Observational Study

Medicine®

OPEN

A comparison of the Plusoptix S09 with an autorefractometer of noncycloplegics and cycloplegics in children

Jae Yon Won, MD[a], Hye Young Shin, MD, PhD[b], Su Young Kim, MD, PhD[b], Young Chun Lee, MD, PhD[b,*]

Abstract

The aim of the study is to compare outcome measures of refractive error obtained using the Plusoptix S09 photorefractor and an autorefractometer of noncycloplegics and cycloplegics in children.

We reviewed the medical records of 40 patients (77 eyes) who were classified using 2 methods. The patients were first assigned to 2 groups consisting of 11 eyes with ≥+3.0 D and 66 eyes with <+3.0 D, and then to 2 groups of 12 and 65 eyes with cycloplegic and noncycloplegic refraction of spherical powers ≥+2.0 D and <+2.0 D, respectively. We compared the outcome measures of refractive error using the Plusoptix S09 photorefractor and an autorefractometer of noncycloplegics and cycloplegics.

There was no statistically significant difference between the Plusoptix S09 photorefractor and cycloplegic autorefractometer in the spherical power and spherical equivalent. In contrast, there was a statistically significant difference between the Plusoptix S09 photorefractor and noncycloplegic autorefractometer ($P < 0.001$). There was a statistically significant difference between the spherical equivalent of the Plusoptix S09 photorefractor and cycloplegic autorefractometer in children with hyperopia ≥+3.0D and with cycloplegic and noncycloplegic refraction of spherical power ≥+2.0 D. We also found a significant difference between the outcomes of the Plusoptix S09 photorefractor and cycloplegic autorefractometer in the spherical power and spherical equivalent for children with hyperopia ≥+3.0 D.

The refractive error of the Plusoptix S09 photorefractor was similar to that of the cycloplegic autorefractometer, in contrast to the noncycloplegic autorefractometer. However, the Plusoptix S09 photorefractor is an inaccurate tool to estimate the refractive errors of children with moderate hyperopia.

Abbreviations: CP = cylinder power, CPR = cycloplegic refraction, D = diopter, NCPR = noncycloplegic refraction, SE = spherical equivalent, SP = spherical power.

Keywords: cycloplegic autorefractometer, Plusoptix S09, spherical equivalent, spherical power

1. Introduction

Amblyopia is the leading cause of decreased vision among children, with refractive errors as the most important cause of this condition.[1] Because of the importance of early diagnosis and treatment of amblyopia, several different screening methods have been assessed for children. Cycloplegic refraction is currently the gold standard method for detecting refractive errors.[2] However, this method is limited because it requires an experienced examiner and an excessive amount of time.[3] To overcome these limitations, several photorefractors were developed. Among these was the Plusoptix S09 photorefractor (Plusoptix GmbH, Nuernberg, Germany), developed for children and the disabled, and is a noninvasive tool for the rapid assessment of both eyes for refractive errors, pupil size, and inter-pupillary distance.[4]

We investigated the effectiveness of the Plusoptix S09 photorefractor in children.

2. Methods

In total 77 eyes in 40 children aged 2 to 10 years were evaluated in Uijeongbu St. Mary's Hospital from October 9, 2012, to November 30, 2012. This study was conducted according to the guidelines of the Association for Research in Vision and Ophthalmology and the 1975 Declaration of Helsinki. Furthermore, parental consent was obtained prior to the start of the procedure. Children were excluded when they had eccentric fixation, optical media opacity, or exceeded the Plusoptix S09 manufacturer's recommendations of a refractive error of a maximum spherical range of –7.00 to +5.00 D and a pupil size range of 3 to 8 mm.[5] The patients were categorized according to 2 methods: (i) 11 eyes with hyperopia ≥+3.0 D and 66 eyes with hyperopia <+3.0 D, emmetropia, and myopia; (ii) 12 eyes with cycloplegic and noncycloplegic refraction of spherical power ≥+2.0 D and 65 eyes with cyclopegic and noncycloplegic

Editor: Khaled Abdulrahman.

The authors have no funding and conflicts of interest to disclose.

[a] Department of Ophthalmology and Visual Science, Seoul St. Mary's Hospital, [b] Department of Ophthalmology and Visual Science, Uijeongbu St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea.

[*] Correspondence: Young Chun Lee, Department of Ophthalmology and Visual Science, Uijeongbu St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Cheonbo-Ro, Uijeongbu-si, Gyeonggi-do, Republic of Korea (e-mail: eyedoc24@naver.com).

Medicine (2016) 95:35(e4596)

Received: 13 July 2016 / Received in final form: 20 July 2016 / Accepted: 25 July 2016

http://dx.doi.org/10.1097/MD.0000000000004596

Table 1

Patient demographics.

Variable	Total (N=77)	Hyperopia ≥+3.0D (N=11)	Hyperopia <+3.0D myopia emmetropia (N=66)	P	CPR-NCPR SP ≥2D (N=12)	CPR-NCPR SP<2D (N=65)	P
Age, y	5.09±1.60	5.09±1.14	5.09±1.76	1.0*	4.83±1.43	5.14±1.73	0.567*
Female N, %	15 (37.5%)	5 (55.6%)	10 (32.3%)	0.204†	1 (12.5%)	14 (46.9%)	0.102†
CPR SP, D	1.33±1.97	4.66±0.93	0.78±1.49	<0.001*	3.23±1.60	0.98±1.84	<0.001*
CPR CP, D	−1.25±1.20	−0.81±0.48	−1.32±1.27	0.194*	−0.77±0.43	−1.34±1.27	0.133*
CPR SE, D	0.73±2.05	4.25±0.8	0.15±1.54	<0.001*	2.84±1.44	0.34±1.91	<0.001*

CP = cylinder power, CPR = cycloplegic refraction, D = diopter, NCPR = noncycloplegic refraction, SE = spherical equivalent, SP = spherical power.
* *t*-test.
† Chi-square test.

refraction of spherical power <+2.0 D. All refractive errors (spherical power, cylinder power, and spherical equivalent) were determined in the following order: (1) photorefraction without cycloplegia using the Plusoptix S09; (2) autorefraction without cycloplegia (noncycloplegic) using the Cannon autorefractometer (RK-F1, Canon, Tokyo, Japan); (3) cycloplegic autorefractometer using 1% cyclopentolate (1% Cyclogyl®). All cycloplegic autorefractomery was performed within 30 minutes of the use of 1% cyclopentolate 3 times per 5 minutes. Comparisons between the measurements were performed using paired *t*-tests and Pearson's correlation analysis. All statistical analyses were performed using the SPSS statistical package 19 (SPSS for Windows, Chicago, IL). A value of $P < 0.05$ was taken to indicate statistical significance.

3. Results

There was no statistical difference between the 11 eyes with hyperopia of ≥+3.0 D and the 66 eyes with hyperopia of <+3.0 D, emmetropia and myopia for age and sex. In addition, there was no statistical difference between the 12 eyes with cycloplegic and noncycloplegic refraction of spherical power ≥+2.0 D and the 65 eyes with cyclopegic and noncycloplegic refraction of spherical power <+2.0 D (Table 1). There was no difference between the Plusoptix S09 and cycloplegic autorefractometer for both spherical power and equivalent in all of the children. In contrast, there was a statistical difference between the Plusoptix S09 and noncycloplegic autorefractometer ($P < 0.001$) (Table 2). Pearson's correlations between the Plusoptix S09 and cycloplegic autorefractometer for spherical power, cylinder power, and spherical equivalent were 0.748, 0.893, and 0.782, respectively, whereas between the Plusoptix S09 and noncycloplegic autorefractometer these were 0.559, 0.870, and 0.580, respectively. These results indicate that the spherical power and spherical equivalent determined using the Plusoptix S09 correlated more closely with those determined using the cycloplegic autorefractometer than using the noncycloplegic autorefractometer (Table 3). Although there was no statistical difference between the Plusoptix S09 and cycloplegic autorefractometer in the spherical power and spherical equivalent in all of the patients (Table 2), the mean spherical power and equivalent recorded using the Plusoptix S09 was 2.91±0.90 D and 2.22±0.93 D, respectively, whereas these recorded using the cycloplegic autorefractometer were 4.66±0.93 D and 4.25±0.80 D in hyperopia of ≥+3.0 D, respectively. There was a statistical difference between the Plusoptix S09 and cycloplegic autorefractometer for the spherical power and spherical equivalent in hyperopia of ≥+3.0 D (paired *t*-test, $P < 0.05$). In addition, in patients of cycloplegic and noncycloplegic refraction of spherical power ≥+2.0 D, there was a statistical difference between the Plusoptix S09 and cycloplegic autorefractometer for the spherical equivalent (paired *t*-test, $P = 0.015$) (Table 4). There was significant difference between the Plusoptix S09 and

Table 2

Mean values of refractive parameters.

Group		Total (N=77)	P*
Spherical power, D	Plusoptix	1.53±2.01	
	NCPR	0.13±1.96	<0.001†
	CPR	1.33±1.97	0.238‡
Cylinder power, D	Plusoptix	−1.89±1.63	
	NCPR	−1.34±1.22	<0.001†
	CPR	−1.25±1.20	<0.001‡
Spherical equivalent, D	Plusoptix	0.61±2.02	
	NCPR	−0.54±1.97	<0.001†
	CPR	0.73±2.05	0.428‡

CPR = cycloplegic refraction, D = diopter, NCPR = noncycloplegic refraction.
* Paired *t*-test.
† Comparison Plusoptix with non-CPR.
‡ Comparison Plusoptix with CPR.

Table 3

Correlation coefficient values between 3 methods for refractive parameters.

Group		*R*	*P*
Plusoptix vs CPR	Spherical power	0.748	<0.001
	Cylinder power	0.893	<0.001
	Spherical equivalent	0.782	<0.001
Plusoptix vs NCPR	Spherical power	0.559	<0.001
	Cylinder power	0.870	<0.001
	Spherical equivalent	0.580	<0.001

CPR = cycloplegic refraction, NCPR = noncycloplegic refraction, *R* = Pearson correlation coefficient.

Table 4

Mean values of refractive parameters at subgroups.

Group		Hyperopia ≥+3.0D (N = 11)	*P**	Hyperopia <+3.0D myopia emmetropia (N = 66)	*P**	CPR-NCPR SP ≥2D (N = 12)	*P**	CPR-NCPR SP <2D (N = 65)	*P**
SP, D	Plusoptix	2.91 ± 0.90		1.3 ± 2.05		2.31 ± 1.05		1.38 ± 2.11	
	NCPR	2.64 ± 1.21	0.562†	−1.38 ± 1.28	<0.001†	−1.13 ± 0.64	<0.00†	−1.38 ± 1.30	<0.001†
	CPR	4.66 ± 0.93	0.002‡	0.78 ± 1.49	0.001‡	3.23 ± 1.60	0.036‡	0.98 ± 1.84	0.020‡
CP, D	Plusoptix	−1.52 ± 0.95		−1.95 ± 1.71		−1.31 ± 0.82		−2.00 ± 1.72	
	NCPR	−1.09 ± 0.78	0.015†	−1.38 ± 1.28	<0.001†	−1.13 ± 0.64	0.157†	−1.38 ± 1.30	<0.001†
	CPR	−0.81 ± 0.48	0.011‡	−1.32 ± 1.27	<0.001‡	−0.77 ± 0.43	0.018‡	−1.34 ± 1.27	<0.001‡
SE, D	Plusoptix	2.22 ± 0.93		0.34 ± 2.03		1.66 ± 0.89		0.42 ± 2.11	
	NCPR	2.09 ± 2.21	0.881†	−0.98 ± 1.56	<0.001†	−1.65 ± 2.65	0.002†	−0.34 ± 1.78	<0.001†
	CPR	4.25 ± 0.80	0.001‡	0.15 ± 1.54	0.126‡	2.84 ± 1.44	0.015‡	0.34 ± 1.91	0.631‡

CP = cylinder power, CPR = cycloplegic refraction, D = diopter, NCPR = noncycloplegic refraction, SE = spherical equivalent, SP = spherical power.

* Paired *t*-test.

† Comparison Plusoptix with NCPR.

‡ Comparison Plusoptix with CPR.

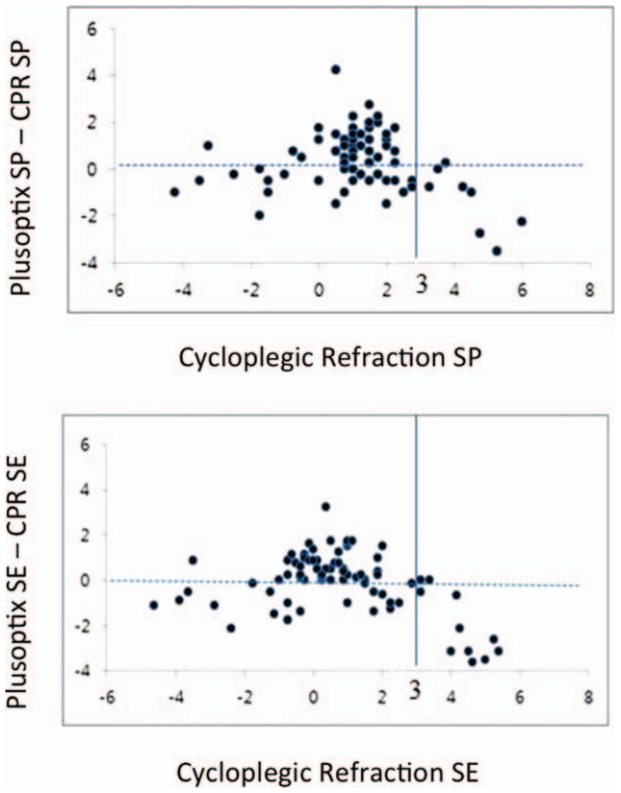

Figure 1. Scatterplot comparing refractive parameters via 2 methods. CPR = cycloplegic refraction, SE = spherical equivalent, SP = spherical power.

cycloplegic autorefractometer according to the scatter plot for spherical power and equivalent in hyperopia of ≥+3.0 D (Fig. 1).

4. Discussion

Amblyopia is the leading cause of decreased vision among children and affects 2% to 5% of the population.[6] Early diagnosis and treatment may lead to better visual outcomes and decrease the severity and prevalence of amblyopia.[1] Because of the importance of early diagnosis, several screening methods for amblyopia are used. The gold standard for detecting refractive error is cycloplegic refraction.[2] However, this method is limited because it requires an experienced examiner, is time consuming, and in general needs sedation of children <3 years old with limited co-operation. In contrast, the photo refractor is easy to use in examining younger children without the need for cycloplegic drops or sedation. Although an ideal screening test would have 100% specificity, 100% sensitivity, and 100% positive predictive value, there is no screening method with this level of accuracy.[7] Many studies have shown the Plusoptix to be a rapid, accurate, and noninvasive refractometer in preschool children and in individuals with intellectual or physical disabilities, and it has excellent specificity and sensitivity.[4,8] The mean spherical power and spherical equivalent recorded using the Plusoptix S09 were 1.53 ± 2.01 D and 1.33 ± 1.97 D, respectively, whereas using the cycloplegic autorefractometer they were 0.61 ± 2.02 D and 0.73 ± 2.05 D, respectively, in all the children, which were not significantly different between the 2 devices (paired *t*-test, $P > 0.05$). We observed significant Pearson's correlation coefficients of 0.748, 0.893, and 0.782 between the Plusoptix S09 and

cycloplegic autorefractometer for spherical, cylindrical, and spherical equivalent refractive errors, respectively. These values are similar to those of 0.76, 0.86, and 0.76, respectively, reported by Rajavi et al.[5]

In contrast, the mean spherical power and spherical equivalent were significantly different using the Plusoptix S09 (2.91 ± 0.90 D and 2.22 ± 0.93 D, respectively) and the cycloplegic autorefractometer (4.66 ± 0.93 D and 4.25 ± 0.80 D, respectively) in hyperopia of $\geq$+3.0 D, (paired *t*-test, $P < 0.05$). Because accommodative capacity leads to a myopic shift in over-moderate hyperopia, a statistical difference between the Plusoptix S09 and cycloplegic autorefractometer for the spherical power and equivalent was expected. This shift was reported to be 3.0 D and 1.9 D in some children by Erdurmus et al[3] and Dahlmann-Noor et al,[9] respectively. Schaeffel et al[10] demonstrated a myopic shift of 2.4 D in children wearing +3.0 D glasses with noncycloplegic photorefraction.

In conclusion, the Plusoptix S09 can provide a rapid and easy method of refraction for amblyopia screening in young children and detecting risk factors for refractive amblyopia. However, when it is used to estimate the refractive error in a child with hyperopia of $\geq$+3.0 D, the refractive error should be corrected after a comparison of the refractive errors of the Plusoptix S09 with those of a cycloplegic autorefractometer.

References

[1] Schmucker C, Kleijnen J, Grosselfinger R, et al. Effectiveness of early in comparison to late(r) treatment in children with amblyopia or its risk factors: a systematic review. Ophthalmic Epidemiol 2010;17:7–17.

[2] Schimitzek T, Haase W. Efficiency of a video-autorefractometer used as a screening device for amblyogenic factors. Graefes Arch Clin Exp Ophthalmol 2002;240:710–6.

[3] Erdurmus M, Yagci R, Karadag R, et al. A comparison of photo-refraction and retinoscopy in children. J AAPOS 2007;11:606–11.

[4] Matta NS, Singman EL, Silbert DI. Performance of the Plusoptix vision screener for the detection of amblyopia risk factors in children. J AAPOS 2008;12:490–2.

[5] Rajavi Z, Parsafar H, Ramezani A, et al. Is noncycloplegic photo-refraction applicable for screening refractive amblyopia risk factors? J Ophthalmic Vis Res 2012;7:3–9.

[6] Simons K. Preschool vision screening: rationale, methodology and outcome. Surv Ophthalmol 1996;41:3–0.

[7] Lagrèze WA. Vision screening in preschool children: do the data support universal screening? Dtsch Arztebl Int 2010;107:495–9.

[8] Ugurbas SC, Alpay A, Tutar H, et al. Validation of plusoptiX S04 photoscreener as a vision screening tool in children with intellectual disability. J AAPOS 2011;15:476–9.

[9] Dahlmann-Noor AH, Comyn O, Kostakis V, et al. Plusoptix Vision Screener: the accuracy and repeatability of refractive measurements using a new autorefractor. Br J Ophthalmol 2009;93:346–9.

[10] Schaeffel F, Mathis U, Brüggemann G. Noncycloplegic photorefractive screening in pre-school children with the "PowerRefractor" in a pediatric practice. Optom Vis Sci 2007;84:630–9.