Original Article

Comparison of Spot Vision Screener and Tabletop Autorefractometer with Retinoscopy in the Pediatric Population

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Abstract

Objectives: Determining the accuracy of cycloplegic refractive error measurements made with the Spot Vision Screener (SVS, Welch Allyn Inc, Skaneateles Falls, NY, USA) is important for refractive assessment of uncooperative patients during optometric examinations. This study compared cycloplegic refractive errors measured by SVS and tabletop autorefractometer to cycloplegic retinoscopy in children.

Materials and Methods: Eighty-eight eyes of 44 subjects were examined in the study. Refractive error measurements were obtained under cycloplegia using retinoscopy, SVS, and Nidek ARK-530 tabletop autorefractometer (ARK-530, Nidek, Japan). Spherical and cylindrical values, spherical equivalents (SE), and Jackson cross-cylinder values at axes of 0° (J0) and 45° (J45) were recorded. Correlations between methods were analyzed using intraclass correlation coefficient (ICC) and Bland-Altman analysis.

Results: The mean age was 7 years (range: 6 months-17 years). Sixteen (36%) of the subjects were female and 28 (64%) were male. For SE there was excellent agreement between retinoscopy and SVS (ICC: 0.924) and between retinoscopy and tabletop autorefractometer (ICC: 0.995). While there was a moderate correlation between retinoscopy and SVS for cylindrical values (ICC: 0.686), excellent correlation was detected between retinoscopy and autorefractometer (ICC: 0.966). J0 and J45 cross-cylinder power values were not correlated between retinoscopy and SVS (ICC: 0.472) or retinoscopy and tabletop autorefractometer (ICC: 0.442). Retinoscopy was correlated with both SVS and tabletop autorefractometer for all parameters within ±1.96 standard deviations in Bland-Altman analysis.

Conclusion: Cycloplegic retinoscopy is the gold standard for refractive error measurement in the pediatric population. However, it requires time and experienced professionals. This study revealed moderate to good agreement between SVS and retinoscopy, with better agreement in spherical errors than cylindrical errors. Although the SVS is intended for screening programs, it may also be useful in the pediatric eye office to estimate spherical refractive error in uncooperative patients.

Keywords: Autorefractometry, photoscreening, refraction, retinoscopy, Spot Vision Screener

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Introduction

Visual system maturation continues throughout childhood, a period in which untreated ocular pathologies can lead to amblyopia at a prevalence of up to 2%.[1] A recent study on visually impaired children revealed that almost one-third of cases were due to avoidable reasons.[2] Detection and treatment of refractive errors is one of the most important tasks in ophthalmologic examination of the pediatric age group, especially in preschool age, to prevent amblyopia.[3] The gold-standard method for measurement of refractive errors in children is cycloplegic retinoscopy, which is a basic necessary skill for every ophthalmologist. In addition, various handheld autorefractometers and screeners that can make approximations of refractive errors in a few seconds have been developed in recent years. In clinical practice, these devices are used by non-ophthalmologist healthcare professionals to detect children who have risk factors of amblyopia. However, the ability of these devices to measure refractive errors correctly remains a subject of investigation.[4,5,6]

The Welch-Allyn Spot Vision Screener (SVS) is a new handheld infrared photoscreener designed to detect refractive errors along with pupil size, interpupillary distance, and ocular alignments.[7] It is already shown to be an effective device for community screening of amblyopia risk factors. In several studies performed with various age groups, it was reported to have a sensitivity of 60.9-89.8% and specificity of 70.4-94.9%, with a tendency to overlook hyperopia.[8,9,10,11] To compare, the sensitivity and specificity of a handheld autorefractometer was reported as 95% and 94%, respectively.[12] The purpose of this study was to compare the cycloplegic refractive measurements of the SVS with those of a tabletop autorefractometer and retinoscope, and determine if the SVS used with cycloplegia would provide measurements that have acceptable agreement with cycloplegic retinoscopy in the pediatric age group.

Materials and Methods

In this cross-sectional study, 88 eyes of 44 children were examined for refractive errors in the ophthalmology department of a tertiary level hospital. Patients with strabismus and any ocular pathology that prevented reliable measurement (e.g., corneal scars and cataracts) were excluded from study. The study was performed in compliance with the ethical principles of the Declaration of Helsinki and was approved by the Ankara University Clinical Research Ethics Comittee (registration number: 2023/415, decision no: İ06-430-23, date: 27.07.2023). A written informed consent form was obtained from the parents or guardians of all subjects before examination. After a complete ophthalmologic examination, 1% cyclopentolate hydrochloride eye drops (Sikloplejin, Abdi İbrahim, Türkiye) were applied to all eyes twice with a 5-minute interval. After adequate cycloplegia (waiting period of 45 minutes on average), measurements were obtained consecutively with a retinoscope, SVS (Welch Allyn, Skaneateles Falls, NY, USA), and tabletop autorefractometer (ARK-530, Nidek, Japan). Retinoscopy was performed and recorded before the autorefractometer and SVS measurements to avoid bias. For SVS measurements, the device was held approximately 1 meter away from the patient. While the patient focused on the display of twinkling lights and sounds of the device, the measurement was obtained in approximately 2 seconds. As a screening device, the SVS is not designed to be used with cycloplegia. However, in this study assessments were performed after cycloplegia to compare its efficacy to that of the tabletop autorefractometer and retinoscopy under cycloplegia. Patients with adequate cooperation (children aged 4 years and older) were placed with their forehead on the forehead rest of the tabletop autorefractometer and measurement was performed. The mean spherical and cylindrical values and spherical equivalents (SE) were recorded for all three methods. In addition, Jackson cross-cylinder values at axes of 0° (J0) and 45° (J45) were calculated to compare the variance in the astigmatic component between devices. SE was calculated as sphere + cylinder/2; J0 power as -(cylinder/2) x cos(2α); and J45 power as -(cylinder/2) x sin(2α), where α represents the axis value.[13]

Statistical Analysis

Data from right and left eyes were analyzed separately to prevent bias associated with interdependence of observations from the same subject. All statistical analyses were performed with the SPSS software package (version 22.0, IBM Corp., Armonk, NY, USA). The normality of distribution and the homogeneity of variances of the data were tested using the Shapiro-Wilk test. Based on the results, all parameters were analyzed by non-parametric tests. Wilcoxon signed-rank test was used to compare the spherical, cylindrical, SE, J0, and J45 values obtained with SVS, tabletop autorefractometer, and retinoscope. The degree of agreement between methods was evaluated using intraclass correlation coefficient (ICC). ICC values range from 0 to 1, and higher ICC indicates closer agreement between the compared methods. ICC values of 0.00-0.50, 0.50-0.75, 0.75-0.90, and 0.90-1.00 were interpreted as poor, moderate, good, and excellent correlation, respectively. Negative ICC values were considered unreliable for comparison. Bland-Altman plot and 95% limits of agreement, which was calculated as mean ±1.96 standard deviations (SD) of the inter-device difference, were used to visualize the level of correlation between two given methods.

Results

Eighty-eight eyes of 44 children were examined in the study; 16 (36%) of the subjects were female and 28 (64%) were male. The mean age was 7 years (range: 6 months-17 years). Ten (23%) of the cases were infants and toddlers (aged 0-3 years), 7 (16%) were preschool age (4-5 years), 22 (50%) were school age (6-11 years), and 5 (11%) were adolescents (aged 12-17 years). All subjects underwent SVS and retinoscopy measurements. Thirty-one (70.4%) cooperative subjects also underwent tabletop autorefractometer measurement, 4 (13%) of whom were preschoolers, 22 (71%) were school age, and 5 (16%) were adolescents. None of the infants and toddlers underwent autorefraction. The mean age of subjects who underwent autorefraction was 9 years (range: 4-17 years). The mean spherical values as measured by cycloplegic SVS, tabletop autorefractometer, and retinoscopy were 1.3±3.5 diopters (D), 1.1±4.6 D, and 1.0±3.9 D for the right eye and 1.7±3.3 D, 1.4±4.6 D, and 1.3±3.9 D for the left eye, respectively. There were no significant differences in spherical value between cycloplegic tabletop autorefractometer and cycloplegic retinoscopy for both right and left eyes ($p>0.05$). However, the mean spherical value obtained from SVS was more hyperopic than cycloplegic retinoscopy for the left eye ($p=0.02$). The mean SE value obtained with SVS was statistically significantly more hyperopic than retinoscopy for both eyes ($p=0.003$). There were no significant differences between SVS and retinoscopy in terms of cylindrical, J0, or J45 values (Wilcoxon signed rank test $p>0.05$). The mean spherical, cylindrical, SE, J0, and J45 values and results of statistical analysis are shown in Table 1.

For SE values, there was good to excellent agreement between retinoscopy and SVS (ICC: 0.924 and 0.888 for right and left eyes, respectively) and excellent agreement between retinoscopy and tabletop autorefractometer (ICC: 0.995 and 0.991 for right and left eyes, respectively).

For cylindrical values, the correlation between retinoscopy and SVS was noted to be moderate (ICC: 0.686 and 0.622 for right and left eyes, respectively), but good to excellent agreement was detected between retinoscopy and tabletop autorefractometer (ICC: 0.838 and 0.966 for right and left eyes, respectively). J0 and J45 cross-cylinder power values determined by the SVS showed poor correlation with retinoscopy (J0: ICC=0.156 and 0.291, J45: ICC=0.472 and 0.278 for right and left eyes, respectively). There was also poor correlation between J45 cross-cylinder power values obtained by tabletop autorefractometer and retinoscopy (ICC=0.442 for the right eye). Negative ICC values were not taken into consideration (Table 2). However, Bland-Altman analysis showed that both the SVS and tabletop autorefractometer were compatible with retinoscopy for all parameters in the range of ±1.96 SD (Table 3, Figures 1, 2).

Discussion

Photoscreening and autorefraction devices are the preferred method for detecting refractive errors and amblyogenic risk factors in younger children.[14,15] Handheld autorefractors and photoscreeners are often able to provide a fast refractive measurement in uncooperative children and disabled patients. The reliability and validity of various autorefractometer and photoscreener models have been reported in the literature.[16,17,18,19,20,21]

The SVS is a photoscreener that has been evaluated in detail in multiple studies and is proven to be a good screening device for amblyopia risk factors in children.[8,9,10,22,23,24,25,26,27,28] Its sensitivity to detect refractive errors was reported to range between 60.9% and 96.0% and its specificity between 70.4% and 95.0% in various studies performed with children in different age groups.[8,9,10] However, a more recent study showed that although the device's overall sensitivity for refractive errors was 82.35%, its sensitivity for hyperopia was 27.27%, indicating a failure to overcome accommodation or an intrinsic technical weakness for the detection of hyperopia.[9]

This study stands out from previous ones in that it was designed to compare the refractive error measurements of retinoscopy, tabletop autorefractometer, and SVS under

Table 1. Refractive values obtained with the Spot Vision Screener, retinoscopy, and tabletop autorefractometer under cycloplegia

	Variables	Spot Vision Screener (n=44)	Retinoscopy (n=44)	Tabletop autorefractometer (n=31)	p 1	p 2
Right eye	**Sphere (D)** Mean ± SD Median (min/max)	1.3±3.5 0.75 (-7.5/7.0)	1.0±3.9 1.12 (-15.5/6.5)	1.1±4.6 2.25 (-16.0/6.5)	0.051	0.345
	Cylinder (D) Mean ± SD Median (min/max)	1.3±1.4 0.8 (-0.5/5.5)	1.3±1.3 1.0 (-0.5/4.5)	1.2±1.5 0.7 (-2.0/4.75)	0.209	0.680
	SE (D) Mean ± SD Median (min/max)	2.02±3.3 1.6 (-7.5/7.5)	1.7±3.7 1.7 (-13.75/6.9)	1.7±4.3 1.9 (-14.5/7.0)	0.003	0.176
	J0 (D) Mean ± SD Median (min/max)	0.1±0.6 0.05 (-1.7/2.1)	0.2±0.5 0.1 (-1.6/1.3)	0.1±0.7 0.08 (-1.7/2.1)	0.194	0.339
	J45 (D) Mean ± SD Median (min/max)	0.1±0.7 0.01 (-1.7/2.2)	0.3±0.6 0.2 (-1.5/1.8)	0.05±0.6 -0.05 (-1.5/2.2)	0.388	0.026
Left eye	**Sphere (D)** Mean ± SD Median (min/max)	1.7±3.2 1.4 (-7.5/7.25)	1.3±3.9 1.1 (-16.5/6.5)	1.4±4.6 2.0 (-16.75/7.0)	0.023	0.907
	Cylinder (D) Mean ± SD Median (min/max)	1.3±1.4 1.1 (-1.0/5.25)	1.3±1.4 0.8 (-0.75/5.5)	1.6±1.6 1.0 (-0.5/5.0)	0.185	0.089
	SE (D) Mean ± SD Median (min/max)	2.3±3.1 2.0 (-7.5/7.9)	1.9±3.6 1.6 (-14.75/6.6)	2.1±4.3 2.6 (-14.75/7.2)	0.003	0.457
	J0 (D) Mean ± SD Median (min/max)	0.1±0.6 0.1 (-2.2/1.4)	0.1±0.6 0.1 (-2.7/1.3)	0.06±0.8 0.04 (-1.4/1.8)	0.599	0.456
	J45 (D) Mean ± SD Median (min/max)	0.1±0.7 0.02 (-1.9/2.4)	0.09±0.7 0.1 (-2.2/1.8)	-0.1±0.8 -0.9 (-1.9/1.5)	0.953	0.198

p 1: Retinoscopy vs. Spot Vision Screener, Wilcoxon signed rank test, p 2: Retinoscopy vs. tabletop autorefractometer, Wilcoxon signed rank test, SD: Standard deviation, min/max: Minimum/maximum, D: Diopters, SE: Spherical equivalent, J0: Jackson cross-cylinder at the 0° axis, J45: Jackson cross-cylinder at the 45° axis cycloplegia. The SVS and retinoscopy showed high agreement in terms of spherical and SE values according to ICC analysis. Mean spherical and SE values obtained with the SVS were both slightly more hyperopic than retinoscopy, although statistically insignificant. Our findings show that under cycloplegia, SVS is highly effective in the measurement of spherical refractive errors. Similarly, a study that compared the performance of the SVS for refractive error measurement before and after cycloplegia revealed that its sensitivity increased from 60.9% to 85.3%.[9] On the other hand, a recent study reported that the reliability of SVS measurements under cycloplegia decreased in eyes with high myopia.[29]

Agreement for cylindric values and J0 and J45 cross-cylinder power values was moderate to poor between the SVS and retinoscopy according to ICC. These findings agree with the literature, which reports lower sensitivity and specificity for astigmatism than spherical values.[8,22,23,24,25] Barugel et al.[9] reported 78.57% sensitivity and 89.71% specificity for astigmatism, which was lower than the overall sensitivity and specificity. Srinivasan et al.[28] stated that the device overestimated astigmatism in a patient group 6-36 months of age, with a greater difference in mean values at higher SE values. On the other hand, Bland-Altman plots showed that the SVS was compatible with retinoscopy for all parameters within the range of ±1.96 SD. This suggests that the statistical differences between the devices may be considered clinically insignificant, and SVS may be useful for obtaining a fast approximation of refractive error in disabled and uncooperative patients. In another study, de Jesus et al.[30]

Table 2. Agreement of cycloplegic Spot Vision Screener and Q Nidek QRK-530 tabletop autorefractometer with retinoscopy measurements according to intraclass correlation coefficients

	Variables	Spot Vision Screener vs. retinoscopy				Autorefractometer vs. retinoscopy			
		ICC	95% Confidence interval		p	ICC	95% Confidence interval		p
			Lower bound	Upper bound			Lower bound	Upper bound	
Right eye	Sphere	0.906	0.804	0.847	<0.001	0.995	0.990	0.998	<0.001
	Cylinder	0.686	0.491	0.816	<0.001	0.836	0.691	0.918	<0.001
	SE	0.924	0.865	0.958	<0.001	0.995	0.989	0.997	<0.001
	J0	0.156	-0.150	0.433	0.156	-0.403	-0.681	-0.45	0.986
	J45	0.472	0.210	0.672	0.001	0.442	0.122	0.682	0.003
Left eye	Sphere	0.866	0.767	0.924	<0.001	0.992	0.983	0.996	<0.001
	Cylinder	0.622	0.400	0.775	<0.001	0.966	0.928	0.984	<0.001
	SE	0.888	0.803	0.938	<0.001	0.991	0.981	0.996	<0.001
	J0	0.291	-0.009	0.541	0.028	-0.354	-0.656	0.026	0.967
	J45	0.278	-0.20	0.530	0.034	-0.583	-0.805	-0.253	1.000

ICC: Intraclass correlation coefficient, SE: Spherical equivalent, J0: Jackson cross-cylinder at the 0° axis, J45: Jackson cross-cylinder at the 45° axis

Table 3. Agreement of cycloplegic Spot Vision Screener and Q Nidek QRK-530 tabletop autorefractometer with retinoscopy measurements assessed with Bland-Altman analysis

		Spot Vision Screener vs. retinoscopy			Autorefractometer vs. retinoscopy		
	Variables	MD	SD	95% LOA (MD ± 1.96 SD)	MD	SD	95% LOA (MD ± 1.96 SD)
Right eye	Sphere	0.05	1.52	-2.9-3.0	-0.04	0.44	-0.9-0.8
	Cylinder	-0.06	1.03	-2.08-1.9	-0.05	0.3	-0.65-0.54
	SE	0.05	1.37	-2.6-2.7	0.03	0.44	-0.84-0.9
	J0	-0.006	0.5	-1.05-1.04	-0.08	0.27	-0.62-0.45
	J45	-0.003	0.52	-1.02-1.02	0.1	0.47	-0.8-1.03
Left eye	Sphere	-0.02	1.68	-3.3-3.2	-0.03	0.60	-1.2-1.1
	Cylinder	-0.1	1.03	-2.1-1.9	-0.17	0.34	-0.8-0.5
	SE	0.01	1.63	-3.1-3.2	-0.1	0.58	-1.2-1.03
	J0	-0.06	0.5	-1.1-1.02	-0.09	0.39	-0.8-0.6
	J45	-0.002	0.6	-1.2-1.2	-0.03	0.35	-0.7-0.6

MD: Mean difference, SD: Standard deviation, LOA: Limits of agreement, SE: Spherical equivalent, J0: Jackson cross-cylinder at the 0° axis, J45: Jackson cross-cylinder at the 45° axis

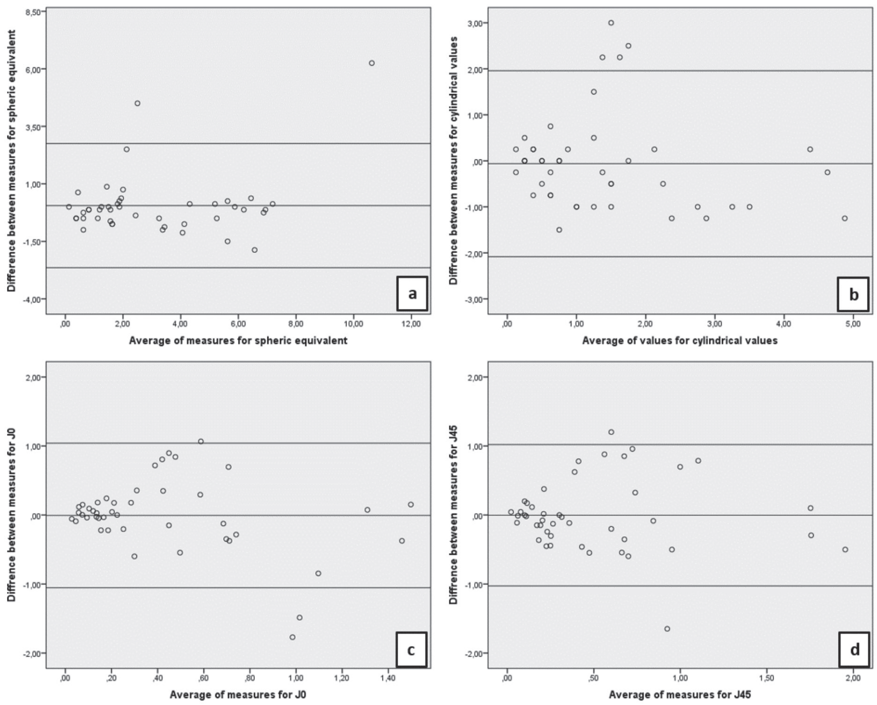

Figure 1. Analysis of agreement between cycloplegic Spot Vision Screener and retinoscopy measurements of spherical equivalent (a), cylindrical values (b), J0 values (c), and J45 values (d) with Bland-Altman plot. The middle line indicates the mean difference; the top and bottom lines show the 95% limits of agreement

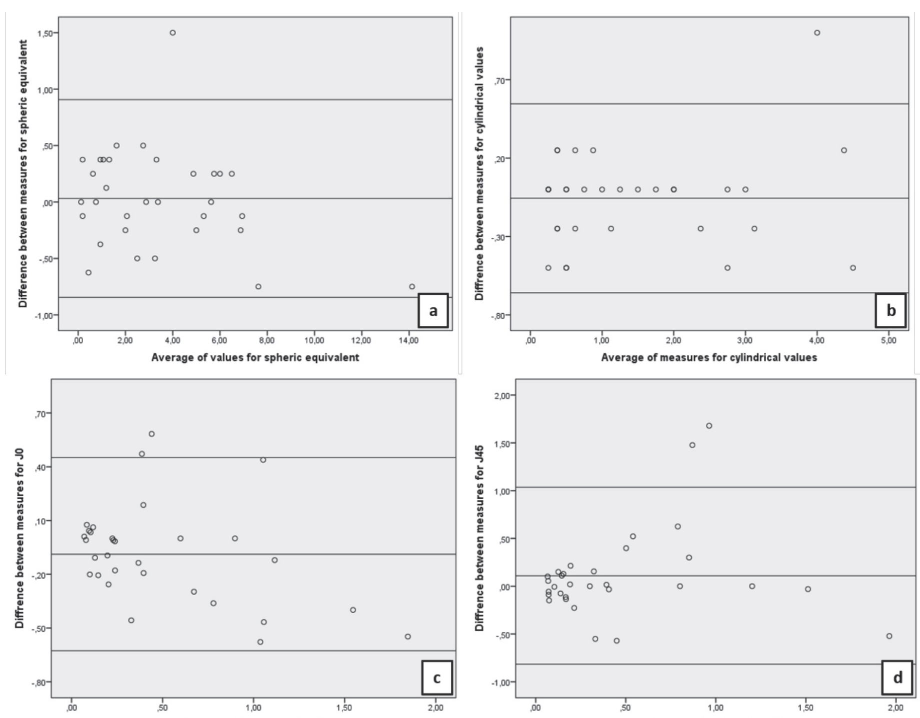

Figure 2. Analysis of agreement between cycloplegic tabletop autorefractometer and retinoscopy measurements of spherical equivalent (a), cylindrical values (b), J0 values (c), and J45 values (d) with Bland-Altman plot. The middle line indicates the mean difference; the top and bottom lines show the 95% limits of agreement

evaluated the efficacy of the SVS in measuring refractive errors under cycloplegia in a patient group ranging from 7 to 50 years of age. Although some statistically significant differences in SE, 90° axis, and 45° axis measurements were observed between SVS and retinoscopy, the authors of the study concluded that these differences were of little relevance in clinical settings and reported SVS as a reliable ancillary method for refractive error measurements.

We also compared the accuracy of cycloplegic tabletop autorefractometer with retinoscopy to evaluate the role of these devices in ophthalmic practice. Excellent agreement was found between tabletop autorefractometer and retinoscopy for spherical, cylindrical, and SE values obtained under cycloplegia. However, J0 and J45 cross-cylinder power values showed poor correlation with retinoscopy according to ICC analysis. Bland-Altman analysis showed that both SVS and tabletop autorefractometers were compatible with retinoscopy with all parameters in the range of ±1.96 SD. Previous studies have shown a good correlation between cycloplegic autorefractometer and retinoscopy measurements.[31,32] Choong et al.[32] compared three different autorefractometers and subjective refraction with cycloplegia and reported that all three autorefractors, including tabletop autorefractor, were accurate under cycloplegia as they found little difference for spherical, cylindrical, or axis values.

Study Limitations

Limitations of the present study are the small sample size and few subjects with high refractive errors. As a result, the performance of the SVS in patients with high D refractive errors may not have been sufficiently tested. Another limitation is the uneven age distribution between groups. The higher agreement of the tabletop autorefractometer with retinoscopy than that of the SVS may be because autorefraction was performed on more cooperative patients over the age of 4 years. On the other hand, only 23% of the children that underwent SVS measurements were in the 0-3 age group, which may have led to an underrepresentation of the refractive error measurements in more difficult and uncooperative cases.

Conclusion

According to the results of our small study, it seems that SVS may provide accurate refractive error measurements under cycloplegia. In contrast to its tendency to underdiagnose hyperopia in non-cycloplegic conditions, SVS measurements under cycloplegia showed excellent agreement with retinoscopy for spherical values under cycloplegia. While its agreement with retinoscopy was lower for cylindrical values and astigmatism, it seems to be acceptable in clinical conditions. Therefore, cycloplegic SVS measurements may be used as a tool to guide unexperienced clinicians assessing uncooperative or disabled patients. More studies are necessary to test its efficacy in cases of higher refractive errors.

Ethics

Ethics Committee Approval: Ankara University Clinical Research Ethics Committee (registration number: 2023/415, decision no: İ06-430-23, date: 27.07.2023).

Informed Consent: Obtained.

Authorship Contributions

Surgical and Medical Practices: M.A.E., H.N.B., H.A., Concept: M.A.E., H.N.B., H.A., Design: M.A.E., H.N.B., H.A., Data Collection or Processing: M.A.E., H.N.B., Analysis or Interpretation: M.A.E., H.N.B., H.A., Literature Search: M.A.E., H.N.B., Writing: M.A.E., H.N.B., H.A.

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