Original Article

Tribal Odisha Eye Disease Study # 4: Accuracy and utility of photorefraction for refractive error correction in tribal Odisha (India) school screening

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Purpose: To compare the photorefraction system (Welch Allyn Spot™) performance with subjective refraction in school sight program in one Odisha (India) tribal district. **Methods:** In a cross-sectional study school students, aged 5–15 years, referred after the preliminary screening by trained school teachers received photoscreening and subjective correction. The photoscreener was compared to subjective refraction in the range of +2D to −7.5D. Statistical analysis included Friedman nonparametric test, Wilcoxon signed-rank test, linear regression, and Bland–Altman plotting. **Results:** The photoscreener was used in 5990 children. This analysis included 443 children (187 males, 256 females, and the mean age was 12.43 ± 2.5 years) who received both photorefraction and subjective correction, and vision improved to 6/6 in either eye. The median spherical equivalent (SE) with spot photorefraction was 0.00 D (minimum −5.0D; maximum +1.6 D), and with subjective correction was 0.00D (minimum −6.00 D; maximum +1.5 D). The difference in the SE between the two methods was statistically significant ($P < 0.001$) using Friedman nonparametric test; it was not significant for J 45 and J 180 ($P = 0.39$ and $P = 0.17$, respectively). There was a good correlation in linear regression analysis ($R^2 = 0.84$) and Bland–Altman showed a good agreement between photorefraction and subjective correction in the tested range. **Conclusion:** Photorefraction may be recommended for autorefraction in school screening with reasonable accuracy if verified with a satisfactory subjective correction. The added advantages include its speed, need of less expensive eye care personnel, ability to refract both eyes together, and examination possibility in the native surrounding.

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The Eastern Indian state, Odisha is home for 9.7% of the tribal population of the country. At 8.14 million people, the tribal population in Odisha was 22.1% of Odisha's population in 2011 census. The tribal population exceeds 50% of the total state population in 4 of 30 districts; they are Malkangiri (57.4%), Rayagada (55.8%), Nabrangpur (55%), and Mayurbhanj (56.6%).[1] In general, the tribal people are poor and live in remote areas with poor access to health and education. The Tribal Odisha Eye Disease Study is an attempt to study various eye health aspects of people living in the tribal districts of Odisha.

Uncorrected refractive error is an important cause of visual impairment. Refraction consists of objective retinoscopy and subjective correction. The objective retinoscopy is an essential technical step; it uses a retinoscope and skilled technical personnel, such as the optometrists. The objective retinoscopy could also be completed using an autorefractometer that requires a less skilled person. Over a period, the autorefractometers have become technically more robust, and physically less bulky. It is possible that it could replace a traditional retinoscopy in the future, at least, as a screening tool.

A new technique in autorefractometer is photorefraction. Photorefraction is the refraction of both eyes using a camera or other image capturing device, most often from a distance of 1-m or more. The estimate of the eye's defocus is derived from the distribution of reflected light across the patient's pupil.[2] In the past three decades, there is a lot of interest in photographic and videographic automated objective refractions. The basic principle of video retinoscopy for estimating the refractive error is based on the analysis of light reflected from both the pupils simultaneously. With the availability of infrared light-emitting diode, the video retinoscopy is easier as the pupils would not constrict.

The Spot Vision Screener (Welch Allyn, New York, USA) is a portable, hand-held device designed to detecting a refractive error, and anisocoria from a distance of 1-m with a fixation of a random visual target and audible sound to grab attention of the patient. Following a trial in all age group of patients in the hospital and revealing the accuracy of the spot phoroscreener in children,[3] we used this device in Rayagada district school sight program (SSP) and compared its finding with the subjective correction in a particular range of refractive error.

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Methods

The Rayagada district SSP, described in detail earlier,[4] essentially was a multistage screening of school students partly done in the school and partly in the hospital. The first-stage screening was performed by the trained school teachers in the school, the second-stage phorefraction was performed by optical dispensing person, specifically trained in photorefraction, followed by subjective correction by an optometrist in the school, the third stage comprehensive eye examination was conducted by an ophthalmologist in the community eye hospital, and the final stage of amblyopia therapy/surgical corrections, if any, were done by the specialist pediatric ophthalmologist in the tertiary eye hospital. The L V Prasad Eye Institute, Bhubaneswar Ethics committee approved the study (2016-15-CB-14) and the protocol adhered to the provision of the Declaration of Helsinki for research involving human beings. Written informed consent was obtained from the teachers in the school for examination in their premises and from the parents when the children were examined in the hospital.

In photorefraction, the spot refractometer was held at a 1-m distance at the eye level of the patient. The patient was asked to look at the target inside the screener and the device was moved in a manner that the examiner captured both the eyes on the screen. (The screen turns blue if the device is either too close or too far from the patient. The screen turns gray when the device is stable and the screening wheel appears on the screen; this indicates that the results are captured). The device prompts one to adjust the room light if the pupils are too small. The results are displayed on the screen at the end of the process; the information includes the pupil size, the vertical and horizontal alignment in degrees, the pupillary distance, and complete refraction values including spherical equivalent (SE), sphere, cylinder, and axis. The objective retinoscopy was done in a standard manner and the refractive error was determined by placing the lenses manually in the trial frame until the reflex was neutralized in all meridians.

Even though photoscreener was done in all children, the subjective refraction was done only in those children whose unaided visual acuity was <6/6 in one or both eyes, the photoscreener values were between −7.5 and +2 D and in children who did not have any external ocular abnormalities. Those who had visual acuity of 6/6 and no external ocular abnormalities did not receive any further examination. Those who had photoscreener beyond −7.5D and +2D, had external ocular abnormalities such as strabismus or media opacity and those who did not improve to 6/6 with subjective correction were referred to the rural eye center for further examination. Since cycloretinoscopy was not done at the site and prescriptions were based on photorefraction-based subjective correction only, we tested it in the range of −7.5D to +2D and referred the children beyond this range for cycloretinoscopy in the hospital. In another study done in the clinic, the accuracy of spot screener has been compared to cycloretinoscopy in the entire range of refraction.[3] Analysis was performed for the students in whom both photoscreener testing and subjective correction were done and in those whose vision improved to 6/6 with subjective correction.

The results were converted into M (Median SE), J45, and J180 vectors for statistical analysis. The formula for calculating these three parameters were as follows.[5]

$$M = \frac{S + C}{2} \qquad J\,180 = \frac{-C\,\mathrm{Cos}\,(2\alpha)}{2} \qquad J\,45 = \frac{-C\,\mathrm{Sin}\,(2\alpha)}{2}$$

C = cylinder; M = SE; S = Sphere; α = axis.

Statistical analysis

Only the right eye values (or the left eye if the right eye was emmetrope) were used for statistical analysis. Friedman nonparametric test was used for statistical analysis. The pseudomedian was calculated with spot screener and subjective correction. Wilcoxon signed-rank test was applied to test if the difference between the results obtained from the Spot photoscreener and subjective correction was significant. Linear regression was made to assess the correlation between the results obtained from those different methods. The coefficient of determination (R^2) was used to determine the relationship of variables. Bland–Altman plots were used to assess the agreement between spot and subjective correction.

Results

The photoscreener (Spot) was used in 5990 children referred after school teacher's initial screening of 153,107 children. Of the referred, 4677 children had visual acuity 6/6 in both eyes and did not have any external ocular anomaly. They did not undergo any further examination. Five hundred and fifty-six children had some ocular anomaly such as strabismus and media opacity; they were referred directly to the rural eye center for evaluation by the ophthalmologist. Seven hundred and fifty-seven children had visual acuity <6/6 and did not have any external ocular anomaly. One hundred and five of 757 children (13.9%) were referred for outlier photorefraction (>2D: 99 children; >–7.5D: 6 children) and 652 of 757 (86.1%) children had photorefraction between −7.5 and 2 D and they received subjective correction. Four hundred and forty-three of 652 children (67.9%) improved to 6/6 with subjective correction;

Table 1a: Median of refractive components M (spherical equivalent), J 45, and J 180 measured by Spot™ screener and subjective refraction

Refractive components	MedianSpot™ screener (Q1, Q3)	Median subjective refraction (Q1, Q3)	*P* (Friedman nonparametric test)
SE (M)	0.00 (–0.50, 0.50)	0.00 (–0.50, 0.00)	<0.001
J 45	0.00 (–0.34, 0.37)	0.00 (0.00, 0.08)	0.39
J180	0.00 (–0.08, 0.15)	0.00 (–0.25, 0.35)	0.17

SE: Spherical equivalent

these children were prescribed spectacles. Two hundred and nine of 652 children (32.1%) did not improve with subjective correction; these children were referred for further evaluation. Thus, the analysis was done for these 443 children; it included 187 boys, 256 girls, and the mean age was 12.43 ± 2.5 (range 5–15 years) [Fig. 1]. These 443 children had received both spot photorefraction and subjective correction, and in all of them, the vision had improved to 6/6 in both eyes with the photoscreener suggested subjective refraction.

The median SE of the patients with Spot photorefraction was 0.00 D (minimum −5.0 D; maximum +1.6 D), and median SE with subjective refraction was 0.00 D (minimum −6.00 D; maximum +1.5 D). Thus, Spot screener and subjective refraction values were similar. Friedman nonparametric test was performed for *P* value for all ways of measuring refractive errors results [Table 1a]. The difference in the SE between the two methods was statistically significant ($P < 0.001$), but not for J 45 and J 180 ($P = 0.39$ and 0.17, respectively) using Friedman nonparametric test. Wilcoxon Signed-Rank Test was used to compare the pseudomedian difference between Spot refractometer and subjective correction [Table 1b]. The difference between the Spot screener and subjective refraction was statistically significant ($P < 0.001$).

The linear regression analysis between photorefraction and subjective correction had a good correlation with $R^2 = 0.84$ ($P < 0.0001$) [Fig. 2]. The results were plotted in Bland–Altman plot to see the correlation between the spot and subjective refraction. The mean difference in SE values of spot photorefraction and subjective refraction was 0.23 D with an upper limit of 0.69 D and lower limit of −1.16 D. Thus, it overestimated hyperopia and underestimated myopia [Fig. 3]. The 95% limit of agreement is quite acceptable for a screening test.

Table 1b: Pseudomedian difference of values between Spot screener and subjective refraction by Wilcoxon Signed-rank test

Method	Pseudomedian difference	*P*
Photoscreener versus subjective correction	0.499	<0.0001

SE: Spherical equivalent

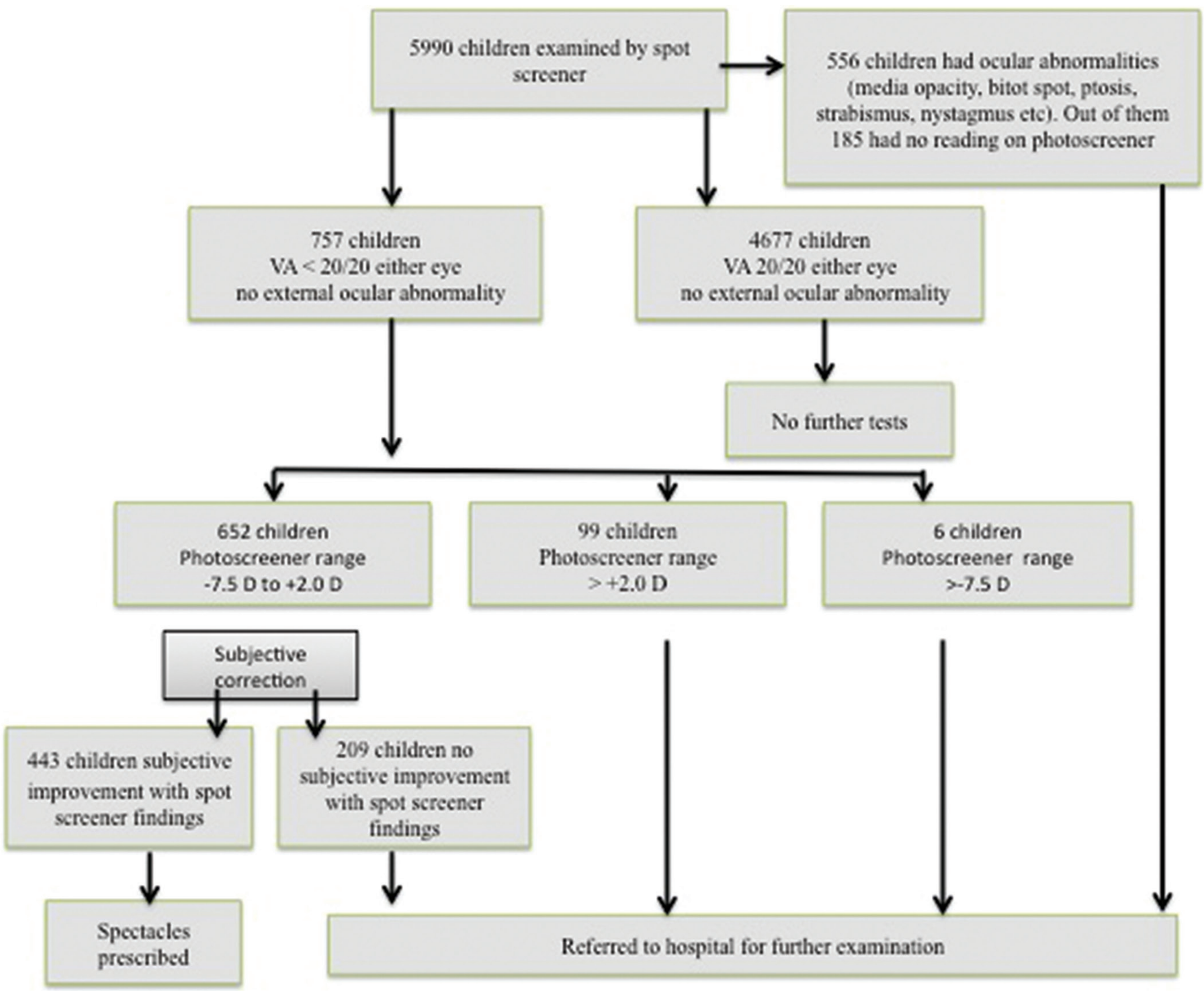

Figure 1: Flow chart of Rayagada school sight program

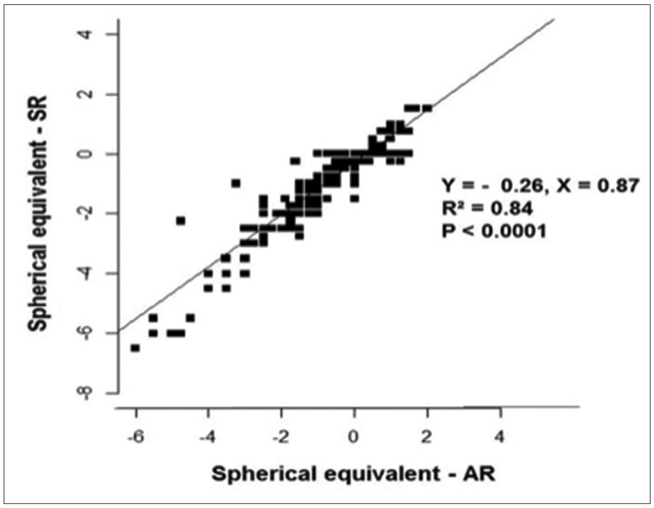

Figure 2: Linear regression analysis between photorefraction and subjective correction in Rayagada school sight program

Discussion

Uncorrected refractive error is a significant cause of visual impairment and is more common in resource-poor regions of the world.[6] Its impact is very high in children as it is likely to affect adversely their mental wellbeing and intellectual development. One of the ways of overcoming this problem is the annual eye screening of students in the school. In a populous country like India and in a difficult terrain like the tribal Rayagada district, this is an uphill task. While the skilled human resource is an ideal answer and the use of technology in objective refraction is a viable alternative.

Photorefraction is a relatively recent advancement, though it existed in some crude form from the 1960s. One distinct advantage is that the device refracts both eyes simultaneously. Early investigators have recorded its advantages in infants.[7,8] The Welch Allyn portable autorefractometer device, the Spot Vision Screener, is based on photorefraction technology. It is designed to detect a refractive error, and anisocoria from a distance of 1-m with a fixation of a random visual target and audible sound to grab attention of the patient. There are three distinct advantages such as it is not bulky, it refracts both eyes together, and does not require head stabilization. As per the product information, the measuring ranges of the instrument are spherical from −7.50 to +7.50 D in 0.25 D steps, cylinder from 0.00 to 3.00 D in 0.25 D steps, at 1°–180° axis in 1° increment, and pupil size from 4.00 to 9.00-mm. The manufacture's literature indicates that it could be used in a wide range of age group, 6 months to 100 years. We found it suitable for children, but with slight underestimation of myopia and overestimation of hyperopia when compared to cycloplegic refraction, considered the gold standard in children.[3] The traditional refraction using a retinoscope is also portable and does not require head stabilization, but cannot refract both eyes together. In addition, a dark room is needed for traditional retinoscopy which may not be possible to create in the school screening site. Again in photorefraction, unlike retinoscope based refraction, one does not need specifically skilled person (such as an optometrist).

Several other studies have used different makes of photorefractometers. The fortune optical (Tomey ViVA)

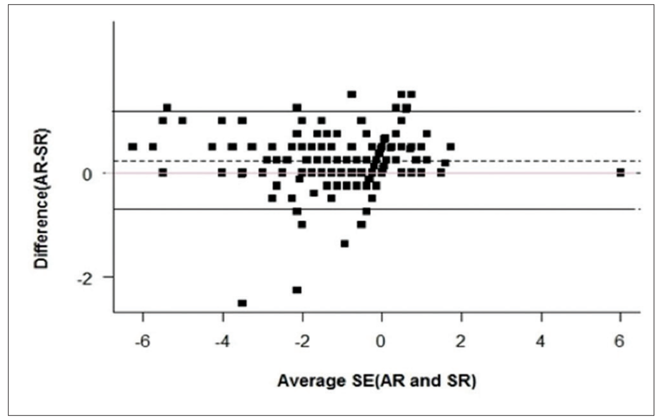

Figure 3: Bland–Altman plot between photorefraction and subjective refraction in Rayagada school sight program

VRB-100 by Tomey Corporation; Nagoya, Japan) video refractor was presumably less accurate in measuring oblique astigmatism.[9] In this study, Bland–Altman plot showed a good agreement between the results. We have documented an overestimation of hyperopia and underestimation of myopia without cycloplegic refraction. The reverse is true in cycloplegic refraction.[10-14] Accommodative effort made by the patient in noncycloplegic photorefraction and temporary paralysis of accommodation in cycloplegic retinoscopy explains this reversal of findings.

Uncorrected refractive error accounted for 61% of visual impairment in South Indian children.[15] The barriers to utilization of eye care included constraints of finance (78%), constraitns of time (70%), absence of an escort (58%), unawareness of gravity of the situation (54%), and fear (28%).[16] The distance barrier could be reduced by reaching the target population as close as possible. We envisage that carrying a photorefraction system to a remote location for providing eye care services in the school for those who have no access or are unable to visit an eye care facility is a good and viable alternative. In addition, this system could help complete screening school children in a short time. With several other studies reporting a good sensitivity and specificity of photorefraction with retinoscopy and autorefraction,[17,18] we feel this method of objective refraction could be adopted in screening school children. In this study, nearly 14% had outlier refraction and only 68% improved in subjective correction. Hence, the utility of photorefraction should be defined under these limitations. The refraction values from the Spot screener could only act as a guide for subjective correction. While prescription of spectacles should not be made without satisfactory subjective correction, we also recognize that photorefraction cannot replace traditional retinoscopy based refraction in any age group and cycloplegic refraction in children.

The weakness of this study lies in the fact that only one make of photoscreener was used, and hence, the recommendations from this study is applied to that make only. The second weakness was that we tested its efficacy in a particular range of photoscreener refraction (from −7.5 to +2 D). The strength lies in the fact that the photorefraction was done in the school premises mimicking a possible real-world situation and analysis was performed who improved to 6/6 with the Spot vision screener suggested lens powers.

Conclusion

Uncorrected refractive error needs urgent attention. A quick reliable refraction such as using an autorefractor is a reliable method. Photorefraction has made the device more portable due to its reduced size and weight. In this study, linear regression showed a good correlation and Bland–Altman showed a good agreement between photorefraction and subjective correction in the tested range. It complements, but does not replace the knowledge and skill of traditional refraction.

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Conflicts of interest

There are no conflicts of interest.

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