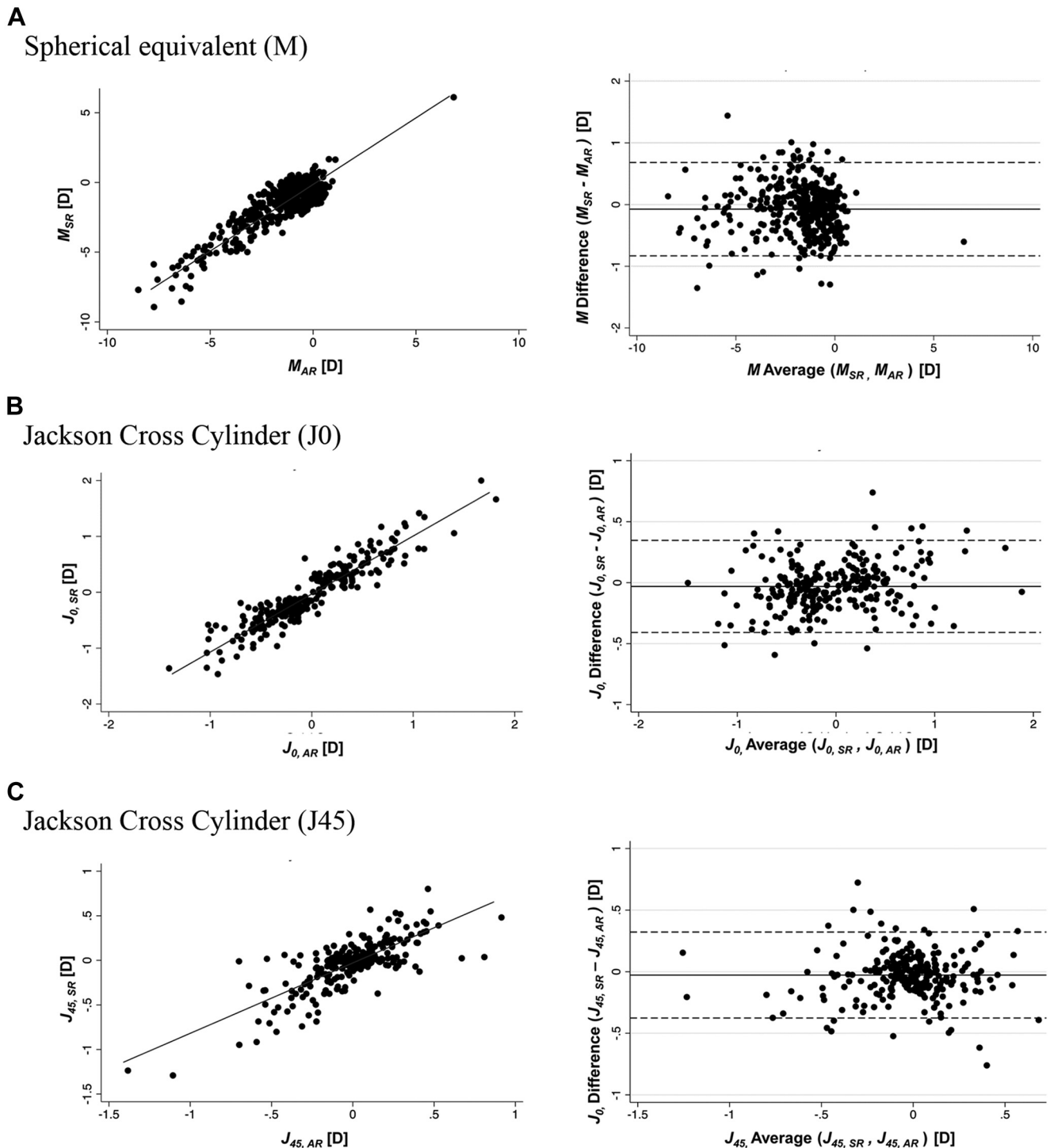


Figure 2. Correlation (left) and Bland–Altman (right) plots comparing agreement of prescriptions measured by SR and AR for (A) spherical equivalent, M, (B) vertical Jackson cross cylinder, J_0 , and (C) oblique Jackson cross cylinder, J_{45} . AR = autorefraction; D = diopters; SR = subjective refraction.

on the acceptability of the commercially available QuickSee flip/e-see-based refraction among study participants who wore eyeglasses with each refraction for a week before deciding their preference.

Strong RE agreement of AR with SR and similar levels of patient preference indicate that it is possible to rely solely on this technology for prescribing eyeglasses. In addition, the device is portable, handheld, easy to use, and more affordable

Table 3. Demographic and Vision Characteristics by Preference for Eyeglasses (N = 301) in a Randomized Trial of Spectacle Provision

Patient Characteristics	Preferred Subjective N = 152 (50.5%)	Preferred Autorefraction N = 149 (49.5%)	P Value
Age, mean (SD)	29.1 (6.5)	27.8 (6.7)	0.11
Female, N (%)	110 (72.4%)	97 (65.1%)	0.17
RE Presenting logMAR, mean (SD)	0.51 (0.38)	0.54 (0.39)	0.61
SR RE spherical equivalent, mean (SD)	-1.59 (1.78)	-1.74 (1.59)	0.44
SR RE J_0 vector, mean (SD)	-0.03 (0.62)	-0.0004 (0.53)	0.73
SR RE J_{45} vector, mean (SD)	-0.05 (0.27)	-0.04 (0.28)	0.79
SE difference, mean (SD)	-0.12 (0.36)	-0.08 (0.40)	0.36
J_0 difference, mean (SD)	-0.05 (0.20)	.01 (.19)	0.05
J_{45} difference, mean (SD)	-0.03 (0.22)	-0.03 (0.16)	0.89
SR BCVA logMAR, mean (SD)	0.01 (0.05)	0.007 (0.38)	0.35
AR BCVA logMAR, mean (SD)	0.03 (0.06)	0.01 (0.05)	0.09
Subjective cylinder < -0.75*, N (%)	54 (55)	46 (46)	0.20

AR = autorefraction; BCVA = best-corrected visual acuity; J_0 = vertical Jackson cross cylinder; J_{45} = oblique Jackson cross cylinder; logMAR = logarithm of the minimum angle of resolution; RE = refractive error; SD = standard deviation; SE = spherical equivalent; SR = subjective refraction.

*Median cylindrical correction.

than traditional autorefractors currently on the market, making it particularly attractive in low-resource settings. Our findings are consistent with previous research in which other autorefractors have shown high concordance with SR.^{15,19-21,24} Authors have also reported that patients are satisfied with eyeglasses prescribed using AR in various settings.^{13,20,25,26}

A shortage of trained refractionists and their concentration in high-resource and urban centers are major problems in the developing world, particularly in semi-urban and rural settings.^{8,10,27,28} It is challenging to address this human resource shortage because of the training, resources, and costs required to develop a clinically competent refractionist and where they choose to work. The autorefractor evaluated in this study, in contrast, can be operated by minimally trained nonclinical personnel from local communities, thereby circumventing the need for and costs of training refractionists, as well as the challenging task of having them work in rural areas. Portable autorefractors such as QuickSee Flip/e-see have the potential to address RE correction needs even in remote locations, because someone in the local area can be trained to use this and generate an acceptable prescription.

The current version of the QuickSee Flip/e-see is able to measure REs within the spherical and cylindrical power ranges of -10 to +10 D and -6 to +6 D, respectively. Within this range, an autorefractor can provide refractive prescriptions to approximately 95% of all adults, depending on the population.²⁸⁻³⁰ Nevertheless, wider implementation of AR-based prescription of eyeglasses will require clear guidelines on when not to solely rely on AR, such as for extremely high REs or those requiring bifocals.

Study Strengths and Limitations

Strengths of our study include the double-masked, randomized, controlled design, a large and adequately powered sample size, and the fact that the trial was conducted in a low-resource setting in India. The study also has limitations. We had a fairly high rate of loss to follow-up (24.6%).

However, no demographic or vision differences were noted between those who were and were not lost to follow-up. We also found that the proportion of participants who received SR- or AR-based eyeglasses was similar among those lost to follow-up. In addition, SR was performed by 3 different refractionists. Although refractionists were standardized, it is possible that different personnel may have had better or worse results of their SRs. That said, in clinical settings, refractionists are likely to have even more variability in performance than the current study, given our efforts to confirm the refractionists' reliability. Patients tended to prefer the first pair of glasses they were randomized to wear, but this was true for both arms, and this bias was unlikely to affect the overall findings. The age range of the study participants (18–40 years) intentionally excluded patients for whom accommodation may be overactive (<18 years) as well as those who may benefit from a bifocal. This range was chosen to simplify the study protocol and interpretation of the results; dilation and cycloplegic refraction would have been required for children aged < 18 years, and presbyopes would have needed an additional near correction. Because this would limit the extrapolation of our results to the excluded age groups, future research is needed to validate the QuickSee among younger and older populations. Additionally, our study sample consisted mostly of people with low myopia; thus, future research should also attempt to capture less common REs. Finally, our study findings may not be generalizable to other settings outside a South Asian population, although this seems unlikely.

In conclusion, refractive error is a common problem that is poorly addressed globally, causing an estimated \$269 billion of lost productivity annually.^{1,5,6,8,9} We confirm that AR using the QuickSee Flip/e-see can provide refractions that satisfy the majority of individuals without the need for highly trained personnel performing SRs. Wider use of this or similar technologies could help reduce the global burden of uncorrected REs.

Table 4. Comparison of Patients' Feedback on Their Experience of Wearing Eyeglasses Prescribed Using Subjective Refraction and Autorefraction

					P Value*
1. Difficulty watching television					
Subjective Refraction	Yes	Yes [n (%)]	Autorefraction	No [n (%)]	0.22
	No	18 (6.4)		35 (12.5)	
2. Difficulty reading phone or newspaper					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.63
	No	14 (4.9)		52 (18.1)	
3. Difficulty cooking					
Subjective Refraction	Yes	Yes	Autorefraction	No	1.00
	No	4 (6.5)		12 (19.4)	
4. Difficulty doing activities outside					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.68
	No	8 (10.4)		11 (14.3)	
5. Difficulty taking care of children or the elderly					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.68
	No	13 (16.9)		11 (13.4)	
6. Difficulty doing your job					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.08
	No	5 (2.0)		30 (12.1)	
7. Difficulty doing social activities					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.34
	No	8 (3.7)		31 (14.4)	
8. Difficulty identifying bus numbers, advertisement boards, or signage					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.62
	No	17 (5.7)		49 (16.6)	
9. Difficulty identifying familiar people's faces					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.91
	No	40 (13.6)		39 (13.3)	
10. Difficulty driving at night (during glare conditions)					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.09
	No	2 (3.3)		5 (8.3)	
Concerns related to using the eyeglasses					
11. Worried about vision in eyeglasses					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.38
	No	1 (0.3)		14 (4.7)	
12. Afraid to do some activities because of vision in eyeglasses					
Subjective Refraction	Yes	Yes	Autorefraction	No	0.41
	No	19 (6.4)		23 (7.7)	
Subjective Refraction	Yes	Yes		No	
	No	3 (1.0)		244 (81.6)	

*McNemar's chi-square test.

Footnotes and Disclosures

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All authors have completed and submitted the ICMJE disclosures form

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Author Contributions:

Conception and design: Joseph, Varadaraj, Dave, Lage, Lim, Aziz, Dudgeon, Ravilla, Friedman

Data collection: Joseph, Dudgeon, Ravilla, Friedman

Analysis and interpretation: Joseph, Varadaraj, Friedman

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Overall responsibility: Joseph, Varadaraj, Dave, Lage, Lim, Aziz, Ravilla, Friedman

Abbreviations and Acronyms:

AEH = Aravind Eye Hospital; **AR** = autorefractor; **CI** = confidence interval; **D** = diopters; **ICC** = intraclass coefficient; **INR** = Indian Rupees; **LoA** = limits of agreement; **RE** = refractive error; **SR** = subjective refraction; **VI** = vision impairment.

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