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Research Article

Reliability of GR-2100 Autorefractometer in Nepalese Population

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Abstract

Objectives: The aim of this study was to determine the reliability of GR-2100 Autorefractometer in measuring refractive error in Nepalese population.

Methods: It was a cross-sectional study. Refractive error of right eyes of 595 subjects was determined by GR-2100 Autorefractometer and conventional method (retinoscopy followed by subjective refining) in Nepal Eye Hospital during one-year period. The variation of mean spherical equivalent (M) and J0 and J45 components of Jackson Cross Cylinder (in eyes with astigmatism) between two methods was determined. Effect of age on the variation between two methods was also analyzed.

Results: Out of the total participants, 54% (321) were female. The mean age of the subjects was 32.5 ± 19.9 years. Forty-five percent of the subjects were in the age group 16 to 30 years. Average M measured by the conventional method was -2.16 ± 3.39D with range -17.63D to +8.50D. Autorefractometer overestimated M (-0.33 ± 0.92, $p < 0.001$) and J0 (0.02 ± 0.24D, $p = 0.021$) and the difference was associated with age of the subjects ($p < 0.05$). However, there was no difference in J45 component of the refractive error within two methods ($p = 0.178$). The highest percentage of agreement (62%) was found in axis followed by cylinder component (59%) of the refractive error.

Conclusion: GR-2100 Autorefractometer overestimates refractive error. Percentage of agreement was higher with axis and cylindrical components of the refractive error. Only this autorefractometer cannot be used for the prescription, however, it can be used in the screening program.

Keywords: Myopia; Autorefractometer; Spherical Equivalent; Overcorrection; Nepal

Introduction

Autorefractometer is a computerized electronic instrument that measures refractive error of an eye objectively without requiring either operator's or patient's judgment. It is widely used in clinical as well as academic and research purposes to determine the refractive error since it's availability in late 1960s. Autorefractometer is easy to operate and is quicker than other techniques [1]. Majority of the modern autorefractometers are reliable and accurate in comparison to conventional refraction [2,3]. However, previously published studies have shown that many a times, these instruments are used only as the starting point of subjective refraction because prescribing the readings of these instruments yields limited comfort for patients [4].

GR-2100 autorefractometer (Grand Seiko Co., Ltd., Japan) is an instrument which measures the refractive error objectively. An illuminated target (image of air balloon) is kept in conjunction with fogging mechanism to relax the accommodation. It can produce many data and if three or more data are produced, it gives the representative data.

Conventional method of refraction involves cycloplegic or non-cycloplegic retinoscopy followed by subjective refining. An experienced refractionist can determine the refractive error accurately [5]. However, retinoscopy is subject to inter examiner variation [6]. These days, autorefractometer is also being used in many eye hospitals and clinics in Nepal. Autorefractometer is free of operator bias and needs no specialized training for operators. GR-2100 is one of the commonest autorefractometers used in Nepal. However, the reliability and the usefulness of this equipment has not been tested in Nepalese population till now. So, this study was designed to determine its reliability in Nepalese subjects. The variation in the magnitude of refractive error with GR-2100 and conventional refraction was determined in different age group of subjects.

Material and Methods

This was a cross-sectional study conducted in patients attending refraction department of Nepal Eye Hospital (NEH). Subjects with any ocular pathology and not willing to participate in the study were excluded. A systematic random sampling was applied to collect 595 patients to get the results in 99% confidence level and 5% confidence interval of 7156 patients visiting refraction department of NEH each year. This study was ethically approved by Institutional Review Board of Nepal Netra Jyoti Sangh. The research followed the tenets of the Declaration of Helsinki. A written informed consent was taken from each subject, following explanation of the nature and possible consequences of the study.

Complete ophthalmic examination was done for all subjects. Visual acuity assessment was done by using Snellen chart. Slit lamp examination and ophthalmoscopy were done to rule out any pathology by an experienced ophthalmologist. Retinoscopy was done with Heine Beta 200 (Heine Co, Germany) retinoscope followed by subjective refining to calculate the refractive error by an experienced optometrist masked with patient's previous glass power and autorefractometer values. Refractive errors, measured in negative cylinder form, were recorded in a performa. In each subject, refractive error was also measured with GR-2100 autorefractometer by another masked optometrist who did not know the refractive error measured by conventional method. Three readings were taken in each eye and the average measurement of right eye was used in the analysis.

Variables in both the measurements were recorded in data sheet of SPSS 21 statistical software. Spherical component, cylindrical component with negative form and axis were entered. Besides the mean spherical equivalent (M = Sphere + ½ (Cylindrical component)), we converted the cylindrical components into vector form of Jackson Cross Cylinder (JCC) into J0 and J45 as follow [7]:

J0 = ½ (Cylindrical component) * Cos (2*Axis)

J45 = ½ (Cylindrical component) * Sin (2*Axis)

Descriptive data was expressed into mean ± standard deviation. Kolmogorov-Smirnov test was applied to detect the distribution of the variables. Parametric tests were applied in normally distributed variables and non-parametric tests were used to others. P value less than 0.05 was considered as statistically significant. Bland-Altman plotting of M, J0 and J45 were done to assess the variation in two measurements.

Results

Right eyes of 595 subjects were included in this study. Fifty-four percent of the subjects were females, and the mean age was 32.5 ± 19.9 years ranging from 5 to 81 years. There was not a significant difference in the number of males and females ($p = 0.129$). Sixty-two percent of the subjects were of age thirty years or less [Table 1].

Age group (in years)	Male	Female	Total
0-15	50	51	101 (17.0%)
16-30	106	164	270 (45.4%)
31-45	38	27	65 (10.9%)
46-60	35	44	79(13.3%)
> 60	45	35	80 (13.4%)
Total	274	321	595 (100%)

Table 1: Age and gender distribution of the subjects.

Average M with conventional method was -2.16 ± 3.39D; while it was -2.50 ± 3.87D with GR-2100 Autorefractometer. The highest amount of astigmatism was -3.50D. Table 2 shows M, J0 and J45 with two measurement systems. Autorefractometer overestimated M and J0 in comparison to the measurement by conventional methods; however, there was no difference in estimation of J45 ($p = 0.178$).

	M	J0	J45
Conventional method	-2.16 ± 3.39	0.02 ± 0.46	-0.02 ± 0.18
Autorefractometer	-2.50 ± 3.87	0.04 ± 0.56	-0.03 ± 0.29
Differences (p values)	p < 0.001	p = 0.021	p = 0.178
Wilcoxon Signed Ranks Test			

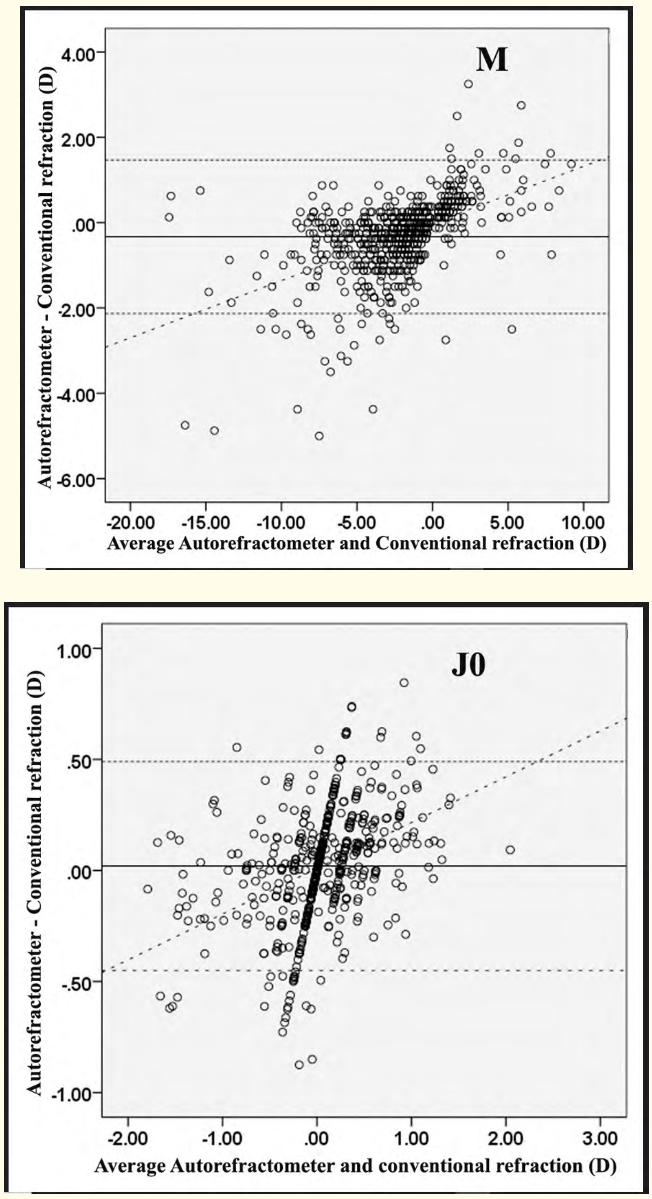
Table 2: Comparison of M, J0 and J45 between two measurement systems. [M: spherical equivalent = Sphere + ½ (Cylindrical component); J0 = ½ (Cylindrical component) * Cos (2*Axis); J45 = ½ (Cylindrical component) * Sin (2*Axis)].

The difference in M and J0 with two measurement methods were associated with age of the subjects ($p < 0.001$). The lower the age of the subjects, the higher was the difference in M and J0. Table 3 shows the percentage of agreement of sphere, cylinder and M (agreement within in ± 0.25D) and axis (agreement within 10^0) measured by autorefractometer with the conventional method. The highest percentage of agreement was found in axis followed by cylinder components of the refractive error. The percentage of agreement in all of the components was found lower in children and older age subjects.

Age groups (in years)	0-15	16-30	31-45	46-60	>60	Total
Sphere	44.5%	50.4%	56.7%	47.5%	37.2%	47.3%
Cylinder	53.6%	58.6%	66.7%	70.4%	52.5%	59.3%
Axis	68.1%	63.9%	78.6%	59.3%	62.3%	62.1%
M	34.0%	35.8%	43.3%	45.0%	39.5%	38.0%
Sphere + Cylinder + Axis	29.7%	36.3%	43.1%	30.4%	26.3%	33.8%

Table 3: Percentage of agreement of the measurement obtained by autorefractometer with conventional method with different age group. The agreement was within ± 0.25D difference in spherical and cylindrical components and M and ± 10^0 in axis [M: spherical equivalent = Sphere + ½ (Cylindrical component)].

Figure 1 shows the Bland Altman plottings of three components: M, J0 and J45 of two measurements. It shows that the autorefractometer overestimation of M is higher in the subjects with higher degree of refractive error.



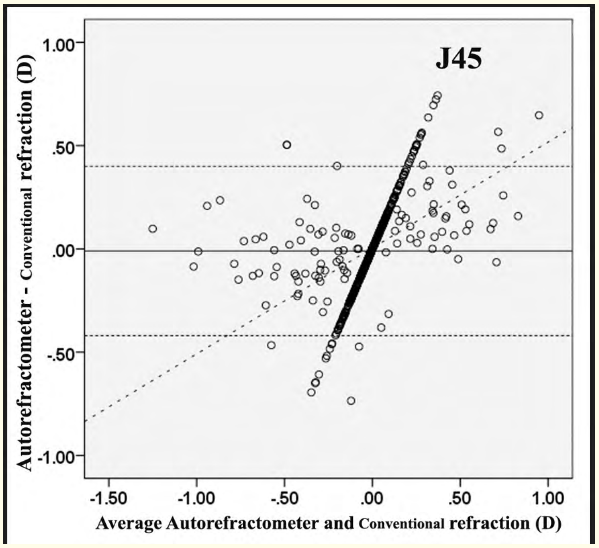


Figure 1: Bland-Altman plotting of the two methods of refraction (conventional and autorefractometry) of three components: a. M; b. J0; and c. J45 of the Jackson Cross Cylinder. Two dotted lines show the 95% confidence interval of the mean variation. Oblique dotted lines show the trend of variation with different degree of myopia.

Discussion

We investigated the validity of GR-2100 autorefractometer because it is one of the most common refractometers used in Nepal. Validity of an autorefractometer is generally expressed in terms of its agreement with the conventional findings [3,8]. If the difference is smaller in refractive error measured by these two methods, the autorefractometer will be more valid.

Overall, the mean difference in the M between two methods was found to be -0.33D ± 0.92D in our study. It is statistically and clinically significant difference. Supporting to our findings, Harvey., *et al*. [9]. also found significant difference in refractive error measured by autorefractometer and retinoscopy. The mean difference between Retinomax autorefractometer (Nikon, USA) and the retinoscopy was 1.03 ± 0.59D in their study. Similarly, McCullough., *et al*. found statistically significant difference in refractive error estimation by Shin-Nippon SRW-5000 autorefractometer and IRX3 aberrometer in M, J0 and J45 [10]. However, the difference was not clinically significant. Jorge., *et al*. concluded that retinoscopy is more accurate than automatic refraction giving a better starting point to non-cycloplegic refraction [11]. Cooper., *et al*. [12] used Humphrey autorefractometer and Vilaseca., *et al*. [13] used TOPCON KR-8100 autokerato-refractometer in myopic subjects to compare the findings with subjective methods. Both of these studies found overestimation of myopia. In contrary to our findings, Shneor., *et al*. [14] found similar measurements by autorefractometer and subjective methods where the mean difference in spherical equivalent was 0.01 ± 0.13D (p = 0.37). However, they had used L80 wave + autorefractometer (Visionix Luneau, Chartres, France) and the sample size was smaller (N = 50) in comparison to the current study.

In a study by Prabakaran., *et al*. [15], there was not significant difference in the refractive error value measured by table mounted autorefractometer and the streak retinoscopy (p = 0.66). However, they found significant difference in refractive error measured by hand-held Retinomax and streak retinoscopy (p < 0.001). In another study, Farook., *et al*. [16] found that Retinomax autorefractometer showed more minus compared with the subjective refraction.

We determined the percentage of agreement in sphere, cylinder, and M within 0.25D and in axis within 10^0 between two methods. The agreement was found highest in axis with two measurements and lowest in M. The difference was more than 0.25D in more than half of the eyes which is clinically significant. This implies that autorefractometer better estimates axis in astigmatism cases rather than cylinder component or sphere. Contrary to our findings, the agreement was higher in cylinder power in the study conducted by Jorge., *et al*. [11]. In another study conducted by Sheppard and Davies [17], spherical components in 61% of the eyes were within ± 0.25D of the subjective findings. However, they have used different instrument, WAM. Autorefractometer overestimated simple astigmatism (J0) but no significant difference was found in the oblique astigmatism (J45). This may apply that GR-2100 autorefractometer is also not reliable in measuring refractive error in astigmatism subjects. The trend in Bland-Altman plotting in M shows that the variation is higher in higher refractive error regardless of the types of error: myopia or hypermetropia. The line of fittings in Bland-Altman plotting of J45 is steeper in comparison to the line of fittings with J0. This may indicate that the difference in J45 between two measurement methods can be higher in higher oblique astigmatism. Jorge., *et al*. found significant differences in

M, J0 and J45 between autorefractometer and subjective refraction, but in our study, only the M and J0 were significantly different but not J45 component [11]. However, our sample size was larger with different age subjects unlike that study.

The percentage in agreement in refractive error measurement by two methods was dependent upon age of the subjects. The agreement was lower in younger age subjects, higher in third decades to fifth decades of age and again started to decline. This implies that measurement of refractive error by GR-2100 autorefractometr in younger and older age subjects is less accurate than in adult population. Harvey., *et al*. [18] measured astigmatism by Welch Allyn SureSight in 825 children with age 3-7 years. They concluded that, autorefractometer is helpful in categorization of the astigmatism but does not provide accurate measurement. The cause of overestimation of refractive error by autorefractometer in younger age population may be due to the role of accommodation but it is unknown in case of older population. In contrary to our study, Harvey., *et al*. [9] did not find any correlation of the dioptric variation with the age of the subjects.

There are some limitations in this study. In our knowledge, there has not been any study conducted comparing refractive error measurement between GR-2100 autorefractometer and conventional method. So, the comparison of the findings of this study with other studies should be carefully interpreted. The study was conducted in refraction department of a tertiary eye hospital. The findings may not be applied in the general population. However, this large sample size study included both ametropic and emmetropic subjects regardless of the types of refractive error. Subjects of this study are supposed to represent the majority of the cases requiring refraction service.

Conclusion

In conclusion, GR-2100 autorefractometer has low validity in measuring refractive error as it overestimates refractive error, particularly in younger and older age population. It is more reliable in measuring the axis than the spherical or cylindrical components of refractive error. Eye care practitioners should keep in mind that this instrument can be used in the screening of the patients but cannot be used for the prescription of glasses without subjective refining as it overestimates. The overestimation is highly affected in eyes with high refractive error.

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