Original Article

Performance of Plusoptix A09 Photo Screener in Refractive Error Screening in School Children Aged between 5 and 15 Years in the Southern Part of India

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Abstract

Purpose: To evaluate the performance of Plusoptix A09 in detecting ametropia, warranted against frequently-used technique of retinoscopy in children attending school (5–15 years) and its probability as a screening tool.

Methods: This study was the subset of a larger epidemiological study visual acuity refractive error squint conducted in schools to determine the prevalence of ocular morbidity among the 5–15 years' school children population. Every 7th student in the class (each school had mean value of 100 students) was randomly selected for this study after ascertaining their eligibility as per the inclusion criteria. A cohort of a total of 150 children within the age group of 5–15 (mean, 10.21 ± 2.83) years were recruited from 11 schools of Udupi district. Students with best corrected visual acuity of 20/20, refractive error within ±5.00 diopter (D), without any eccentric fixation, and no history of ocular pathology or seizures were recruited. Refractive error was tested by Plusoptix photorefractor followed by non-cycloplegic and cycloplegic retinoscopic techniques. The examiners performing these tests were masked and unware of the findings. Bland Altman plotted the agreement between the techniques, followed by the receiver operating characteristic curve (ROC), and sensitivity of Plusoptix.

Results: One-way analysis of variance calculated statistical differences among Plusoptix, objective retinoscopy, and cycloplegic retinoscopy for mean spherical value (1.12 ± 1.16 D, 0.65 ± 0.69 D, and 0.8 ± 0.82 D), cylindrical value (−0.83 D ± 1.27, −0.32 D ± 0.86, and −0.34 D ± −0.93), and spherical equivalent value (0.71 D ± 1.06, 0.45 D ± 0.7, and 0.61 D ± 0.81), with $P = 0.0001$, 0.0001, and 0.097, respectively. Bland Altman plots showed good agreement for spherical equivalent values of Plusoptix and objective retinoscopy. However, the area under the ROC curve (0.386) suggests that lower diagnostic ability of this device in this age group population in comparison to retinoscopy (0.575) with the sensitivity and specificity of Plusoptix was 69.2% and 84.8%.

Conclusions: This study fails to report ideal sensitivity mandated for a screening tool, although good specificity and agreement are observed. Along with retinoscopy, this tool will be effective in screening a children's population aged between the age group of 5 and 15 years.

Keywords: Plusoptix, Refractive errors, Retinoscopy, School children, Sensitivity

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Introduction

Globally, uncorrected refractive errors continue to be the leading cause of visual impairment.[1,2] Around 12.8 million children aged from 5 to 15 years are visually impaired due to uncorrected refractive errors, as reported by the World Health Organization.[3,4] A significant proportion of visual impairment in the urban and rural areas of India are due to uncorrected refractive error.[5,6] The quicker method of identifying children

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with uncorrected refractive errors is through school vision screening.[7-9]

There has been a wide expansion of screening tools for the pediatric population. The most commonly used is Plusoptix photo screener, a screening tool simultaneously assessing both eyes with greater acceptability among the practitioner and children. The infrared images captured by this device based on the red eye reflex estimate the refractive error, media opacities, ocular deviations, and inter pupillary distance at one measurement.

Studies have reported the effectiveness of photo screening devices for vision screening of children in the detection of anisometropia, hyperopia, myopia, and astigmatism.[10-14] Recently, studies globally are reporting the comparison of various types of photo screeners with forms of retinoscopy in the pediatric age group. Thus, the awareness on usability of photo screeners and verification of testability is taking place globally.[15-19]

Retinoscopy is still considered to be the gold standard in determining the refractive error in children.[20,21] Nevertheless, retinoscopy is limited by the need to maintain fixation, object distance, control over the accommodation, and precise scoping of the visual axis which accounts for the variability in its values. The ease of execution in photo screener as Plusoptix has made it popular for refractive error assessment in young children and individuals with intellectual disabilities. Moreover, Indian eyes have been found to be structurally different in comparison to their Chinese and Caucasian counterparts in terms of their axial length, lens thickness, corneal curvature, and anterior chamber depth which primarily governs the refractive error.[22-25]

This study tried to evaluate the performance of Plusoptix A09 in detecting ametropia, warranted against the frequently-used technique of retinoscopy in children attending school (5–15 years) and its probability as a screening tool.

Methods

A cohort of a total of 150 children within the age group of 5–15 (mean, 10.21 ± 2.83) years were enrolled from 11 schools of the Udupi district. This was the subset of an epidemiological study visual acuity refractive error squint conducted in 11 schools to determine the prevalence of ocular morbidity among the 5–15-year-old population of school children. Every 7th student in the class (each school had mean value of 100 students) was randomly selected for this study after ascertaining their eligibility as per the inclusion criteria. The study was conducted in accordance with the 1975 declaration of Helsinki. Permissions from the Institutional Ethical Committee (Manipal Academy of Higher Education), District Health Administration Board, and concerned school authorities were obtained. Written consents from parents and verbal consents from participants were also obtained. The study setting was the respective school, taking into consideration, the standard lighting condition for Plusoptix to operate. The study duration was from May 2013 to February 2014.

Children with best corrected visual acuity (BCVA) of 20/20 and refractive error within ±5.00 diopter (D) without any specific ocular pathology, strabismus, and seizures (the instillation of cycloplegic drug may trigger the condition) were recruited in the study. Students with BCVA < 20/20 were not recruited, considering the chances of amblyopia and other blinding retinal conditions. Students with significant phoria (2 prism diopters) or any eccentric fixation noticed were excluded since it would alter the Plusoptix reading.[26]

The procedure included visual assessment using Bailey Lovie LogMAR chart, refractive error measurement with photo refraction (Plusoptix A09, Germany) followed by non-cycloplegic (objective) and cycloplegic retinoscopy (REF 18240, NY USA Welch Allyn). Measurement with Plusoptix was done twice, and the average of its value was considered for the analysis. However, retinoscopic measurements were performed once.

The child was asked to sit at a distance of 3 m from the instrument during Plusoptix measurement and fixate at the smiley face at the center of the device. Meanwhile, the examiner re-aligned the instrument in the visual axis of child and captured the scan. The measurements were taken twice, and the average values were considered. A non-cycloplegic retinoscopy followed it. Three drops of cyclopentolate 1%, administered in 5-min intervals, followed. After 30 min, with 6 mm dilated pupil, cycloplegic retinoscopy was performed. To reduce the examiner bias, Plusoptix was performed and documented by a trained optometry intern, and the non-cycloplegic and cycloplegic retinoscopy was performed by a senior optometrist. Plusoptix values were masked from the senior optometrist. Due to the high incidence of aberrations in dilated pupils and inducing error measurement during photo screening, cycloplegic refraction using Plusoptix was not performed. The right eye measurements were considered for the analysis.

Myopia was considered when the measured objective refraction was more than or equal to −0.75 spherical equivalent diopters in one or both eyes. Participants were categorized as hyperopic when the measured objective refraction was >+2.00 spherical equivalent diopters in one or both eyes, provided that no eye was myopic. Astigmatism was considered to be visually significant if ≥1.00 D.[27]

Data analysis and tabulation were done using the SPSS software for Windows version 16 (SPSS Inc., Chicago, IL, USA). Analysis of variance (one-way ANOVA) was used to compare the mean sphere, cylinder, and spherical equivalents. Bonferroni correction was used to check the significance between the groups. We estimated the test–retest variability with repeatability coefficient (RC), coefficient of variation (CV), and intraclass correlation coefficient (ICC). RC, defined as "2.77 × within subject standard deviation (Sw)," is an estimated average of measurement variability in a population.[28] The Sw is

the square root of the within-subject mean square of error (the unbiased estimator of the component of variance due to random error). CV was defined as 100 × Sw/overall mean.[29]

ICC was interpreted as <0.75 represents poor-to-moderate reliability, 0.75–0.90 represents good reliability, and >0.90 represents excellent reliability for the clinical measures.[30]

Bland Altman plots were used to display the agreement of the measurements and to assess the difference in refraction between the three techniques. The area under the receiver operating characteristic curve (ROC) was used to assess the ability of the instrument to differentiate the refractive errors in spherical equivalent against eyes without refractive error. The ROC was used to select the best cut-off points related to the sensitivity and specificity based on the technique described by Unal *et al*.[31] The point closest to (0, 1) corner in the ROC plane defined the optimal cut-point as the point minimizing the Euclidean distance between the ROC curve and the (0, 1) point. Area under the ROC curve (AUC) of 1.0 represented perfect discrimination, and 0.5 represented chance discrimination. $P < 0.05$ was considered to be statistically significant.

Sample size was estimated using G*Power 3.1 power analysis software (Faul, Erdfelder, Buchner, & Lang, 2007) which showed that to attain a power of 0.95, with a moderate effect size of 0.3 and α error probability of 0.05, the sample size required was 134. A *post hoc* power calculation using the same effect size and α error probability and sample size of 150 had a power (1−β error probability) of 0.969 for this study.

Results

Out of the 150 children, 8 myopes, 34 astigmates, and 140 hypermetropes were observed. The mean age of 150 participants was 10.21 (±2.83) years, ranging from 5 to 15 years (46% boys and 54% girls). Statistical significance was observed for sphere and cylinder values between three methods ($P = 0.0001$), with ANOVA analysis having Bonferroni correction of 0.04. Spherical equivalent failed to show any statistical significance [Table 1].

Variance of coefficient and standard deviation were larger for the spherical values (40.54, 0.45). Interclass correlation was found to be good (0.92) and (0.99) for spherical power and cylindrical power among the three methods, suggesting the interchangeability of these techniques, whereas poor correlation (0.70) was observed for the cylindrical axis. The RC was 1.26 diopter sphere (DS) (1.12–1.40) for spherical error, 0.5 diopter cylinder (DC) (0.45–0.56) for cylinder error, and 96.44° (85.52–107.35) for cylinder axis. This suggests that the absolute difference between any two future measurements made by Plusoptix on the spherical power, cylindrical power, and cylindrical axis is estimated to be no >1.26 DS, 0.5 DC, and 96.44° on 95% of occasions, respectively. Cylindrical axis depicted greater CV 45.57 (40.42–50.73), followed by 40.54 (35.96–45.11) and -21.76 (−19.31–24.21) for cylindrical power and spherical power. Least standard deviation was observed for cylindrical power 0.18 (0.16–0.20), followed by spherical power 0.45 (0.40–0.51), and cylindrical axis 34.79 (30.85–38.73) [Table 2].

Bland Altman plot showed good agreement for Plusoptix sphere-objective sphere (2.2, −1.3) [Figure 1], Plusoptix sphere-cyclo sphere (2.0, −1.7) [Figure 2], Plusoptix spherical equivalent-objective spherical equivalent (1.74, −1.30) [Figure 3], and Plusoptix spherical equivalent-cyclo spherical equivalent (1.60, −1.40) [Figure 4]. AUC (0.386) suggests that lower diagnostic ability of this device in this age group of the population in comparison to retinoscopy (0.575) with the sensitivity and specificity of Plusoptix was 69.2% and 84.8% [Figure 5].

Discussion

Early visual screening plays a significant role in reducing the prevalence of visual impairment. It is important to adopt

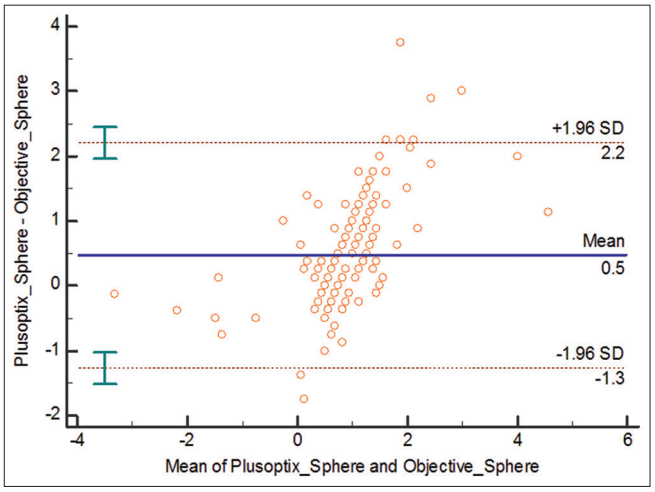

Figure 1: Agreement between Plusoptix sphere and objective retinoscopy sphere using Bland Altman plot

Table 1: Comparison between the Plusoptix A09, objective retinoscopy, and cycloplegic retinoscopy for spherical, cylindrical, and spherical equivalent values

Total (*n*=151)	Sphere (D)			Cylinder (D)			Spherical equivalent (D)		
	Mean±SD	95% CI	*P*	Mean±SD	95% CI	*P*	Mean±SD	95% CI	*P*
Cycloplegic retinoscopy	0.8±0.82	0.67-0.94	NA	0.34±0.93	−0.55-0.25	NA	0.61±0.81	0.48-0.74	NA
Objective retinoscopy	0.65±0.69	0.54-0.76	NA	0.32±0.86	−0.46-0.18	NA	0.45±0.7	0.38-0.60	NA
Plusoptix	1.12±1.16	0.94-1.31	0.0001	0.83±1.27	−1.04-0.63	0.0001	0.71±1.06	0.53-0.88	0.097

D: Diopter, SD: Standard deviation, CI: Confidence interval, NA: Not available

Table 2: Values on interobserver repeatability coefficient, coefficient of variance, within subject standard of deviation, and intraclass correlation of Plusoptix A09 spherical power, cylindrical power and axis

	95% CI			
	RC	CV	Sw	ICC
Spherical power	1.26 (1.12-1.40)	40.54 (35.96-45.11)	0.45 (0.40-0.51)	0.92 (0.89-0.94)
Cylindrical power	0.5 (0.45-0.56)	-21.76 (−19.31-24.21)	0.18 (0.16-0.20)	0.99 (0.98-0.99)
Cylindrical axis	96.44 (85.52-107.35)	45.57 (40.42-50.73)	34.79 (30.85-38.73)	0.70 (0.59-0.78)

RC: Repeatability coefficient, CI: Confidence interval, CV: Coefficient of variance, Sw: Within subject standard deviation, ICC: Intraclass correlation coefficient

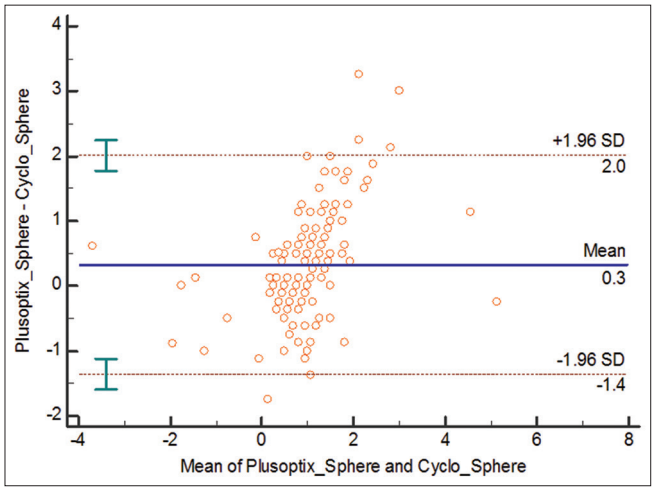

Figure 2: Agreement between Plusoptix sphere and cycloretinoscopy sphere using Bland Altman plot

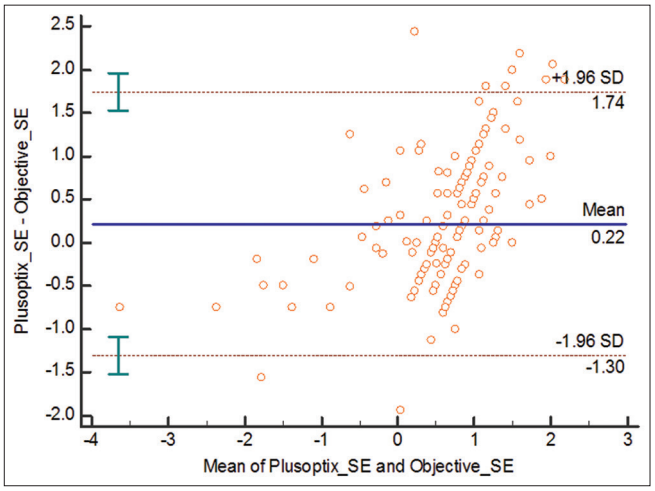

Figure 3: Agreement between Plusoptix spherical equivalent and objective retinoscopy spherical equivalent using Bland Altman plot

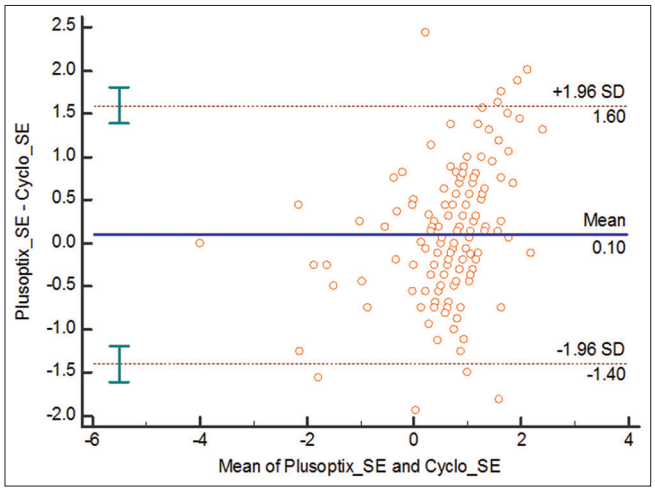

Figure 4: Agreement between Plusoptix spherical equivalent and cycloretinoscopy spherical equivalent using Bland Altman plot

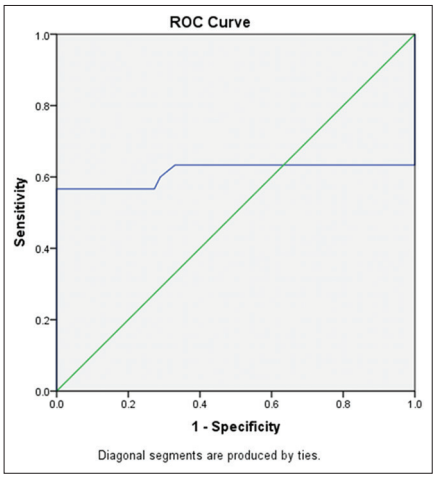

Figure 5: Receiver operating characteristics curve to plot the sensitivity and specificity of Plusoptix. Area under the curve: 0.614, 95% confidence interval: 0.444–0.783, Standard error: 0.086

newer and quicker techniques with promising sensitivity and specificity for this task. This study evaluated the performance of the Plusoptix A09 in detecting refractive errors in school children aged 5–15 years. Photorefraction and retinoscopy (with and without cycloplegia) were used to determine the refractive error. Significance was found for spherical and cylindrical contents between the three techniques, whereas no significance was observed for spherical equivalent values.

Photorefraction without cycloplegia was performed considering the manufacturer's recommendation as dilated pupil would induce peripheral aberrations leading to off-axis refraction. Furthermore, the accuracy of cylindrical power and axis is compromised for cycloplegic photorefraction.[32]

The current study showed the 95% intraclass correlation between Plusoptix and objective retinoscopy techniques for

spherical and cylindrical power to be 0.92 and 0.99, suggesting the interchangeability of these techniques. Bland Altman plots showed agreements for Plusoptix sphere-objective sphere, Plusoptix sphere-cyclo sphere, Plusoptix spherical equivalent-objective spherical equivalent, and Plusoptix spherical equivalent and cycle spherical equivalent.

However, in terms of sensitivity and specificity (69.2% and 84.8%), the Plusoptix device failed to show a promising outcome. Considerable low measures were observed for this device. Since Plusoptix was the point of concern in this study, the accuracy measure checks were confined only to Plusoptix.

The accuracy of the screening test was summarized by the AUC and compared with retinoscopy. AUC (0.386) suggests lower diagnostic ability of this device in this age group of the population in comparison to retinoscopy (0.575). These results are also contradicting to a study performed under 7 years at a different geographical location.[33] The refractive cut-off values used here were as per the AAPOS guidelines.[27] A modification in the referral criteria (for myopia, hypermetropia, and astigmatism) could improve the sensitivity and specificity values. One of the studies had modified the referral criteria for hypermetropia (+1.12 D and +2.60 D instead of +2.00 D and +3.50 D) to get a revised sensitivity value (65.38% to 84.62% and from 46.15% to 69.23%).[34] Few studies have reported the underestimation of refractive error and having higher accuracy in myopia than hyperopia in the pediatric population.[34,35] In this study, an overall hyperopic shift in the values was observed in comparison to retinoscopy. As per AAPOS, ≥+0.50 DS was considered hyperopic. This could be due to the strong, uncontrolled accommodation of children.

Regarding the cylindrical results, studies agree with the consistency of the cylindrical power between the Plusoptix and cycloretinoscopy.[34] A similar phenomenon was observed here with 0.50 DC higher results in comparison to retinoscopy.

The Plusoptix has been reported to be a useful screening tool compared to Suresight, SPOT, Retinomax, and MTI[18,36-38] by various researchers. However, at this setup, we could not substantiate the use of Plusoptix as standalone test for screening. Probably, the age group, levels of refractive error, and testing conditions could have contributed in this varied result.

This study could not recruit children from the secondary grades due to the rigorous academic schedule of these higher grades. Factor of uncontrolled accommodation was observed which could have been controlled by the standard measures.

In conclusion, this study failed to report ideal sensitivity mandated for a screening tool, although good specificity and agreement were observed. Revised referral criteria cut-offs could further improve the sensitivity value. However, in conjunction with retinoscopy, this tool would be effective in the screening of refractive errors in a population aged between 5 and 15 years, especially myopia and astigmatism within the refractive error range of ±5.00 D.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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