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Comparing Plusoptix A09 photorefractometer results with autorefractometer using Bland-Altman analysis

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比较 Plusoptix A09 摄影验光仪和普通自动验光仪结果的 Bland-Altman 分析

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摘要

目的:比较儿童患者中散瞳或不散瞳状态下使用 Plusoptix A09 摄影验光仪与普通自动验光仪的准确性。

方法:共评估了 90 例患儿 180 眼的屈光状态。在散瞳或不散瞳状态下使用 Plusoptix A09 摄影验光仪检测屈光度,并与散瞳后使用普通自动验光仪测得的结果进行比较。使用 Bland-Altman 分析比较等效球镜、球镜度数、柱镜度数和柱镜轴 J0、J45 值。

结果:患者年龄 3~13(7.48±3.01)岁。未散瞳状态下的 Plusoptix A09 摄影验光仪检测所得球镜度数和等效球镜与散瞳后的普通自动验光仪结果之间存在显著差异(P<0.001),但是在柱镜度数、J0 和 J45 值没有发现显著差异(P>0.05)。散瞳后 Plusoptix A09 摄影验光仪检测的球镜度数、等效球镜和散瞳后普通自动验光仪结果之间存在显著差异(P<0.001),但是在柱镜度数、J0 和 J45 值没有发现显著差异(P>0.05)。Bland-Altman 相关性分析显示在球镜度数、柱镜度数和等效球镜的测量中未散瞳及散瞳的 Plusoptix A09 检测结果与散瞳后的普通自动验光仪检测结果有很好的一致性,但在 J0 和 J45 测量上一致性较差。

结论:为了检测儿童的屈光度,散瞳或不散瞳状态下 Plusoptix A09 可以得到可靠结果。但是在测量柱镜轴和高屈光度时,这项检测并不合适。这一设备是检测、筛查不合作儿童屈光度时的有效选择。

关键词:普通自动验光仪;Plusoptix A09;儿童;摄影验光仪

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Abstract

• AIM: To evaluate the accuracy of the Plusoptix A09 photorefraction with and without cycloplegia compared to an autorefractometer in pediatric patients.

• METHODS: We assessed the refractive status of 180 eyes in 90 pediatric patients. Refractions were measured with the Plusoptix A09 photorefractor (Plusoptix GmbH, Nürnberg, Germany) with and without cycloplegia and compared with those obtained by autorefractometer (Topcon KR-8900, Tokyo, Japan) after cycloplegia. Spherical equivalent, spherical power cylindrical power and cylindrical axis J0, J45 values measurements were analyzed with Bland-Altman analysis.

• RESULTS: The mean age of the patients was 7.48±3.01 (range 3 to 13y). Between the non-cycloplegic Plusoptix A09 photorefractometer and the cycloplegic autorefractometer measurements, there was significant difference between spherical power and spherical equivalent values (P<0.001) but there was no significant difference between cylindrical power, J0 and J45 values (P>0.05). Between the cycloplegic Plusoptix A09 photorefractometer and the cycloplegic autorefractometer measurements, there was significant difference between spherical power and spherical equivalent values (P<0.001) but there was no significant difference between the cylindric power, J0 and J45 values (P>0.05). Bland-Altman correlation analysis revealed an excellent correlation for the spherical power, cylindrical power and spherical equivalent measurements, but poor correlation for J0 and J45 values between the non-cycloplegic, cycloplegic Plusoptix A09 and the cycloplegic autorefractometer measurements.

• CONCLUSION: To determine refractive errors in children, the Plusoptix A09 measurements with and without cycloplegia can give reliable results. But it is inadequate when measuring the cylindrical axis and high refractive values. This device can be an effective option to detect and screen refractive errors in uncooperative children.

• KEYWORDS: autorefractometer; Plusoptix A09; pediatric age; photorefractometer
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INTRODUCTION

Refractive errors are the most common visual problems and the leading cause of amblyopia among children[1]. Thus,

Table 1 Comparison of the measurements $\bar{x}\pm s$

Parameters	Plusoptix A09 without cycloplegia	Plusoptix A09 with cycloplegia	Autorefractometer with cycloplegia	^aP	^bP
Spherical power	0.53±1.66 (0.75)	1.49±1.91 (2)	1.02±1.56 (1.25)	<0.001	<0.001
Cylindrical power	−0.72±0.78 (−0.5)	−0.76±0.78 (−0.5)	−0.72±0.77 (−0.5)	0.714	0.644
Spherical equivelant	0.18±1.67 (0.5)	1.14±1.97 (1.63)	0.67±1.56 (1)	<0.001	<0.001
J0	0.00±0.34 (0.03)	0.01±0.37 (0)	−0.02±0.35 (0)	0.660	0.905
J45	−0.02±0.40 (0)	−0.03±0.37 (0)	0.02±0.38 (0)	0.502	0.593

P: Wilcoxon signed ranks test; ^aP: Plusoptix A09 without cycloplegia *vs* Autorefractometer with cycloplegia; ^bP: Plusoptix A09 with cycloplegia *vs* Autorefractometer with cycloplegia.

early detection of refractive errors in the pre-school age group is a major goal of the screening programs[2]. Even though cycloplegic retinoscopy is the gold standard method to detect refractive errors, it is not always useful as a screening procedure. The major problems with retinoscopy are the need for cycloplegia, allergic reactions to cyclopentolate and uncooperative children during examination. It also requires an experienced examiner[1-5]. Autorefractometer have been widely used since the 1990s because they are easier, faster and more practical than retinoscopy[6-9].

In recent years, portable photorefractometers have become available. The photorefraction method works with light that is sent from a distance of 1 meter into the patient's eyes and then measures refraction with the detection of retinoscopy-like reflections. The main advantage of this device is that refractive errors in the eyes of small children and infants can be measured easily. It is also portable, so it can be carried to an operating room or a patient's bed[4-8,10-12].

In this prospective study, measurements using a Plusoptix A09 photorefractometer with and without cycloplegia were compared with autorefractometer measurements after cycloplegia using the Bland-Altman statistical method. Thus, we evaluated the accuracy of Plusoptix A09 measurements in terms of spherical power, cylindrical power, spherical equivalent and cylindrical axis J0, J45 values.

SUBJECTS AND METHODS

Consecutive patients were selected between 3-13y of age in Emsey Hospital. Refractive errors were measured using the Plusoptix A09 photorefractometer (Plusoptix GmbH, Nürnberg, Germany) with and without cycloplegia and the autorefractometer (Topcon KR-8900, Tokyo, Japan) with cycloplegia in 180 eyes of 90 patients [58.9% ($n=53$) male, 41.1% ($n=37$) female]. The mean age of the patients was 7.48±3.01. All patients underwent a complete ophthalmological examination including a visual acuity test, anterior segment and fundus examination, Hirschberg test, cover and alternating cover tests. The patients who had other ophthalmological pathologies such as ptosis, glaucoma, optical media opacities, or retinal diseases excluded. Patients were also excluded if it was not possible to take a measurement with the Plusoptix A09 and autorefractometer properly for any reason.

All three measurements were taken on the same day and by one ophthalmologist, firstly by Plusoptix A09 without cycloplegia. After that, cycloplegia was obtained with cyclopentolate 1%, three times, ten minutes apart. Thirty minutes after the third instillation, Plusoptix A09 and autorefractometer measurements were taken. Astigmatic values were recorded in minus cylinder notations. Plusoptix A09 was carried out by an ophthalmologist located at approximately one meter from the patient.

Spherical equivalent values were also noted (spherical equivalent = sphere + (cylinder/2)[13] The axis component was converted into a vector representation for analysis: Jackson cross cylinder at axis 0° with power J0 = −(cylinder/2) cos (2Xaxis); Jackson cross cylinder at axis 45° with power J45 = −(cylinder/2) sin (2Xaxis). Informed consent was obtained from all the parents; the study was approved by the ethics committee.

For statistical analyses, NCSS (Number Cruncher Statistical System) 2007 Statistical Software (NCSS LLC, Kayswille, Utah, USA) software was used in this study. Wilcoxon Signed Ranks test was used for descriptive statistical methods (average, standard deviation, median minimum and maximum, and frequency and ratio) as well as quantitative data for intra-group comparisons. Intraclass correlation coefficient test and Bland-Altman test were used for inter-device compatibility evaluations. The results were evaluated in a confidence interval of 95% and significance level of $P<0.05$.

RESULTS

A total of 180 eyes of 90 patients were included in the study. Average spherical power, cylindrical power and cylindrical axis values were measured with Plusoptix A09 photorefrometer with and without cycloplegia was compared with Topcon KR-8900 autorefractometer with cycloplegia.

The differences in cylindrical power, J0 and J45 values measured by non-cycloplegic Plusoptix A09 and cycloplegic autorefractometer were not statistically significant ($P>0.05$).

The spherical power and spherical equivalent values measured by non-cycloplegic Plusoptix A09 was statistically lower than the cycloplegic autorefractometer measurements ($P<0.001$).

The differences in cylindrical power, J0 and J45 values measured by cycloplegic Plusoptix A09 and cycloplegic autorefractometer were not statistically significant ($P>0.05$).

The spherical power and spherical equivalent measured by cycloplegic Plusoptix A09 was statistically lower than the cycloplegic autorefractometer measurements ($P<0.001$) (Table 1).

With Bland Altman analysis, intraclass correlation between non-cycloplegic Plusoptix A09 and cycloplegic autorefractometer,

Table 2 Evaluation of the measurements using Bland-Altman and intraclass correlation coefficient

Parameters		Median	Lower/upper limit	ICC (95% CI)	*P*
Plusoptix without cycloplegia *vs* cycloplegic autorefractometer	Spheric power	−0.50	−1.88/1.00	0.927	<0.001[a]
	Cylindric power	0.00	−0.96/0.75	0.940	<0.001[a]
	Spherical equivelant	−0.50	−2.05/0.93	0.928	<0.001[a]
	J0	0.01	−0.86/1.37	0.351	0.002[a]
	J45	0.00	−1.62/0.83	−0.464	0.994
Cycloplegic Plusoptix *vs* cycloplegic autorefractometer	Spheric power	0.50	−1.25/2.25	0.893	<0.001[a]
	Cylindric power	0.00	−0.75/0.75	0.938	<0.001[a]
	Spherical equivelant	0.50	−1.31/2.18	0.904	<0.001[a]
	J0	−0.01	−0.77/1.34	0.246	0.030[b]
	J45	0.00	−1.56/0.86	0.028	0.425

ICC (95% CI): Intraclass correlation coefficient (95% confidence interval). ICC<0.40: Poor; ICC=0.40-0.59: Fair; ICC=0.60-0.74: good; ICC=0.75-1.00: excellent. [a]*P*<0.01; [b]*P*<0.05.

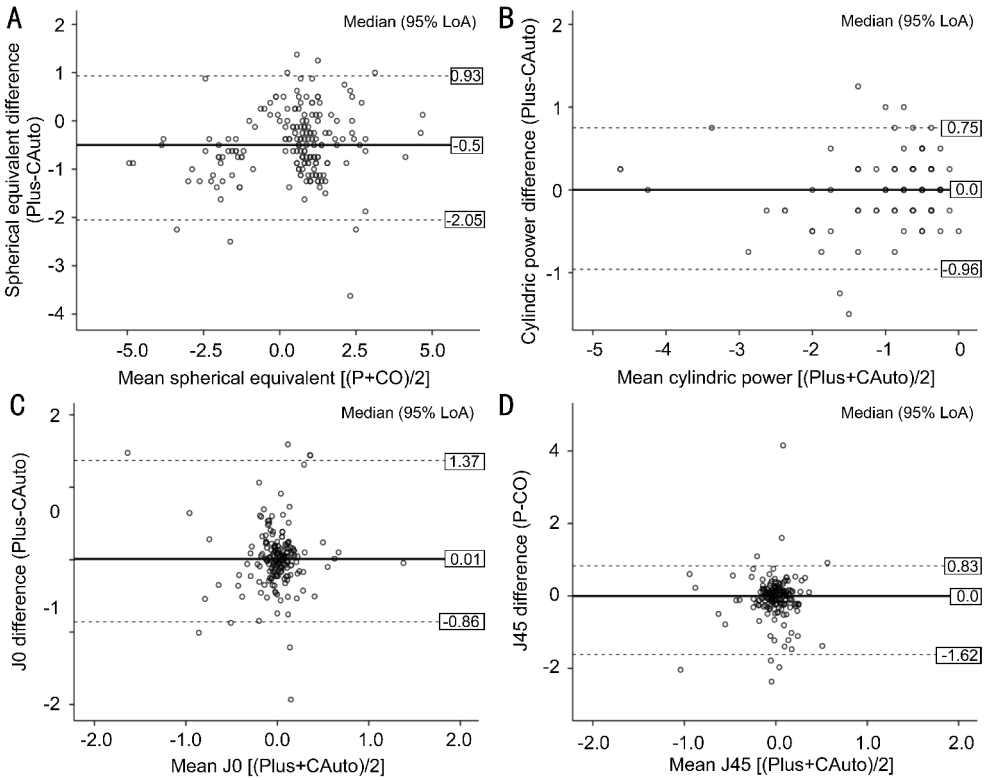

Figure 1 Bland-Altman analysis for correspondence of mean spherical equivalent values (A), cylindrical power (B), Jackson 0° (C) and Jackson 45° (D) values Differences between Plusoptix A09 without cycloplegia (Plus) and autorefractometer with cycloplegia (CAuto).

intraclass correlation coefficient (ICC) was excellent for spherical power, cylindrical power and spherical equivalent values, but poor for J0 and J45 values. Also for cycloplegic Plusoptix A09 and cycloplegic autorefractometer, ICC was excellent for spherical power, cylindrical power and spherical equivalent values, but poor for J0 and J45 values (Table 2) (Figure 1 and Figure 2).

DISCUSSION

Cyloplegic retinoscopy is still gold standard method to detect refractive errors in children but it is challenging for screening refractive errors; its time consuming and uncomfortable for the children. Plusoptix A09 measures refractive error by sending an infrared light into the patient's eye and evaluates the reflex coming from the patient's retina. The device's working distance is large and measures two eyes simultaneously which is advantageous as it allows a shorter examination time. As a simple and portable device, Plusoptix A09 might be a good tool for screening refractive errors and early detecting anisometropia and amblyopia[14-18].

Various reports about Plusoptix A09 have been published over the years. Yilmaz *et al*[9] compared non-cycloplegic refraction measured by Retinomax K-Plus 3 and Plusoptix A09 with gold standard retinoscopy in 200 eyes of 200 patients and reported that non-cycloplegic photorefraction using Plusoptix A09 is a good option for vision screening in children. They also speculated that the Plusoptix A09 may eliminate the need for

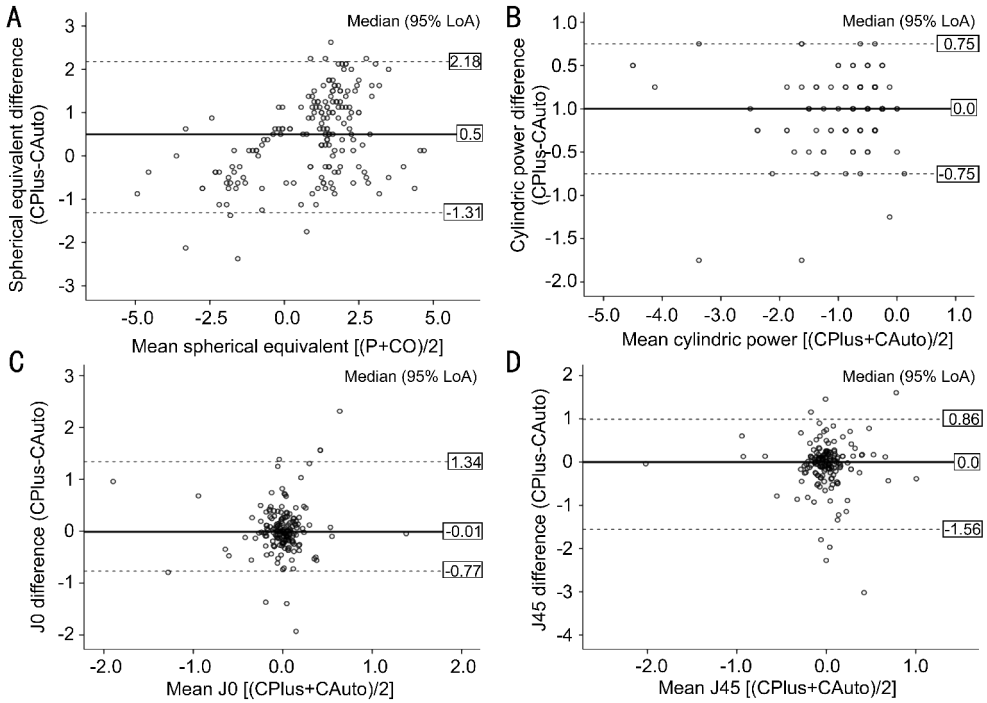

Figure 2　Bland－Altman analysis for correspondence of spherical equivalent values (A), cylindrical power (B), Jackson 0° (C) and Jackson 45° (D) values　Differences between Plusoptix A09 with cycloplegia (CPlus) and autorefractometer with cycloplegia (CAuto).

cycloplegia for the detection of refractive errors in children[9]. Acar *et al*[5] compared the refractive errors measured with Righton Speedy K autorefractometer and Plusoptix A09 photorefractometer in adults. They showed that photorefraction can also be used as a screening test as it is quick and easy to apply, and can also be used in patients with mental retardation.

Silbert *et al*[19] reported that Plusoptix A09 is appropriate for the screening of amblyopia risk factors. Yan *et al*[15] assessed the accuracy of the Plusoptix A09 to detect amblyopia risk factors in children and showed that Plusoptix A09 underestimated hyperopia and overestimated myopia when compared with cycloplegic retinoscopy.

In our study, with this Bland－Altman analysis, there was a correlation for the spherical power, cylindrical power and spherical equivalent values between the non－cycloplegic and cycloplegic Plusoptix A09 and cycloplegic autorefractometer measurements. Additionally, average spherical power and spherical equivalent values of non－cycloplegic and cycloplegic Plusoptix A09 were 0.5 diopter lower than cycloplegic autorefractometer measurements. For the average cylindrical power the difference between the measurements were zero. This shows that when a lack of cooperation by patients precludes taking the cycloplegic refraction with the retinoscopy and autorefractometer, we may rely on the cycloplegic results taken with the Plusoptix A09 photorefractometer.

Similar to our study, Ozdemir *et al*[20] compared the results of non－cycloplegic and cycloplegic Plusoptix A09 measurements, cycloplegic refraction with autorefraction and/or standard retinoscopy in 196 eyes of preschool and non－verbal children. They compared spherical equivalent, spherical power, cylindrical power and cylindrical axis measurements. They found that the Plusoptix A09 measurements gave incorrect results after the instillation of cyclopentolate and showed that photorefraction with cycloplegia leads to an overestimation of the spherical equivalent and spherical power. They speculated that because of mydriasis, the accuracy of refraction is influenced by pupil diameter. Additionally, Ozdemir *et al*[20] found that the cylindrical power measured by Plusoptix A09 with or without cycloplegia is higher. However, our findings show the non－cycloplegic and cycloplegic Plusoptix A09 measurements can give reliable results in terms of spherical power, cylindrical power and spherical equivalent values but not for the cylindrical axis J0, J45 values with cycloplegic autorefractometer measurements.

Because cycloplegia produces mydriasis as well, the accuracy of refraction with and without cycloplegia is also influenced by pupil diameter. In this study, we could not take the Plusoptix A09 measurements in 10 patients because of dilated pupils, high hyperopia and high myopia. Ozdemir *et al*[20] reported that cycloplegic photorefraction was not possible in 12 children (10.9%) due to large pupil size. They also reported that it was not possible to measure refractive errors with Plusoptix A09 after the instillation of cyclopentolate.

Accommodation is an impediment to obtaining accurate refractions in small children; in the literature there are studies compairing the photorefractometers and cycloretinoscopy[21-22]. Our study shows that Plusoptix A09 demonstrates good consistency with cycloplegic autorefractometer measurements. This can be explained by the Plusoptix A09 device being used from 1 meter, thus negating most of the accommodation problem. We also did not find any statistically significant

difference between the Plusoptix A09 measurements with or without cycloplegia.

In conclusion, for the determination of refraction in children, with and without cycloplegia, Plusoptix A09 is a practical and effective hand-held photorefractor. There is a correlation between the spherical power, cylindrical power and spherical equivalent values of Plusoptix A09 when compared with the cycloplegic autorefractometer measurements. This indicates that when cycloplegic refractions using retinoscopy is impractical because of uncooperative patients, the cycloplegic results taken with the Plusoptix A09 photorefractometer can be trusted. But the limitation of the Plusoptix A09 is that this device does not detect high myopic and hyperopic values.

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