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GENERAL ARTICLE

Difference of refraction values between standard autorefractometry and Plusoptix

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Abstract

Aim: Comparison between the objective refraction measurement results determined with Topcon KR-8900 standard autorefractometer and Plusoptix A09 photo-refractometer in children.

Material and methods: A prospective transversal study was performed in the Department of Ophthalmology of "Sf. Spiridon" Hospital in Iași on 90 eyes of 45 pediatric patients, with a mean age of 8,82 ± 3,52 years, examined with noncycloplegic measurements provided by Plusoptix A09 and cycloplegic and noncycloplegic measurements provided by Topcon KR-8900 standard autorefractometer. The clinical parameters compared were the following: spherical equivalent (SE), spherical and cylindrical values, and cylinder axis. Astigmatism was recorded and evaluated with the cylindrical value on minus after transposition. The statistical calculation was performed with paired t-tests and Pearson's correlation analysis. All the data were analyzed with SPSS statistical package 19 (SPSS for Windows, Chicago, IL).

Results: Plusoptix A09 noncycloplegic values were relatively equal between the eyes, with slightly lower values compared to noncycloplegic auto refractometry. Mean (± SD) measurements provided by Plusoptix AO9 were the following: spherical power 1.11 ± 1.52, cylindrical power 0.80 ± 0.80, and spherical equivalent 0.71 ± 1.39. The noncycloplegic auto refractometer mean (± SD) measurements were spherical power 1.12 ± 1.63, cylindrical power 0.79 ± 0,77 and spherical equivalent 0.71 ± 1.58. The cycloplegic auto refractometer mean (± SD) measurements were spherical power 2.08 ± 1.95, cylindrical power 0,82 ± 0.85 and spherical equivalent 1.68 ± 1.87. 32% of the eyes were hyperopic, 2.67% were myopic, 65.33% had astigmatism, and 30% eyes had amblyopia.

Conclusions: Noncycloplegic objective refraction values were similar with those determined by autorefractometry. Plusoptix had an important role in the ophthalmological screening, but did not detect higher refractive errors, justifying the cycloplegic autorefractometry.

Keywords: objective refraction, autorefractometer, Plusoptix, children, cycloplegia

Introduction

Cycloplegic retinoscopy and subjective refraction are still the gold standard for measuring the refractive error in children, but cycloplegia usage takes more time and causes patient discomfort. Therefore, autorefractometers have become widely used to

determine the objective refractive status [**1**]. Photorefraction is a refraction state screening method that allows a rapid and feasible evaluation from 6 months by using a photography of the eye. There are three types of photorefraction: orthogonal, isotropic, and eccentric. In contrast to the first two types, the eccentric photorefraction can measure a large range of refractive errors, being similar with retinoscopy [**2,3**].

Photorefraction is described as a retinoscopy based videorefraction method to determine the refractive state from a distance of one meter or more, without cycloplegia [**1**] and allows a rapid (0.8 seconds of acquisition time) and feasible evaluation from 6 months [**4,5**]. One of the current photoretinoscopy instruments is Plusoptix A09, an US Food and Drug Administration (FDA)-approved infrared photoscreener that measures refraction, pupil size, interpupillary distance, and gaze deviation [**4**]. Plusoptix A09 photorefractor (Plusoptix, Inc, Atlanta, Georgia, and USA) is marketed to ophthalmology and optometry practices as an autorefractor [**6**].

Being non-invasive and easy-to-use, Plusoptix A09 provides valuable data for amblyopia risk factors. The large working distance of 1 meter, the Warble sound produced by the device and the smiley face and flashing lights as fixation target, makes it proper for the pediatric evaluation [**4**]. Photorefraction is unique in enabling the measurement of accommodation, vergence, and pupil size in both eyes simultaneously, objectively, remotely (typically the camera is placed at 1 m from the eyes) and continuously. The measuring principle is based on eccentric photorefraction.

Plusoptix A09 can measure binocular or monocular refraction with a spherical range and a cylindrical range between +5.00/ -7.00 D in 0.25 D steps and a pupil size of 4.0-8.0 mm in 0.1 mm steps. If the spherical equivalent (SE) is out of range, the measurement value only displays "Hyperopia" or "Myopia". Ocular misalignment ≥10° could not be measured binocularly, and was changed to a sequential monocular measurement mode [**7**].

Topcon KR-8900 autorefractometer works according to Scheiner's double pinhole principle [**8**] and can measure the monocular refraction with a spherical range between -25.00/ +22.00 D in 0.12 or 0.25 D steps and a cylindrical range between -10.00/ +10.00 D in 0.12 or 0.25 D steps.

The aim of this study was the comparison between the objective refraction measurement results determined with Topcon KR-8900 standard autorefractometer and Plusoptix A09 photo-refractometer.

Material and methods

The present cross-sectional study was performed between September and December 2015 in the Ophthalmology Department of "Sf. Spiridon" Emergency Hospital in Iaşi, Romania. The parents or guardians of all the children gave their informed consent prior to their inclusion in the study. The children were prospectively and consecutively enrolled. All the patients underwent a comprehensive ophthalmic examination including: uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), objective refraction, ocular alignment evaluation, synoptophore and prism measurements of the angle of deviation, eye movements evaluation and synoptophore binocular vision assessment and anterior segment and fundoscopy, by direct ophthalmoscope examination for children under 5 years old and slit lamp examination for children above 5 years old.

For the objective refraction assessment, Topcon KR-8900 standard autorefractometer (KR-8900; Topcon, Tokyo, Japan) and Plusoptix A09 photo-refractometer (Plusoptix GmbH, Nürnberg, Germany) were used. The exclusion criteria were uncooperative child, age above 18 years, values of sphere and cylinder above the Plusoptix A09 limits.

Cycloplegic and noncycloplegic objective refraction were determined by Topcon KR-8900 standard autorefractometer and noncycloplegic objective refraction was determined by Plusoptix A09. Cycloplegia was obtained after the instillation of one drop of 1% cyclopentolate hydrochloride (1% Cyclogyl®) at every 5 and 10 min. Cycloplegic autorefraction was performed after 45 to 60 min following the first instillation. Astigmatism was recorded and evaluated with the cylinder value on minus after transposition. According to the visual acuity, the cases were divided into 3 categories of amblyopia: mild (VA

> 0.5), moderate (VA = 0.5-0.1) and profound (VA < 0.1).

Statistical analysis

The mean and median of the spherical equivalent (SE) between the right and left eyes were compared. SE, spherical and cylindrical values, and cylinder axis were compared by using paired t-tests and Pearson's correlation analysis. Statistical significance was set at $p < 0.05$.

Results

A total of 54 children were evaluated: 9 children (18 eyes) were excluded from the statistical analysis because Plusoptix A09 refraction could not be recorded: 16 eyes because the refraction error was above Plusoptix A09 limits. In 2 eyes, Plusoptix A09 refraction could not be recorded in spite of the admitted range according to the manufacturer. 25 girls (55.55%) and 20 boys (44.45%) were examined. The mean age of the pediatric patients was 8.82 ± 3.52 years, and the limit age was between 3 and 15 years.

The most prevalent refractive error (n = 75) was astigmatism (49 eyes, 65.33%); 2 eyes (2.67%) had myopia, 24 eyes (32%) had hyperopia; 15 eyes (16.70%) were emmetropic (**Fig. 1**). From a total of 49 eyes (100%) with astigmatism, 16 eyes (32.65%) had astigmatism above ≥ 1.5 D and 33 eyes (67.34%) had astigmatism under ≤ 1.25 D; 35 eyes (71.42%) had mixed astigmatism.

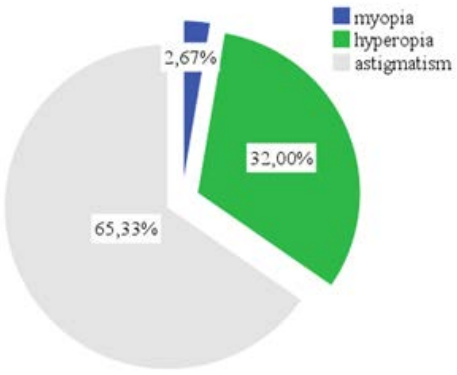


Fig. 1 Refractive errors in the study group

The mean UCVA was 0.62 ± 0.32 and BCVA was 0.92 ± 0.24. According to BCVA, there were 27 (30%) amblyopic eyes: one (3.7%) eye had profound amblyopia, 7 (25.9%) eyes had moderate amblyopia and 19 (70.4%) eyes had mild amblyopia (**Fig. 2**). There were 13 patients with convergence insufficiency and 22 patients had ocular misalignment (15 with exotropia and 17 with esotropia).

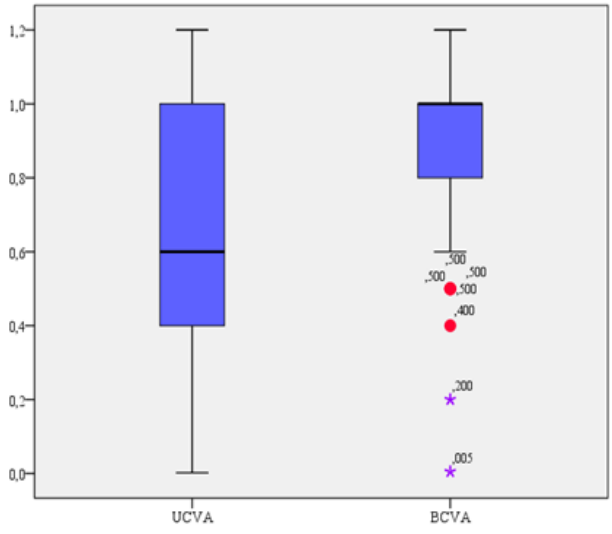


Fig. 2 Comparison between mean UCVA and BCVA

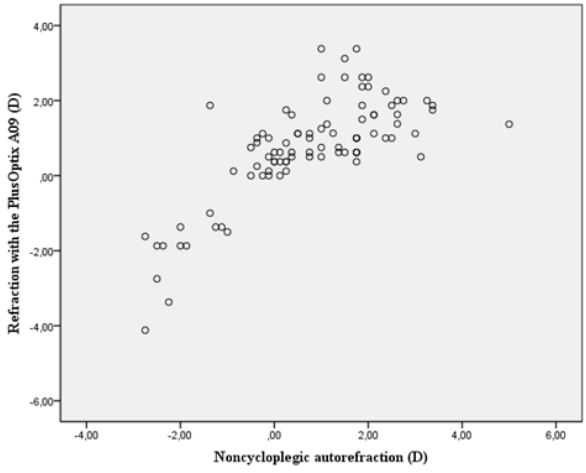
There was no statistically significant difference in the measurement of SE for the RE and the LE with the noncycloplegic autorefraction, Plusoptix A09 and cycloplegic autorefraction (p = 0.77, p = 0.87 and p = 0.87, respectively).

The differences between SE with the noncycloplegic autorefraction and cycloplegic autorefraction and between SE with the PlusoptixA09 and cycloplegic autorefraction were statistically significant (*p = 0.00*, *p = 0.00*, respectively). There were no significant differences in noncycloplegic autorefraction and Plusoptix A09 SE (*p = 0.98*). The sphere values differed and were statistically significant between noncycloplegic autorefraction and cycloplegic autorefraction (*p = 0.00*) and between the Plusoptix A09 and the cycloplegic autorefraction (p = 0.00). There were no significant differences in cylinder and axis values comparing all three methods used (*p > 0.05*) (**Table 1**).

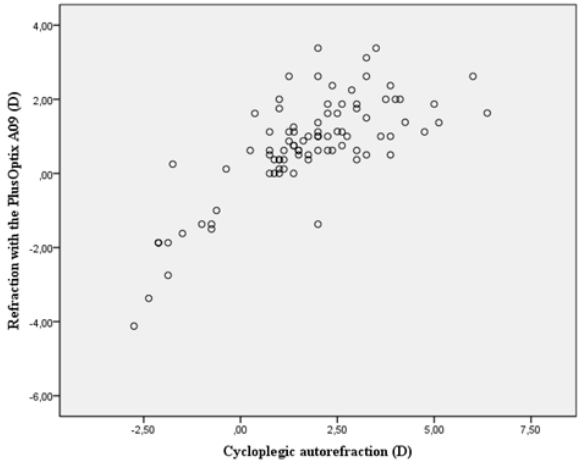
Table 1. Mean values spherical equivalent, sphere, cylinder, and axis with each method

		Spherical equivalent (SE)	Sphere	Cylinder	Axis
Noncycloplegic autorefraction		0.71 ± 1.58	1.12 ± 1.63	-0.79 ± 0,77	94.12 ± 66.23
Plusoptix noncycloplegic	A09	0.71 ± 1.39	1.11 ± 1.52	-0.80 ± 0.80	93.18 ± 63.14
Cycloplegic autorefraction		1.68 ± 1.87	2.08 ± 1.95	-0,82 ± 0.85	90.80 ± 69.23

Pearson's correlations for spherical equivalent, sphere and cylinder were 0.84, 0.85 and 0.86, respectively (noncycloplegic autorefraction and cycloplegic autorefraction); 0.75, 0.74 and 0.78, respectively (noncycloplegic autorefraction and Plusoptix A09); 0.76, 0.77, 0.83 (cycloplegic autorefraction and Plusoptix A09) showing a positive correlation between each two groups (**Fig. 3a-c**).



a



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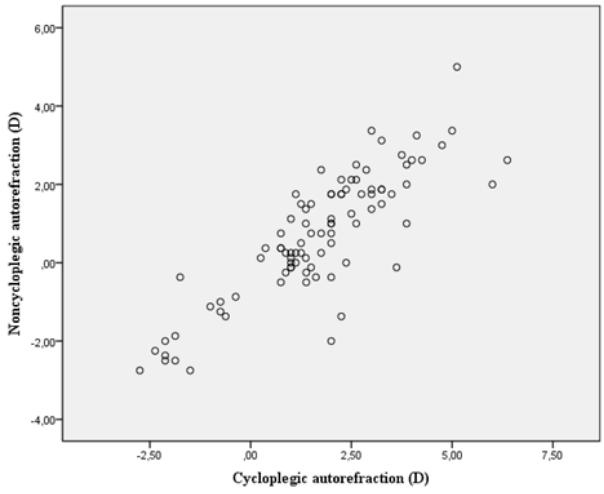

c

Fig. 3a-c Correlation between autorefractometry and Plusoptix for spherical equivalent

Discussion

Refractive errors are an important issue in children and accurate measurement is essential for the early prevention of amblyopia [**1**]. Photoscreening is a single cost-effective test that can be administered quickly by nonmedical personnel, can be used in many environments, and does not require a prolonged patient cooperation [**9**]. Various studies suggested that noncycloplegic photorefraction has a reasonable accuracy and repeatability compared to cycloplegic retinoscopy and subjective refraction. However, in a study, it was demonstrated that the accommodation might not be completely neutralized, which is especially important in children who have a high accommodative reserve [**1**]. Ozdemir et al. compared noncycloplegic photorefraction with the Plusoptix A09 and cycloplegic photorefraction with the same device 10 minutes after one drop of 1% cyclopentolate and found

that photorefraction with cycloplegia overestimated the spherical power and the spherical equivalent and that in 10.9% children measurements were not possible after cycloplegia due to mydriasis [**2,12-15**]. In our study, Plusoptix A09 noncycloplegic values were relatively equal between the eyes, with slightly lower values compared to noncycloplegic autorefractometry. The mean (±SD) measurements provided by Plusoptix AO9 were the following: spherical power 1.11 ± 1.52, cylindrical power -0.80 ± 0.80 and spherical equivalent 0.71 ± 1.39. The noncycloplegic autorefractometer mean (± SD) measurements were spherical power 1.12 ± 1.63, cylindrical power -0.79 ± 0,77 and spherical equivalent 0.71 ± 1.58.

Demirel el al. concluded that Plusoptix S08 is a good guide for the measurement of refractive errors in children, although it is inaccurate for prescribing lenses [**1**]. Arici et al. showed that the photo-refractometer is beneficial in the measurement of refractive errors in schoolchildren, with the disadvantage that the measurable refractive error range is limited [**10**]. Bregman et al. demonstrated that the Spot v.2.1.4 photoscreener is an effective tool for detecting amblyopia risk factors when used in a general pediatrics clinic (age 12-72 months), their study results supporting the ongoing efforts to introduce and standardize the use of automated screening practices in the medical home [**9**]. Tidbury el al. performed a literature search of databases focusing on the publications from the past 5 years and concluded that Plusoptix photoscreener could provide a useful tool for screening, offering a good level of accuracy for the detection of amblyogenic risk factors in children, with a sensitivity ranging between 47 and 99%, and a specificity between 49 and 100% [**11**]. The mean UCVA was 0.62 ± 0.32 and BCVA was 0.92 ± 0.24. According to BCVA, there were 27 (30%) amblyopic eyes: one (3.7%) eye had profound amblyopia, 7 (25.9%) eyes had moderate amblyopia and 19 (70.4%) eyes had mild amblyopia.

The limitation of the study was the small number of patients, the inclusion of both eyes and that the examinations were not done by a single ophthalmologist.

Conclusions

In conclusion, Plusoptix has an important role in ophthalmological screening, but does not detect higher refractive errors, justifying cycloplegic autorefractometry. Noncycloplegic objective refraction values are similar with those determined by autorefractometry. Refraction with Plusoptix can be also done by an ophthalmologist or a nurse (optometrist or orthoptist), who has special instructions for this examination.

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