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Original Article

Effect of cycloplegia on refractive errors measured with three different refractometers in school-age children

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Aim: To compare 3 different refractometers with and without cycloplegia and to examine whether the photorefractometer necessitates cycloplegia in the measurement of refractive errors.

Materials and methods: Included in the study were 62 eyes of 31 pediatric patients. The refractive errors of all of the eyes were measured with and without cycloplegia using a table-top autorefractometer (Potec PRK-6000), hand-held autorefractometer (Nidek ARK-30), and photorefractometer (Plusoptix S08), respectively. The spherical power, cylindrical power, cylindrical axis, spherical equivalent, and interpupillary distance values obtained were statistically compared.

Results: The average age of the patients was 10.03 ± 2.79 years. There were statistically significant differences between the cycloplegic and noncycloplegic spherical powers and the spherical equivalent values of each device. However, the response to cycloplegia was not significant for the cylindrical values. The Jackson cross-cylinder values at axis 0° and 45° (J0 and J45) of each device similarly was not significantly affected by the cycloplegia. Noncycloplegic spherical equivalent, cylindrical power, and J0 and J45 values measured with the Plusoptix S08 did not have a significant difference from the same values measured with the Potec PRK-6000 for cycloplegia.

Conclusion: Accommodation has a prominent effect on the detection of refractive errors of school-age children. The photorefractometer method eliminates the need for cycloplegia in the detection of refractive errors of children from this age group. In the measurements performed with a hand-held autorefractometer, the tendency of myopia as a result of marked accommodation can be seen.

Key words: Ocular accommodation, child, cyclopentolate, refractometry, refractive errors

Okul çağı çocuklarında üç farklı refraktometre ile ölçülen refraksiyon kusurlarının üzerine sikloplejinin etkisi

Amaç: Üç farklı refraktometre cihazını siklopleji öncesi ve sonrası refraksiyon kusurlarını ölçmede karşılaştırmak ve fotorefraktometrenin refraksiyon kusurlarını ölçerken sikloplejiye olan gereksinimi karşılayıp karşılayamadığını incelemek.

Yöntem ve gereç: Çalışmaya 31 pediatrik olgunun 62 gözü dahil edildi. Tüm gözlerin refraksiyon kusurları sırasıyla masaüstü otorefraktometre (Potec PRK-6000), elde-taşınır otorefraktometre (Nidek ARK-30) ve fotorefraktometre (Plusoptix S08) ile önce sikloplejisiz ve daha sonra sikloplejili olarak ölçüldü. Her üç cihazla elde edilen sferik güç, silindirik güç, silindirik aks, sferik ekivalan ve interpupiller mesafe değerleri birbiriyle istatistiksel olarak karşılaştırıldı.

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Bulgular: Olguların ortalama yaşı 10,03 ± 2,79 idi. Her üç cihazın kendi içinde elde edilen sikloplejisiz ve sikloplejili sferik güç ve sferik ekivalan değerleri arasında istatistiksel olarak anlamlı farklılıklar mevcuttu. Ancak silindirik değerlerde sikloplejiden etkilenmenin anlamlı olmadığı görüldü. Yine her üç cihazın 0° ve 45° akstaki Jackson çapraz silindir güç değerleri (J0 ve J45) açısından da sikloplejiden istatistiksel olarak anlamlı bir düzeyde etkilenmediği bulundu. Plusoptix S08 ile ölçülen sikloplejisiz sferik ekivalan, silindirik güç ve J0 ve J45 değerleri ile Potec PRK-6000 ile sikloplejili olarak ölçülen aynı değerler arasında istatistiksel olarak anlamlı bir farklılık yoktu.

Sonuç: Okul çağı çocuklarının refraksiyon kusurlarının saptanmasında akomodasyon belirgin şekilde etkili olmaktadır. Fotorefraktometre yöntemi, bu yaş grubu çocukların refraksiyon kusurlarının saptanmasında sikloplejiye olan ihtiyacı önleyebilmektedir. Elde taşınır otorefraktometre ile yapılan ölçümlerde belirgin akomodasyon sonucu miyopiye kayış izlenmektedir.

Anahtar sözcükler: Oküler akomodasyon, çocuk, siklopentolat, refraktometre, refraktif bozukluk

Introduction

Early diagnosis of refractive errors, which are the most common eye problems, is mandatory for the prevention of amblyopia. Amblyopia, the most frequent cause of monocular visual loss in children and young adults with a frequency of 5%-7%, can be prevented with optical correction if detected early (1-4). For detection of amblyopia in early childhood, a photorefractometer and hand-held autorefractometers are convenient devices, especially for the detection of refractive error in patients with physical and mental disabilities.

Accommodation has a significant effect on the measurement of refractive error, especially in school-age children. In a study where cycloplegic and noncycloplegic measurements were performed in 3 different age groups, in children (between 3 and 20 years old) the average spherical equivalent was 0.96 diopter (D), more hyperopic compared with measurements prior to cycloplegia, and in young adults (between 21 and 40 years old) it was 0.6 D, more hyperopic at the end of the same measurement. In older adults (between 41 and 73 years old), a significant difference was not detected (5). Therefore, use of cycloplegic agents for removing the effect of accommodation in refractive error measurements is an important subject (6-8).

Interpupillary distance (IPD) is also an important parameter in the construction of optical devices used for the treatment of refractive errors. Measurement errors in corrections with glasses cause an unwanted prismatic effect and optical aberrations (9). For this reason, correct measurement of IPD is an important matter.

There are various devices that operate based on different methods for the measurement of refractive errors. There are many studies investigating the correlation of these devices with each other. Among these, a variety of studies have been conducted in which the correlations of photorefractometers and hand-held autorefractometers with table-top refractometer devices were examined separately (6,10-12). However, there is no study in the literature investigating noncycloplegic and cycloplegic measurement results in combination and involving all 3 photorefractometers, hand-held refractometers, and table-top refractometers. Moreover, to our knowledge, no prior study investigating whether photorefractometer and autorefractometer devices are correlated in IPD measurement has been conducted.

The purpose of this study was to compare the remote binocular measurement-capable photorefractometer with the hand-held autorefractometer and table-top autorefractometer in a school-aged pediatric population and to investigate the possible effect of cycloplegia on such measurements. Another purpose was to investigate whether the refractometer method meets the needs for cycloplegia in the measurement of refractive errors.

Materials and methods

This study was performed in the Ophthalmology Department of Gülhane Military Medical Faculty, Ankara, Turkey, between July 2010 and September 2010. Ethics committee approval was granted for the study. Included in the study were 62 eyes of 31 patients applying to the ophthalmology polyclinics for examination of a refractive error. Informed consent was obtained from all of the patients.

Inclusion criteria

The main criterion for inclusion was the absence of an additional ocular pathology other than a refractive error in the patients. Patients who had diseases that may affect measurement in any eye like cornea diseases, pterygium, cataract, vitreous opacity, retina diseases, strabismus, or nystagmus; those who had eccentric fixation; and those unwilling to participate were not included in the study. Any patients who had a prior eye operation for any reason or who were not compliant during the measurements were also excluded from the study.

Devices used in the study

Plusoptix S08 (Plusoptix GmbH, Nuremberg, Germany): The device works based on the eccentric photorefraction method. As it performs the measurements from a distance of 1 m, it gives a relaxation of accommodation. Especially in children, its main advantages are that it does not cause a feeling of fear due to lack of physical contact, and it assists in the detection of anisometropia without accommodation difference due to its capability of binocular measurement. The device also detects the pupil size and IPD values during refraction measurement.

Nidek ARK-30 hand-held autorefractometer (Nidek Co. Ltd., Hiroishi, Japan): It consists of 2 parts. The main body and the hand-held measurement device are connected wirelessly to the main body, and it is similar to a video camera in size and weight (980 g). The Nidek ARK-30 measures monocularly, and the measurement distance from the eye is 6 cm. It automatically records 10 measurements from each eye and gives a single best result that is determined based on the measured values.

Potec PRK-6000 (Potec Co. Ltd, Daejeon, South Korea): It is a table-top autorefractometer giving the possibility of quick refraction measurement monocularly, with a touch-screen function. The device also performs IPD measurements between 10 and 85 mm, in addition to refraction measurements.

Examination

Detailed eye examination involving the anterior and posterior segment, cover test, and central fixation examination was performed on each patient. In addition, the refractive errors of all of the eyes were measured without cycloplegia using the Potec PRK-6000 table-top autorefractometer, Nidek ARK-30 hand-held autorefractometer, and Plusoptix S08, respectively. One drop of 1% cyclopentolate (Sikloplejin®, Abdi İbrahim, İstanbul, Turkey) was instilled into both eyes of each of the patients. The application of 1% cyclopentolate was repeated 5 min later. The presence of light activation was checked in the pupillae of the patients 45 min after the first drop. No pupillary activity was observed in any of the patients. Measurement of all of the patients was repeated using 3 refractometers.

For measurements with the Potec PRK-6000, the patients were made to sit on the unit chair connected to the device and lean their foreheads and chins onto relevant locations on the device. The heads of moving children were held stable by their parents for a short time during measurement. For measurements with the Plusoptix S08, the examiner adjusted the mobile camera to the face of the patient at a distance of 1 m, and at the end of the measurement, the refraction data indicated in green on the monitor were taken as the basis. For measurements with the Nidek ARK-30, the foreheads of the patients were placed onto the forehead part of the device, the device instructions were taken as the basis, and the measurements were performed.

Refraction measurements of the patients were performed by 3 investigators under the same conditions, each device being used by the same investigator. The measurements of the other devices were masked. All of the measurements were repeated at least 3 times and the average values of the obtained results were recorded in order to be used in the study.

The measurements generated in the study were categorized into 2 groups, noncycloplegic (Group 1) and cycloplegic (Group 2). The spherical, cylindrical, cylindrical axis, spherical equivalent, and IPD values obtained in both groups using all 3 of the devices were statistically compared. The following formulas were used for the calculation of the spherical equivalent and axis values (10,13):

Spherical equivalent [diopter (D)] = sphere (D) + [cylinder (D)/2];

Jackson cross-cylinder at axis 0° (J_0) = (–[cylinder (D)/2] cos[2 × axis]);

Jackson cross-cylinder at axis 45° (J_{45}) = (–[cylinder (D)/2] sin[2 × axis]).

Statistical analysis

Age and refractive error values obtained from the study group are presented as averages ± standard deviation. Compliance of numeric data to normal distribution was tested using a single-sample Kolmogorov-Smirnov test. The relationship between the spherical, cylindrical, and spherical equivalent values and the J_0 and J_{45} values of the 3 devices was examined using variance analysis in repeated measurements where parametric conditions were met and with Friedman analysis where they were not met. The level of effect of cycloplegia on repeated measurements of all 3 devices was studied with paired samples and the Wilcoxon test. Furthermore, the spherical equivalent values gained with the Plusoptix S08 without cycloplegia and with the Potec PRK-6000 and Nidek ARK-30 with cycloplegia were compared in pairs of 2 using the Bland-Altman test (14). $P < 0.05$ was considered statistically significant.

Results

The mean age of the 31 pediatric patients (12 males and 19 females) was 10.03 ± 2.79 years (range: 6-16). A total of 372 noncycloplegic and cycloplegic measurements were recorded on 62 eyes using 3 different devices, but only 59 noncycloplegic eyes and 37 cycloplegic eyes were included for analysis of the results from the Plusoptix S08 instrument. Measurements generated based on the groups are given in Table 1, where it can be seen that the spherical power and spherical equivalent values of all 3 of the devices were affected by cycloplegia. Significant differences were found between the spherical power and spherical equivalent values with and without cycloplegia for the Potec PRK-6000, Nidek ARK-30, and Plusoptix S08 ($P < 0.0001$ for all). However, the effect of cycloplegia was not significant for cylindrical values in the measurements of all 3 of the devices ($P = 0.258$, $P = 0.166$, and $P = 0.693$, respectively). The J_0 and J_{45} values of all 3 of the devices were also not statistically significantly affected by the cycloplegia (J_0: $P = 0.282$, $P = 0.538$, and $P = 0.401$; J_{45}: $P = 0.743$, $P = 0.956$, and $P = 0.636$, respectively).

When the devices were compared with each other for the measurements without cycloplegia, while there was a statistically significant difference in terms of spherical power and spherical equivalent values among all 3 of the devices ($P < 0.05$ for all), there was no significant difference in terms of cylindrical power ($P = 0.767$). In the measurements without cycloplegia, similarly, there was no statistically significant difference between the devices in terms of the J_0 and J_{45} values ($P = 0.053$ and $P = 0.67$, respectively).

When the devices were compared with each other for the measurements with cycloplegia, while there was a statistically significant difference in terms of spherical power and spherical equivalent values among all 3 of the devices ($P < 0.05$ for all), no significant difference was found in terms of cylindrical power ($P = 0.127$). In the measurements after cycloplegia, similarly, there was no statistically significant difference between the devices in terms of the J_0 and J_{45} values ($P = 0.235$ and $P = 0.499$, respectively).

When the noncycloplegic spherical equivalent value measured with the Plusoptix S08 was compared with the cycloplegic spherical equivalent values measured with the other 2 devices, while no statistically significant difference was seen between the measurements from the Plusoptix S08 and Potec PRK-6000 ($P = 0.266$), a statistically significant difference was found between the measurements from the Plusoptix S08 and Nidek ARK-30 ($P < 0.0001$). The J_0 and J_{45} values without cycloplegia measured with the Plusoptix S08 did not have a statistically significant difference from the J_0 and J_{45} values measured with the other 2 devices with cycloplegia (J_0: $P = 0.225$, J_{45}: $P = 0.385$).

When the Bland-Altman analysis was performed in comparisons of 2 spherical equivalent values measured with the Plusoptix S08 without cycloplegia and the spherical equivalent values measured with the Potec PRK-6000 and Nidek ARK-30 with cycloplegia, it was seen that almost all of the differences between the measurements remained within the range of ±2 SD on average (Figures 1 and 2).

Table 1. Comparison of Group 1 (without cycloplegia) and Group 2 (with cycloplegia) refraction values obtained with the 3 devices from the cases in the study.

Values	Groups	Potec PRK-6000		Nidek ARK-30		Plusoptix S08	
		n	Mean	n	Mean	n	Mean
Spherical power (D)	1	62	−0.91 ± 1.92 [(−5)-(2.75)]	62	−1.57 ± 1.84 [(−5.25)-(2.25)]	59	−0.17 ± 2.06 [(−4.75)-(3)]
	2	62	−0.19 ± 2.15 [(−4.25)-(4.5)]	62	−0.88 ± 2.16 [(−5.25)-(4)]	37	0.2 ± 2.31 [(−3.75)-(4.5)]
	P-values		<0.0001		<0.0001		<0.0001
Cylindrical power (D)	1	62	−0.85 ± 0.7 [(−3)-(0)]	62	−0.84 ± 0.64 [(−3)-(0)]	59	−0.87 ± 0.71 [(−2.5)-(0)]
	2	62	−0.89 ± 0.77 [(−3.5)-(0)]	62	−0.91 ± 0.75 [(−3.25)-(0)]	37	−0.78 ± 0.81 [(−2.75)-(0)]
	P-values		0.258		0.166		0.693
Spherical equivalent (D)	1	62	−1.33 ± 1.99 [(−6.5)-(2.38)]	62	−1.99 ± 1.9 [(−6.75)-(1.63)]	59	−0.61 ± 2.14 [(−5.75)-(2)]
	2	62	−0.64 ± 2.22 [(−6)-(3.88)]	62	−1.34 ± 2.27 [(−6.88)-(3.38)]	37	−0.2 ± 2.33 [(−4.75)-(3.38)]
	P-values		<0.0001		<0.0001		<0.0001
0° Jackson cylinder (D)	1	62	−0.05 ± 0.37 [(−0.87)-(1.11)]	62	0.03 ± 0.35 [(−1.05)-(0.87)]	59	−0.12 ± 0.4 [(−1.08-(1.11)]
	2	62	0.01 ± 0.39 [(−0.91)-(1.48)]	62	0.03 ± 0.44 [(−0.87)-(1.56)]	37	−0.05 ± 0.32 [(−1.13-(0.72)]
	P-values		0.282		0.538		0.401
45° Jackson cylinder (D)	1	62	0.04 ± 0.4 [(−0.75)-(1.48)]	62	0.03 ± 0.4 [(−1.14)-(0.84)]	59	−0.02 ± 0.38 [(−0.99)-(0.91)]
	2	62	0.07 ± 0.44 [(−0.94)-(1.2)]	62	0.02 ± 0.4 [(−0.95)-(1.11)]	37	0.08 ± 0.46 [(−1.25)-(1.32)]
	P-values		0.743		0.956		0.636

Table 2. Comparison of the interpupillary distance values (mm) generated from both groups.

Devices	Group 1 (n = 31)	Group 2 (n = 31)	P-values
Potec PRK-6000	57.19 ± 3.81 (51-67)	57.08 ± 3.5 (51-67)	**0.751**
Plusoptix S08	55.1 ± 4.45 (47-66)	54.63 ± 4.07 (47-64)	**0.073**
P values	**<0.0001**	**<0.0001**	

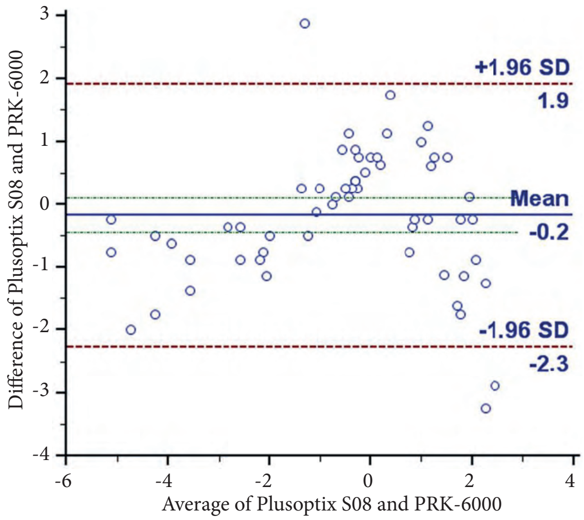

Figure 1. Comparison of the spherical equivalent values generated with the Plusoptix S08 without cycloplegia with the spherical equivalent values generated with the Potec PRK-6000 with cycloplegia, using Bland-Altman plot analysis. Accordingly, the difference distribution of the spherical equivalent values generated with both methods was between ±2.1 D in children.

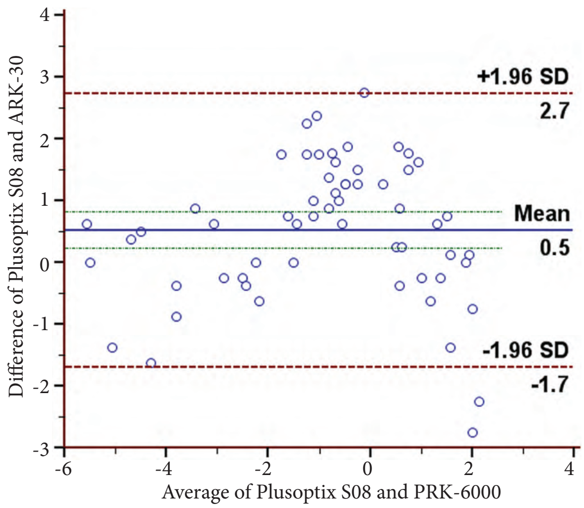

Figure 2. Comparison of the spherical equivalent values generated with the Plusoptix S08 without cycloplegia with the spherical equivalent values generated with the Nidek ARK-30 with cycloplegia, using Bland-Altman plot analysis. Accordingly, the difference distribution of the spherical equivalent values generated with both methods was between ±2.2 D in children.

During the study, all 3 of the devices were well tolerated by the patients from both groups and the measurements were performed without problems. However, the refraction values in 3 eyes without cycloplegia (due to high myopia and hypermetropia) and 25 eyes with cycloplegia (due to large pupil size, high myopia, or hypermetropia) could not be calculated using the Plusoptix S08.

Both with and without cycloplegia, most myopic measurements were performed with the Nidek ARK-30 and most hypermetropic measurements were performed with the Plusoptix S08. Between the Plusoptix S08 and Potec PRK-6000, the average spherical equivalent difference was 0.54 ± 1.14 (ranging from −1.62 to 4.25) D without cycloplegia and 0.56 ± 1.01 (ranging from −1 to 3.38) D with cycloplegia. Between the Plusoptix S08 and Nidek ARK-30, the average spherical equivalent difference was 1.22 ± 1.24 (ranging from −1.13 to 5.38) D without cycloplegia and 1.28 ± 1.06 (ranging from −0.75 to 3.25) D with cycloplegia. Between the Potec PRK-6000 and Nidek ARK-30, the average spherical equivalent difference was 0.66 ± 0.54 (ranging from −0.5 to 2.25) D without cycloplegia and 0.7 ± 0.4 (ranging from −0.5 to 1.5) D with cycloplegia.

IPD values measured with the Potec PRK-6000 and Plusoptix S08 were also compared (Table 2). These values, measured with both devices, had a statistically significant difference in both Group 1 and Group 2 ($P < 0.0001$ for both groups). However, IPD values obtained with both devices were not statistically significantly affected by cycloplegia ($P = 0.751$ and $P = 0.073$, respectively).

Discussion

It has been stated that accommodation has a prominent effect on refraction and affects the spherical equivalent values of school-age children (6,7). Wesson et al. (15) took measurements with and without cycloplegia (with cyclopentolate) on infants using the retinoscopy method and found the measurements with cycloplegia to be 2.12 D more hypermetropic. Saunders and Westall (16) performed a similar study with infants and children and found that the refractive error values were approximately 0.39 D more hypermetropic with cycloplegia. In another study, Broghi and Rouse (17) obtained results that were an average of 0.5-0.75 D more hypermetropic in patients of ages varying between 3.6 and 10 years with cycloplegia. Fotedar et al. (8) compared pre- and postcycloplegic autorefraction in 6- and 12-year-old children and found the mean spherical equivalent difference between these measurements to be 0.84 D more hypermetropic in the 12-year-old children and 1.18 D more hypermetropic in the 6-year-old children with cycloplegia. In agreement with the related literature, cycloplegic refraction measurements in the present study were more hypermetropic compared to the noncycloplegic refraction measurements. The mean differences between the cycloplegic and noncycloplegic results were 0.57 D for the Plusoptix S08, 0.65 D for the Nidek ARK-30, and 0.69 D for the Potec PRK-6000.

Some authors indicated that tropicamide, due to its lower degree of systemic side effects, could be used for reliable detection of refractive defects, as they did not see a statistically significant difference in the effects of cyclopentolate and tropicamide on the solution of accommodation (7,18). However, cyclopentolate is an agent preferred more often for this purpose (19,20). It was indicated that the use of cyclopentolate created a sufficient level of cycloplegic effect in most patients and limited residual accommodation between 1 and 2.5 D (21). In a study performed by Abrahamsson et al. (6), in cycloplegic and noncycloplegic measurements using 1% cyclopentolate with a photorefractometer and the Topcon RM-A2000, there was a statistically significant difference between both the spherical and cylindrical values. In the present study performed with a Plusoptix S08 photorefractometer, Nidek ARK-30 hand-held autorefractometer, and Potec PRK-6000 autorefractometer, it was similarly detected that there was a statistically significant difference between the spherical power and spherical equivalent values measured without cycloplegia and measured after cycloplegia with 1% cyclopentolate drops. However, the effect of cycloplegia was not significant for cylindrical values in the measurements of all 3 devices. It was detected that none of the 3 devices were affected by cycloplegia at a statistically significant level in terms of the J_0 and J_{45} values.

It was stated that cylindrical power and axis measurements with the PowerRefractometer after cycloplegia caused measurement errors (22,23). It has been detected that the measurement errors encountered in 2-flash photorefractometers are also present in the 3-flash devices used today. Peripheral aberrations originating from mydriatic pupils might cause such measurement errors (5). In the present study, no measurements could be performed on 25 of the eyes with cycloplegia with the Plusoptix S08. This might have an effect on the nondetection of a statistically significant difference in the cylindrical power and J_0 and J_{45} values with and without cycloplegia.

In a study in which the PowerRefractometer (a prototype of Plusoptix S08) and Nidek AR800 autorefractometer were compared without cycloplegia, it was indicated that the PowerRefractometer and autorefractometer measurements were similar in terms of both spherical and cylindrical values in adults, and that the PowerRefractometer measured spherical equivalent values that were 0.49 D more hypermetropic than the autorefractometer in children of 3 to 6 years of age (24). Similarly, Allen et al. (25) stated that noncycloplegic PowerRefractometer measurements in adults were more hypermetropic than those of the Nidek AR600-A autorefractometer. Gekeler et al. (26) found spherical values measured with a photorefractometer to be 0.43 D more hypermetropic than those of the Canon R-1 autorefractometer. In our patients, the average spherical equivalent difference before cycloplegia was 0.54 D between the Plusoptix S08 and Potec PRK-6000, 1.22 D between the Plusoptix S08 and Nidek ARK-30, and 0.66 D between the Potec PRK-6000 and Nidek ARK-30.

Harvey et al. (27) showed that measurements with the Nikon Retinomax hand-held autorefractometer (Nikon, Melville, NY, USA) on children under cycloplegic effects were approximately 0.25 D more hypermetropic compared to results from retinoscopy. Schimitzek and Lagreze (5) found the average spherical equivalent difference between the PowerRefractometer and retinoscopy to be –0.73 D without cycloplegia and –0.12 D with cycloplegia. In the present study, the average spherical equivalent difference with cycloplegia was 0.56 D between the Plusoptix S08 and Potec PRK-6000, 1.28 D between the Plusoptix S08 and Nidek ARK-30, and 0.7 D between the Potec PRK-6000 and Nidek ARK-30.

In this study, it was seen that both before and after cycloplegia, most myopic measurements were performed with the Nidek ARK-30 and most hypermetropic measurements were performed with the Plusoptix S08. The measurement of Plusoptix S08 from a distance of 1 m is considered to be a reason for it to give more hypermetropic results than the other devices, due to the partial relaxation it gives in accommodation. Similarly, a high myopic difference in measurements with the Nidek ARK-30 shows the effect of accommodation during measurements.

The average spherical equivalent value with the Plusoptix S08 without cycloplegia was –0.61 D. In the measurement with the Potec PRK-6000 and Nidek ARK-30 with cycloplegic effects, the average spherical equivalent values were –0.64 D and –1.34 D, respectively. Based on such values, while there was no statistically significant difference between the Plusoptix S08 and Potec PRK-6000, there was a statistically significant difference between the Plusoptix S08 and Nidek ARK-30. The J_0 and J_{45} values measured with the Plusoptix S08 without cycloplegia did not have a statistically significant difference from the J_0 and J_{45} values measured with the other 2 devices with cycloplegia. Based on these findings, it can be concluded that the Plusoptix S08 is reliable in detecting refractive errors in school-age children without applying cycloplegia. Furthermore, for children who have problems using the table-top autorefractometer device, mainly patients with physical or mental disabilities, it was seen that measurement with the Plusoptix S08 without using cyclopentolate for detection of refractive risk factors of amblyopia is comparable to measurements with the Potec PRK-6000 after cyclopentolate in terms of measurement reliability and straightness.

Measurement of IPD is an important matter for the detection of head-eye abnormalities and the prescription of optical aids. IPD values may manifest differences based on the methodology used for the measurement (9). IPD measurement may be affected by accommodation status (28). However, in this study, for IPD measurements detected with the Potec PRK-6000 and Plusoptix S08, no statistically significant difference was seen before and after cycloplegia, and a statistically significant difference was detected between the devices for both situations. With the Potec PRK-6000, a virtual image of the actual target is created at a distance of about 6 m with the aid of mirrors and lenses (29). Moreover, IPD detection is performed via monocular measurements. However, the Plusoptix S08 calculates this distance as the result of binocular measurement from a distance of 1 m. Therefore, development of convergence focused on 1 m might explain the measurement differences among the devices, even though it is weak.

In the measurements performed with all 3 of the devices, statistically significant differences were observed in the spherical power and spherical equivalent values after application of cycloplegic effects. However, it was seen that the effect of cycloplegia was not significant for cylindrical values in the measurements of all 3 of the devices. It was also detected that none of the 3 devices were affected by cycloplegia at a statistically significant level in terms of the J_0 and J_{45} values.

The photorefractometer method was found to be quite beneficial in the measurement of refractive errors of school-age children. However, a limited measurable refractive error range and being affected by mydriatic pupils are its disadvantages. In measurements performed with the Nidek ARK-30, a tendency to myopia due to prominent accommodation arising from the shortness of the measuring distance compared to the other 2 devices was observed. In school-age children, refraction measurements without cycloplegia were not found to be reliable with either the Potec PRK-6000 or Nidek ARK-30, because of the prominently effective accommodation.

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