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Performance of Photoscreener in Adults

Meryem Güler Alış, Abdülkadir Alış

Fatih Sultan Mehmet Training and Research Hospital, İstanbul, Turkey

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Abstract

Objective: To investigate the performance of the photoscreener (Plusoptix A12, GmbH, Nuremberg, Germany) in adults by comparing it with a classic table top autorefractometer (ARK-1 Auto Ref-Keratometer, Nidek, Japan).

Methods: A total of 100 eyes (right) of 100 patients aged 18-55 years were prospectively evaluated. Patients' refraction values obtained with the Plusoptix A12 as a photoscreener in monocular and binocular conditions were compared with those of the classic table top autorefractometer. The correlations of spherical equivalent differences in regard to axial length, anterior chamber depth, and central corneal thickness were examined.

Results: When Plusoptix A12 and autorefractometer values in the binocular condition were compared, no significant difference was observed in spherical values, spherical equivalent values, J0, or J45 values. Intraclass correlation coefficient values showed a good degree of agreement between the 2 devices. When Plusoptix A12 values were measured monocularly and autorefractometer values were compared, spherical equivalent, spherical, and cylindrical values were found to be statistically different, although intraclass correlation coefficient values were compatible in both devices. There was no difference between J0 and J45 values. A weak positive correlation was observed between the spherical equivalence differences and anterior chamber depth and axial length.

Conclusion: Plusoptix A12 values measured under binocular conditions and autorefractometer values are compatible and have similar results in the detection of simple myopia without astigmatism, simple hyperopia without astigmatism, and emmetropia in adults. Therefore, Plusoptix can be used to diagnose low-level simple myopia and hyperopia and to detect emmetropia during a pandemic period. However, it should not be forgotten that autorefractometry is the gold standard for higher and/or complex astigmatism and refractive errors.

Keywords: Biometric parameters, photoscreener, Plusoptix A12, refractive error

Introduction

Refractive error is a common condition that can appear at any age. Uncorrected refractive error is the most common cause of visual impairment and the second most common cause of blindness worldwide,[1,2] yet it is easily treated with the proper refractive correction. Detection can be achieved quickly and simply with a classic autorefractometer device. In recent years, photoscreener devices, which are designed for use mostly with children, have been produced. They allow simultaneous data acquisition from both eyes using infrared technology. Their greatest advantage is the ability to take measurements quickly and without the need for cycloplegia. Also, they measure pupil size, pupil distance, and gaze deviation at same time and noninvasively. There are several types of photoscreener devices (Spot Vision Screener, Plusoptix, and iScreen) and there are many studies comparing these devices with cycloplegic autorefractometry and retinoscopy in children,[3-6] but its use in adults is limited.[7,8]

In this study, we aimed to evaluate the effectiveness of the Plusoptix A12 as a photoscreener device in adult patients by comparing it with a classic table top autorefractometer device in this age group. We also compared the spherical equivalent (SE) differences with axial length (AL), anterior chamber depth (ACD), and central corneal thickness (CCT) and investigated the effects of these parameters on its performance. Our aim was to determine whether the Plusoptix A12 could be used in routine practice instead of the autorefractometer, especially during disease outbreaks and, in particular, in the current coronavirus disease 2019 (COVID-19) pandemic when necessary.

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Corresponding author: Meryem Güler Alış, Fatih Sultan Mehmet Training and Research Hospital, İstanbul, Turkey
e-mail: meryem030@hotmail.com
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Methods

This was a prospective, comparative study of 100 eyes (right) of 100 patients. The study was performed in accordance with the Declaration of Helsinki and approved by the ethics committee of İstanbul Fatih Sultan Mehmet Training and Research Hospital Hospital (Date: October 12, 2020; Number: 2020/154). A written informed consent form was obtained from all patients after they were given information about the study. Patients aged 18-55 years with corrected vision of 20/20 and above according to the Snellen chart were included. The subjects included in the study were randomly selected from among the patients who applied to our clinic with a complaint of low vision and with vision above 20/20 as determined by the Snellen chart with refractive correction. Those with a history of ocular surgery or any eye or systemic disease that could cause visual impairment were excluded. All measurements were performed in a room with 200 lux illuminance. First, autorefractometer (ARK-1 Auto Ref-Keratometer, Nidek, Japan) measurements (right eye) were performed on all patients. Next, Plusoptix A12 measurements were taken under monocular (right eye) and binocular (right eye) conditions separately. The patients looked into the Plusoptix A12 from a distance of 1 m. Measurements were taken automatically at the moment of focusing on the eye. In the monocular condition, the left eye was covered using an occluder. Then, ACD, AL, and CCT measurements were made using an optical biometer (AL-Scan Optical Biometer, Nidek, Japan). All measurements were taken by the same experienced ophthalmologist. In addition, all patients underwent complete ophthalmological examinations. The Plusoptix A12 and autorefractometer values were converted to SE, J45, and J0 vectors for statistical analysis. Spherical equivalent was calculated according to the formula spherical + cylindrical/2. J0 and J45 values were calculated according to the formula described by Thibos et al[9]:

$$J0 = -\left[C/2\right] \times \mathrm{Cos}\left[2\alpha\right]$$

$$J45 = -\left[C/2\right] \times \mathrm{Sin}\left[2\alpha\right]$$

C is the cylindrical value and α is the axis.

Autorefractometer measurements were compared with those of the Plusoptix A12 performed under monocular and binocular conditions. The difference between autorefractometer SE and Plusoptix A12 SE was compared to AL, ACD, and CCT.

The compliance of the data with normal distribution was analyzed with the Kolmogorov–Smirnov test, and the measurements were analyzed with Mann–Whitney *U* test in the groups that did not have normal distribution. The reproducibility of the values obtained using both devices was examined using intraclass correlation coefficients (ICCs). Intraclass correlation coefficients reflect agreement between measurements and range from 0 to 1; values closer to 1 represent stronger reliability.[10] Other comparisons of measurements were analyzed for each variable within the limits (mean differences ± 1.96 standard deviation (SD)) using the Bland–Altman graphic plot method. The correlation between quantitative variables was analyzed and interpreted with Spearman's rho correlation coefficient. As descriptive statistics, mean ± SD for numerical variables, median, quarter 1 (Q1: 25th percentile), and quarter 3 (Q3: 75th percentile) for categorical variables were given. Statistical Package for the Social Sciences Windows version 24.0 was used for statistical analysis, and $P < .05$ was considered statistically significant.

Results

The study was conducted with 100 (right) eyes of 100 patients. Of these, 42 were female and 58 were male, and the mean age was 35.67 ± 12.33 years (Table 1). The mean values of the parameters are shown in Table 2. Autorefractometer values were, respectively, spherical: −0.5 [−1.25, 0.25], cylindrical: −0.5 [−1, 0.25], SE: −0.5 [−1.69, 0.25], J0: −0.08 [−0.21, 0.08], and J45: 0.07 [−0.12, 0.25]. Monocular Plusoptix A12 values were, spherical: −0.25 [−2, 0.25], cylindrical: 0.5 [0.25, 1], SE: 0.06 [−1.5, 0.63], J0: 0 [−0.12, 0.12], and J45: −0.03 [−0.2, 0.12]. Binocular Plusoptix A12 values were, spherical: −0.75 [−2, 0.25], cylindrical: 0.5 [0.25, 1], SE: −0.13 [−1.38, 0.38], J0: −0.02 [−0.19, 0.12], and J45: 0.07 [−0.12, 0.16]. When the results of binocular Plusoptix A12 and autorefractometer were compared, no statistically significant differences were found between the spherical and SE values. In addition, the spherical and SE ICC values showed good agreement between the 2 devices (Table 3). Further, no differences were observed in J0 or J45 values (Table 4). In contrast, cylindrical values were statistically different, although they showed a moderate agreement according to ICC. While there was a good agreement between Plusoptix A12 values measured in the monocular condition and autorefractometer values according to ICC values, the spherical, cylindrical, and SE were statistically different (Table 3). There was no difference in terms of J0 and J45 values (Table 4). Bland–Altman plots were used to evaluate the agreement between the Plusoptix A12 and the autorefractometer according to J0 and J45 values (Figures 1 and 2).

When the differences between the autorefractometer's SE value and the monocular Plusoptix A12's SE value were correlated with AL and ACD, a weak positive correlation was detected (Figure 3) (respectively $r = 0.221$, $P = .023$, $r = 0.267$, $P = .007$]. There was no correlation between the binocular Plusoptix A12 measurements and the autorefractometer measurements ($P = .131$].

Table 1. Demographic Features

Age mean ± SD	**35.67 ± 12.33**
Gender	
Male	58 (58%)
Female	42 (42%)

n = 100. SD, standard deviation.

Discussion

In recent years, photoscreener device had become an increasingly utilized option due to its ease of use and its ability to provide measurements quickly. Measurements can be taken in a

Table 2. The Mean Values of Parameters

	Mean ± SD	**Minimum**	**Maximum**
Autorefractometer spherical	−0.49 ± 1.19	−3.50	2.50
Autorefractometer cylindrical	−0.52 ± 0.77	−3.00	0.75
Autorefractometer AKS	92 ± 63	1	180
Autorefractometer SE	−0.67 ± 1.34	−3.88	2.88
Autorefractometer J0	−0.08 ± 0.31	−1.12	0.72
Autorefractometer J45	0.07 ± 0.33	−1.50	0.84
Plusoptix monocular spherical	−0.72 ± 1.78	−5.25	3.50
Plusoptix monocular cylindrical	0.71 ± 0.53	0.25	2.00
Plusoptix monocular AKS	92 ± 52	1	180
Plusoptix monocular SE	−0.29 ± 1.62	−4.38	3.88
Plusoptix monocular J0	0.01 ± 0.29	−1.00	0.81
Plusoptix monocular J45	−0.02 ± 0.34	−0.76	0.87
Plusoptix binocular spherical	−0.80 ± 1.72	−4.75	3.75
Plusoptix binocular cylindrical	0.66 ± 0.42	−0.25	1.50
Plusoptix binocular AKS	89 ± 52	1	179
Plusoptix binocular SE	−0.39 ± 1.53	−4.25	3.38
Plusoptix binocular J0	−0.05 ± 0.29	−0.73	0.69
Plusoptix binocular J45	0.03 ± 0.26	−0.62	0.62
AL	23.38 ±0.79	21.46	25.50
ACD	3.42 ± 0.42	2.55	4.58
CCT	537 ± 35	464	614

SE, spherical equivalent; AL, axial length; ACD, anterior chamber depth; CCT, central corneal thickness.

Table 3. Comparison of Autorefractometer and Plusoptix A12 Refractive Values

		Plusoptix A12		Autorefractometer			
		M [Q1, Q3]	**[min-max]**	**M [Q1, Q3]**	**[min-max]**	**ICC**	***P*[1]**
Spherical	Monocular	0.25 [−2, 0.25]	[−5.25, 3.50]	−0.5 [−1.25, 0.25]	[−3.50, 2.50]	0.908	.005
	Binocular	−0.75 [−2, 0.25]	[−4.75, 3.75]	−0.5 [−1.25, 0.25]		0.822	.116
ICC		0.960					
P[2]		.421					
Cylindrical	Monocular	0.5 [0.25, 1]	[−0.25, 2.00]	−0.5 [−1, 0.25]	[−3.00, 0.75]	0.732	**<.001**
	Binocular	0.5 [0.25, 1]	[−0.25, 1.50]	−0.5 [−1, 0.25]		0.617	**<.001**
ICC		0.849					
P[2]		.904					
SE	Monocular	0.06 [−1.5, 0.63]	[−4.38, 3.88]	−0.5 [−1.69, 0.25]	[−3.88, 2.88]	0.884	**<.001**
	Binocular	−0.13 [−1.38, 0.38]	[−4.25, 3.38]	−0.5 [−1.69, 0.25]		0.886	.131
ICC		0.949					
P[2]		.386					

[1]*P*, comparison between autorefractometer and Plusoptix A12; [2]*P*, comparison between monocular and binocular conditions.
ICC, intraclass coefficient; SE, spherical equivalent; M, median; Q1, quartile 1 (25th percentile); Q3, quartile 3 (75th percentile).

few seconds from a distance of about 1 m with no need for the patient to make physical contact with the device. Additional advantages include its ability to measure both monocularly and binocularly, to measure pupil size, and to detect the presence of strabismus. Since it is most commonly used to determine risk factors for amblyopia in childhood, studies have generally addressed this population.[11-13] Because of the misleading effect of accommodation in children, the gold standard is to take a refractive measurement with cycloplegia.[14,15] Therefore, the photoscreener has generally been compared with cycloplegic autorefractometry and/or retinoscopy in children.[16-18] Some studies conducted with adults have claimed that measurements with cycloplegia should be made in this age group as well.[19,20] In the present study, we used Plusoptix A12 as a photoscreener. In one of their studies, Teberik et al[21] compared different photoscreener devices for use with children and concluded that cycloplegia can be eliminated for detecting refractive errors with the Plusoptix A12 device. Although some studies advocate the necessity of measurement with cycloplegia,[19,20] it is generally not used for refraction examinations in adults[22]; moreover, in clinical practice, refraction measurements in adults are often performed without cycloplegia and are prescribed according to these results. Since our aim in this study was to evaluate the effectiveness of a photoscreneer in clinical practice, we did not take measurements with cycloplegia and did not compare the measurements to cycloplegia autorefractometer measurements. Moreover, very few studies have examined the effectiveness of photoscreeners in adults and all of them have used Spot Vision Screener (Welch allyn) as a photoscreener device.[7,8,23] The present study is the first study to investigate the performance of Plusoptix A12 in adults. In our study, when the autorefractometer values were compared to the binocular Plusoptix A12 values, no statistically significant difference was observed in spherical, SE, J0, or J45 values. In contrast, a statistically significant difference between the values of

Table 4. Comparison of J0 and J45 Values of Autorefractometer and Plusoptix A12

		Plusoptix A12		Autorefractometer		
		M [Q1, Q3]	**[min-max]**	**M [Q1, Q3]**	**[min-max]**	***P*[1]**
J0	Monocular	0 [−0.12, 0.12]	[−1.00, 0.81]	−0.08 [−0.21, 0.08]	[−1.12, 0.72]	.064
	Binocular	−0.02[−0.19, 0.12]	[−0.73, 0.69]	−0.08 [−0.21, 0.08]		.185
P[2]		0.543				
J45	Monocular	−0.03 [−0.2, 0.12]	[−0.75, 0.87]	0.07 [−0.12, 0.25]	[−1.50, 0.84]	.100
	Binocular	0.07 [−0.12, 0.16]	[−0.62, 0.62]	0.07 [−0.12, 0.25]		.519
P[2]		.133				

[1]*P*, comparison between autorefractometer and Plusoptix A12; [2]*P*, comparison between monocular and binocular conditions.
M, median; Q1, quartile 1 (25th percentile); Q3, quartile 3(75th percentile).

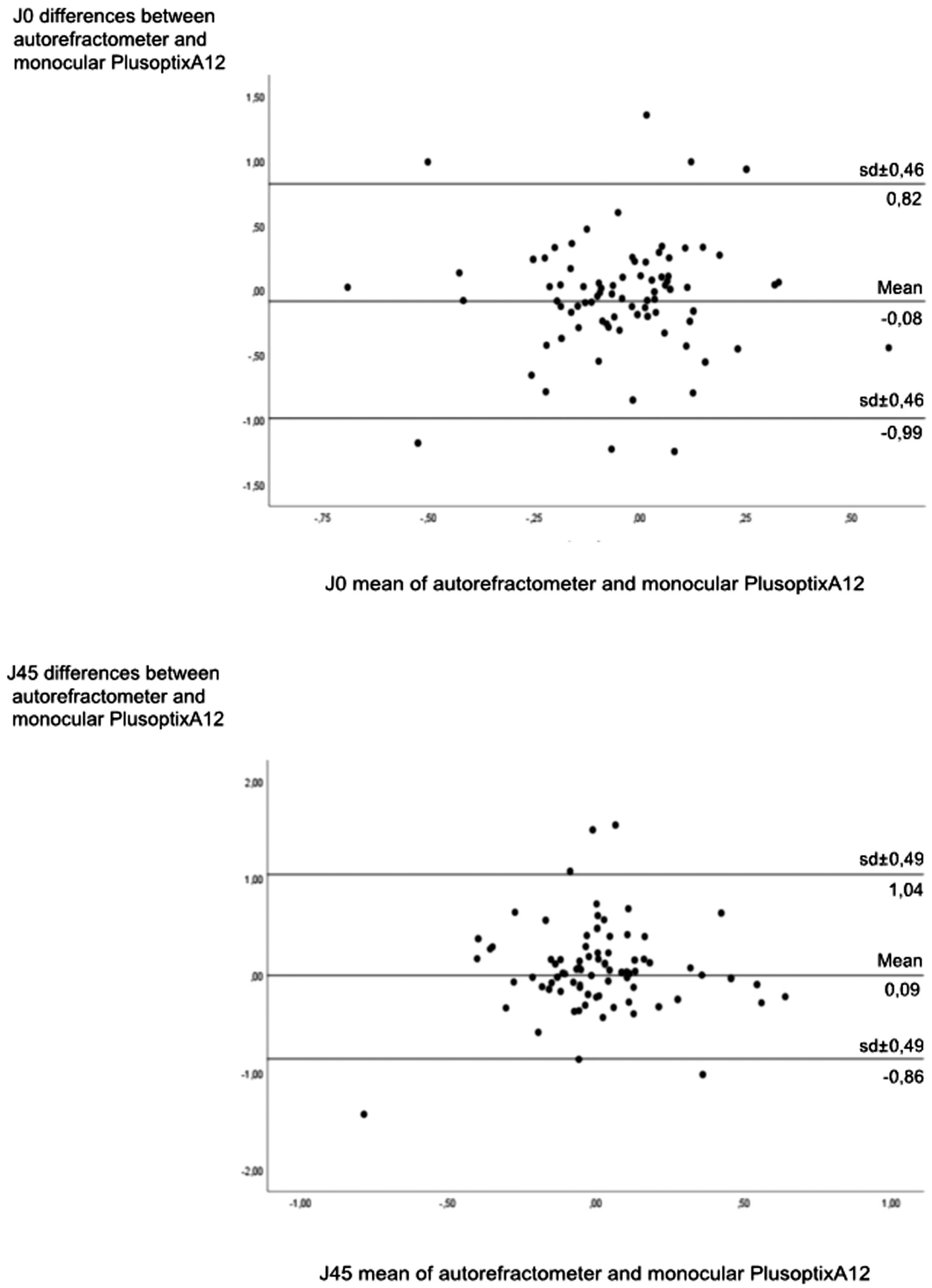
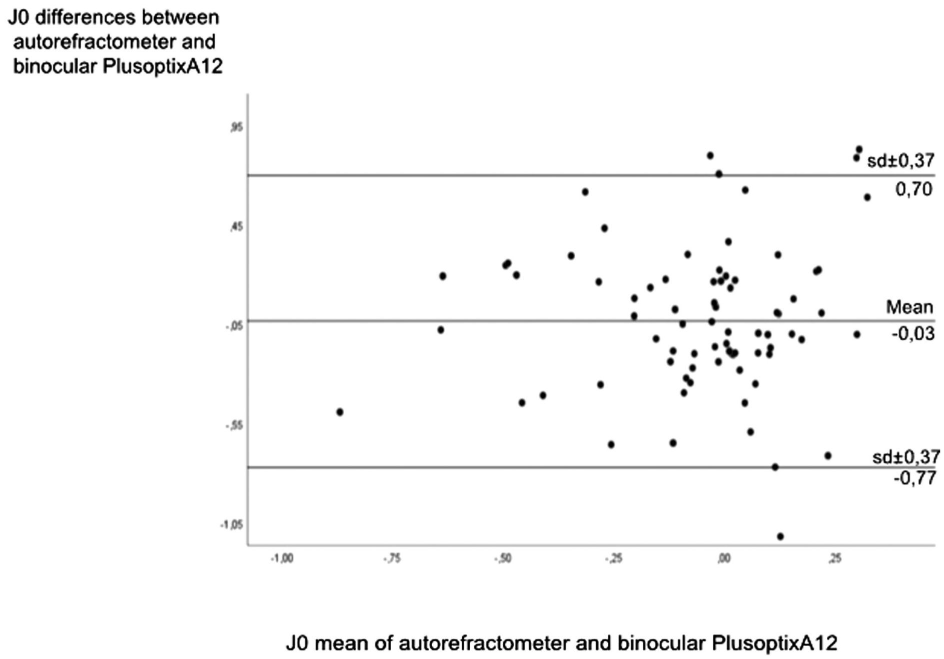


Figure 1. J0 and J45 means in autorefractometer and monocular Plusoptix A12.

the autorefractometer and the monocular Plusoptix A12 values in terms of spherical and SE values was observed. Cylindrical values differed significantly between both the monocular and binocular Plusoptix A12 and the autorefractometer.

However, there was no statistically significant difference between the monocular and binocular values of Plusoptix A12 measurements. Panda et al[7] compared the Spot Vision Screener values with retinoscopy in their study of individuals aged 4-75 years. They reported a statistically significant difference in spherical, cylindrical, SE, and J45 values. As a result, they stated that Spot Vision Screener in adults is not highly reliable.[7] In another study by Jesus et al.[8] the values of autorefractometer and Spot Vision Screener (Welch Allyn) were compared in individuals aged 4-50 years. They reported a statistically significant difference, but it was not clinically significant. Therefore, they claimed that Spot Vision Screener was safe in adults.[8] Another study comparing Spot Vision Screener with autorefractometer in adults was conducted by Satou et al[23] They compared binocular and monocular Spot Vision Screener values with an autorefractometer with binocular and monocular features and reported that, although there was a statistically significant difference, both devices gave similar results according to ICC values. They suggested that the Spot Vision Screener can be used safely when necessary.[23] In a study by Czinder,[24] comparing the handheld photoscreener with the autorefractometer, the pass/fail criteria were determined as follows: ±1.00 diopter of the end sphere, ±0.75 diopters from the last cylinder power, and ±10 degrees from the last axis. In an evaluation of our results according to this reference range, it can be said that the Plusoptix A12, especially the binocular, provided values close to those measured with a table top autorefractometer in simple myopia without astigmatism and in simple hyperopia without astigmatism.



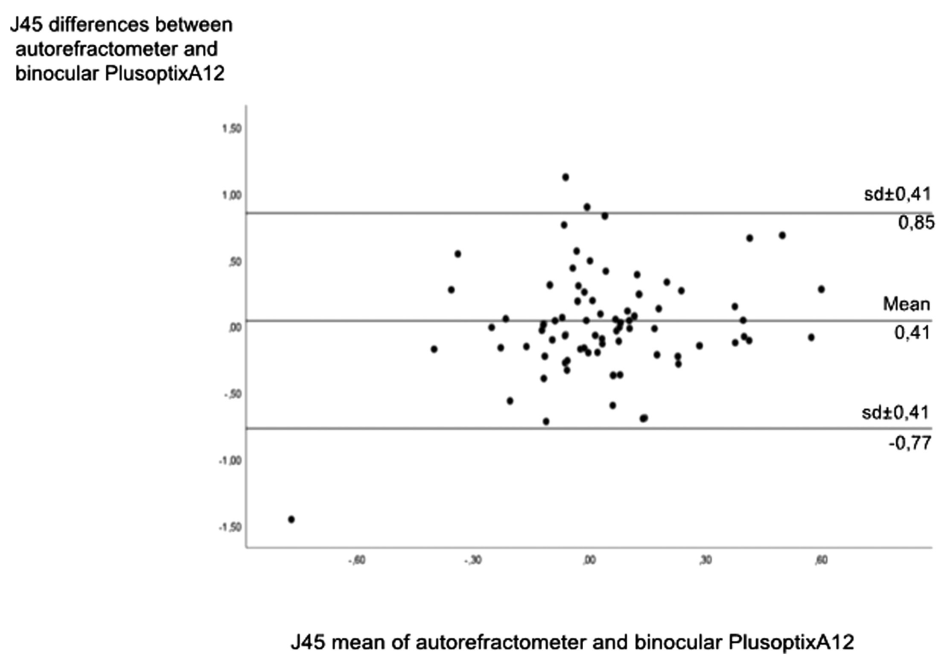
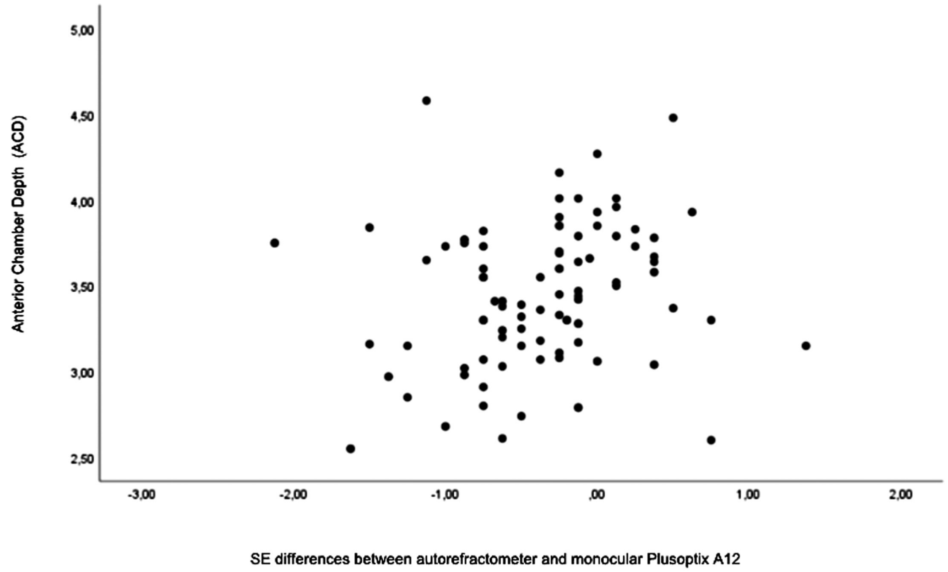


Figure 2. J0 and J45 means in autorefractometer and binocular Plusoptix A12.

The Bland–Altmann analysis enables more realistic comparisons than correlation analysis in the context of comparing data measured by different devices. As a result of this analysis method, the consistency of the measurements obtained with 2 different devices could be evaluated by considering how much the devices differed in 95% of the measurements made.[25] In this study, the consistencies of the mean J0 and J45 measurements of the 2 devices were evaluated in pairs using the Bland–Altmann analysis, and we observed that the measurement differences obtained in the majority of pairs were within ±1 SD. Accordingly, the mean of the J0 difference distribution between the autorefractometer and the monocular Plusoptix measured in this study was −0.08, and the average of the J0 difference distribution between the autorefractometer and the binocular Plusoptix was −0.03. The mean of the J45 difference distribution between the autorefractometer and the monocular Plusoptix A12 was 0.09, and the average of the J45 difference distribution between the autorefractometer and the binocular Plusoptix A12 was 0.04. Since there is no statistically significant difference, it can be said that the 2 devices are comparable in detecting vector defects.

Gwiazda et al.[26] in their study comparing 3 different autorefractometers, stated that an open-field binocular autorefractor resulted in larger hyperopic or smaller myopic values than a closed-vision monocular autorefractor. In another study, it was reported that monocular values are more myopic than binocular values in subjective refraction measurements and that binocular measurement is more



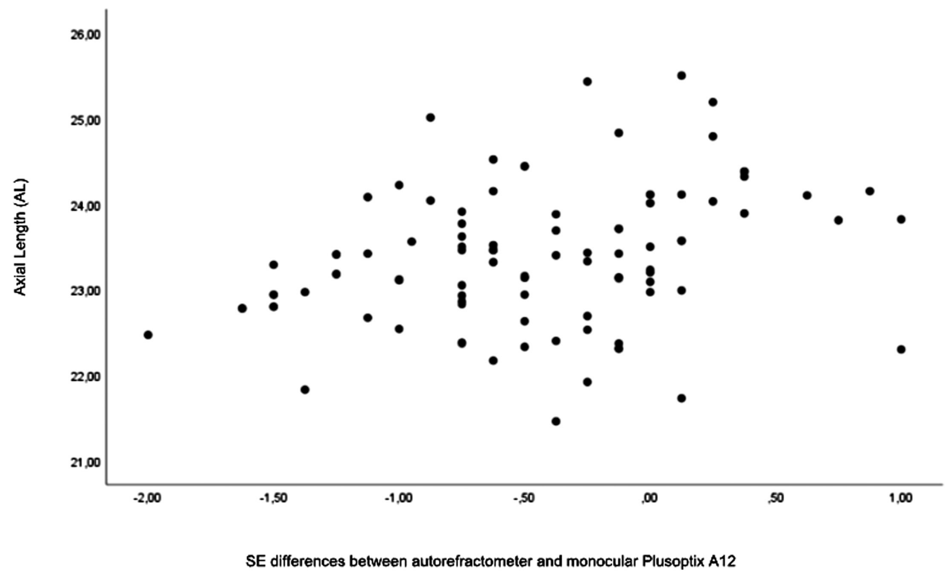


Figure 3. Correlation between biometric parameters and spherical equivalent differences of autorefractometer and monocular Plusoptix A12.

reliable.[27] In the present study, we found no differences between Plusoptix A12 measurements performed under monocular and binocular conditions. The fact that Plusoptix A12 measurement in binocular conditions is easier, faster, and closer to a natural view is an advantage. In addition, the fact that it does not show a statistical difference when compared with autorefractometer measurements should be a primary reason for its preferential use.

Comparing SE differences of the autorefractometer and the Plusoptix A12 with ACD and AL, we found a weak positive correlation between monocular Plusoptix A12 and autorefractometer. There was no correlation between binocular Plusoptix A12 and autorefractometer. However, we do not think that our results can be generalized: the AL, ACD, and CCT values of our patients were within the normal range and differences may occur in a correlation analysis at lower and higher values.

Contrary to our findings, Yakar[28] reported a negative correlation when comparing SE differences between the autorefractometer and Spot Vision Screener with cycloplegia in children with ACD and AL. This difference may be related to the differences in the age groups and devices used.

The strength of our study is that we compared the Plusoptix A12 with the autorefractometer in both monocular and binocular conditions for the first time in adults. However, the somewhat low number of our patients can be considered a weakness. Other limitations of our study include the narrow range of refractive and biometric values, the absence of high myopic and hyperopic values, no comparison with measurements with cycloplegia, and no subgroup analysis.

In short, in simple myopia without astigmatism, simple hyperopia without astigmatism, and emmetropia, we found that the Plusoptix A12 in binocular conditions provides results similar to those provided by an autorefractometer. Although the astigmatic values were low, they differed significantly between the 2 devices. Given that the prescription is established subjectively according to the patient's response, we can rely on Plusoptix A12 in binocular conditions for simple myopia without astigmatism and for simple hyperopia without astigmatism.

Photoscreeners are generally used for screening in children: retinoscopy is the gold standard, but when necessary, photoscreener devices can be used in children and patients with cognitive or orthopedic problems that impede measurement by autorefractometry. While the autorefractometer is the gold standard in adults, the Plusoptix A12 is fast, easy to use, and does not require physical contact with the device itself; therefore, we argue that in simple myopia without astigmatism and hyperopia without astigmatism, the Plusoptix A12 can be used binocularly instead of an autorefractometer in routine practice in adults to prevent the spread of viruses and bacteria—which is especially important in the current COVID-19 pandemic. Nevertheless, it should always be kept in mind that autorefractometry is the gold standard and that the results obtained with Plusoptix A12 in high myopia, hyperopia, and astigmatism should not be trusted. We think that more precise results could be achieved in studies with larger numbers of patients, a wide refraction range, and the inclusion of measurements with cycloplegia.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Health Science University, İstanbul Fatih Sultan Mehmet Training and Research Hospital (Date: October 12, 2020; Number: 2020/154).

Informed Consent: Written informed consent was obtained from all patients after they were given information about the study.

Peer-review: Externally peer-reviewed.

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