A Comparative Study of Astigmatism Measured by Automated Refractometer and Streak Retinoscopy and the Acceptance of These Values Based on Personalized Correction

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ABSTRACT

BACKGROUND
Refractive error is the world's second most common cause of preventable blindness. Astigmatism comprises a major percentage of refractive error. can be estimated by various modalities, commonly used are the Automated Refractometer and Streak Retinoscope. Automated Refractometer is widely used in outpatient department (OPD) setups but the retinoscope is convenient in camps and where automated refractometers are not available. We wanted to compare the precision of the automated refractometer and streak retinoscopy techniques for estimation of astigmatism with personalized correction acceptance.

METHODS
It is a prospective, observational and comparative study done on 200 patients with the refractive error between the ages of 15 – 40 years, who presented to the Department of Ophthalmology at MVJ Medical College between November 2019 - 2021. Ophthalmological examination was done along with automated refractometry and streak retinoscopy followed by a subjective correction. The automated refractometer and streak retinoscope values were compared with the best-corrected visual acuity to see which was better accepted by the patient. Statistically, a P-value < 0.05 was taken as significant.

RESULTS
The study showed that the dioptric value of the spherical and cylindrical powers was better estimated by streak retinoscope and had a statistically significant p-value of < 0.001. However, the axis of the cylindrical component was better estimated by the automated refractometer which also had a significant P-value (< 0.001).

CONCLUSIONS
The dioptric value of the spherical and cylindrical powers was better estimated by streak retinoscope and the axis of the cylindrical component was better estimated by the automated refractometer. The study helps in learning the benefits of the two modalities in day-to-day clinical practice to weigh out their advantages and disadvantages to decide which modality of objective estimation of the refractive error can be used for each patient's subjective refraction.

KEY WORDS
Astigmatism, Refractive Error, Streak Retinoscope, Automated Refractometer.

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BACKGROUND

Normally images will be focused clearly on the retina. But if the eyeball is too short or too long the focal point of the eye changes forming the images in front of or at the back of the retina, leading to refractive error. [1]

Depending on the focal point, refractive errors are of the following types –

- Myopia or short-sightedness
- Hypermetropia or hyperopia or long-sightedness
- Astigmatism

Astigmatism is a condition in which the light rays, after refracting, do not converge to a single point. Due to variations in the curvatures of the cornea or the lens, instead of focusing the light from a point source to a single point, the image consists of two lines, separated from each other. [2]

World Health Organization (WHO) estimates that 153 million people worldwide live with visual impairment due to uncorrected refractive errors. [3]

Globally, at least 2.2 billion people have a near or distance vision impairment. In at least 1 billion, vision impairment could have been prevented. Of this one billion people includes those with moderate or severe distance vision impairment or blindness due to unaddressed refractive error (88.4 million), cataract (94 million), glaucoma (7.7 million), corneal opacities (4.2 million).[4]

Uncorrected refractive error, after cataracts, is the leading cause of vision impairment and the second leading cause of blindness in developing countries, including India. [5]

Considering all age groups, the prevalence of blindness due to refractive error has been reported to be as high as 0.20 % in India.[6]

Taking the population as a whole the prevalence of different types of refractive errors is as follows - emmetropia 40.7 %, myopia 24.8 %, hyperopia 21.0 %, and astigmatism alone 13.5 %.[7]

Therefore, there is a need to accurately diagnose and treat refractive errors. Many modalities are available for the same.

Accurate objective measurement of the refractive state of an eye can be made using the retinoscope. The technique is called retinoscopy.[8]

Refractometry is the estimation of refractive error with a machine and utilizes the principle of the indirect ophthalmoscope. [9]

Both techniques are widely used in clinical practice each bearing its advantages and disadvantages.

This study was undertaken to assess which of the two modalities – automated refractometer (AR) or streak retinoscope (SR), is better accepted by the patient's subjective correction.

METHODS

It is a prospective, observational and comparative study done on 200 patients, between the ages of 15 – 40 years, with difficulty in vision presenting to the Department of Ophthalmology at a tertiary care hospital, between November 2019 and November 2021. These patients were evaluated for refractive error using vision testing charts, Automated Refractometer and Streak Retinoscope. The patient who was found to have astigmatism of 0.25 D or more was included in this study.

The sample size for this study was calculated based on one of the studies where the prevalence was 58.33 %. [10]

Formula is: n= 4pq/L2 {p=prevalence, q=1-p and L= allowable error (10 %)

Due permission and approval were taken from the Institutional Ethics Committee.

The patients who were diagnosed to have astigmatism who volunteered and consented to be a part of the study were selected.

The consent to participate was in English. A translator and orator were used when the patient could not understand English or was illiterate. All participants were explained in detail about the motive of the study, voluntarism to participate, with no compensation, and were assured that they would receive complete medical aid even if they refused to participate in the survey. The same team of doctors, orators, and translators were present for all the 200 patients.

A detailed clinical history was taken. The patient's demographic details like name, age, sex, address, past medical history, treatment history, and usage and compliance of spectacle history were taken.

Inclusion Criteria

- Patient with refractive errors presenting to the Ophthalmology department.
- The patients who gave informed consent.
- Male and female patients were included.
- Patients between the ages of 15 – 40 years were taken.

Exclusion Criteria

Patients who had -

- Opacities in the optical media.
- Pterygium, keratoconus, or other corneal degenerations.
- Glaucoma.
- Pathologies in the retina and optic nerve.
- Ocular inflammations.
- Patients who had undergone refractive error correction surgeries, cataract surgeries, and other ocular surgeries.
- Patients who responded inadequately due to a lack of comprehension, hearing, or speech.
- This was followed by a detailed ophthalmological examination -
- Visual acuity was recorded using Snellen's Chart
- Pinhole values were recorded
- Near vision was recorded using the standard near vision testing chart
- Slit-lamp examination was done to rule out other ocular pathologies
- Intraocular pressure (IOP) was recorded using Goldmann's Applanation Tonometer
- Automated Refractometer (AR) values were recorded for each eye.
- Streak Retinoscopy (SR) values were recorded for each eye following pupil dilation.
- Visual acuity correction was given to the patient based on the patient's subjective correction acceptance.

- Dilated fundus examination was done using a direct ophthalmoscope and 90D lens.
- Values recorded by Automated Refractometer and Retinoscope were compared with the visual acuity correction accepted by the patient.

Statistical Methods

Data collected were entered into Microsoft Excel. Tables and charts were generated using Microsoft Word. Qualitative variables were presented using percentages, and quantitative variables were presented using mean ± standard deviation. The chi-square test was used to calculate the P-value. A P-value < 0.05 was considered statistically significant.

RESULTS

200 patients (400 eyes) with astigmatism underwent automated refractometry, streak retinoscopy and subjective correction among other ophthalmological examinations. In concluding the study, the following tables and charts were compiled for statistical analysis and conclusions.

Table 1 shows the age distribution of the participants in this study.

Age Distribution		
Age (Years)	**Number of Participants**	**Percentage (%)**
15-20	64	32
20-25	82	41
25-30	29	15
30-35	9	5
35-40	16	8
Total	**200**	**100**

Table 1. Age Distribution in this Study

In this study, the predominant number of cases (82 cases/ 41 %) were in the age group between 20 – 25 years.

The youngest patient was 15 years and the oldest patient was 40 years.

The predominant number of cases, 143 cases (71.5 %), was females and 57 participants (28.5 %) were males.

Table 2, Figures 1, 2, and 3 show the difference in spherical power, cylindrical power and cylindrical axis in the 400 eyes between automated refractometer and streak retinoscope compared with subjective refraction.

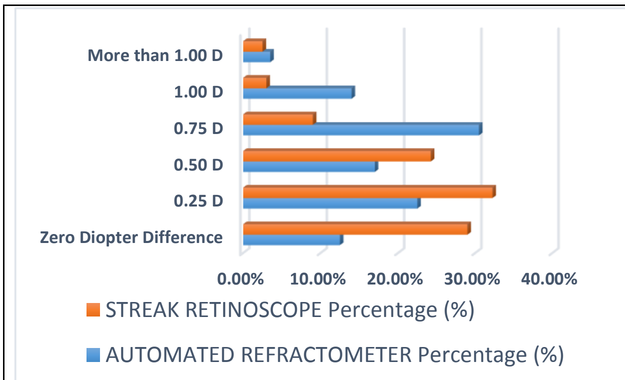

Figure 1. Graph Showing the Difference in Spherical Power of 400 Eyes between Automated Refractometer and Streak Retinoscope Compared with Subjective Correction

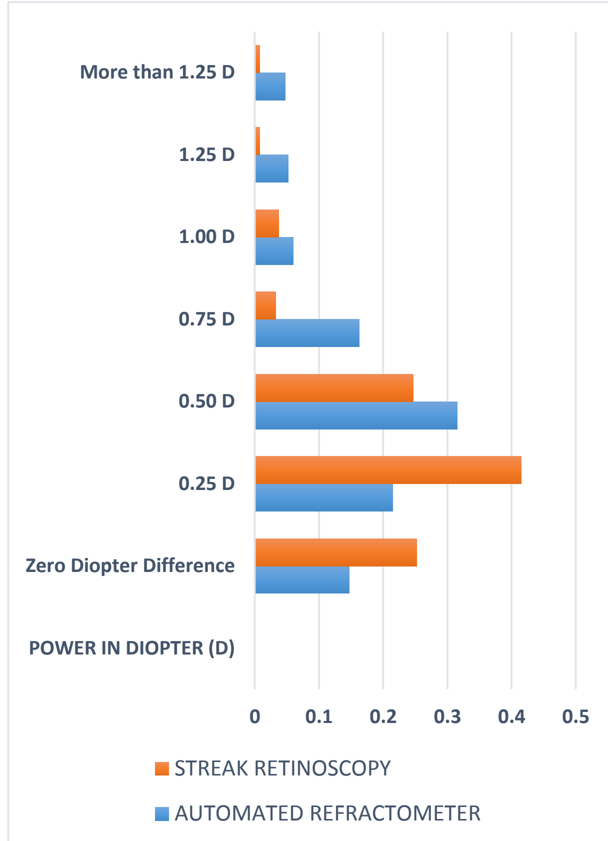

Figure 2. Graph Showing the Difference in Cylindrical Power of 400 Eyes between Automated Refractometer and Streak Retinoscope Compared with Subjective Correction

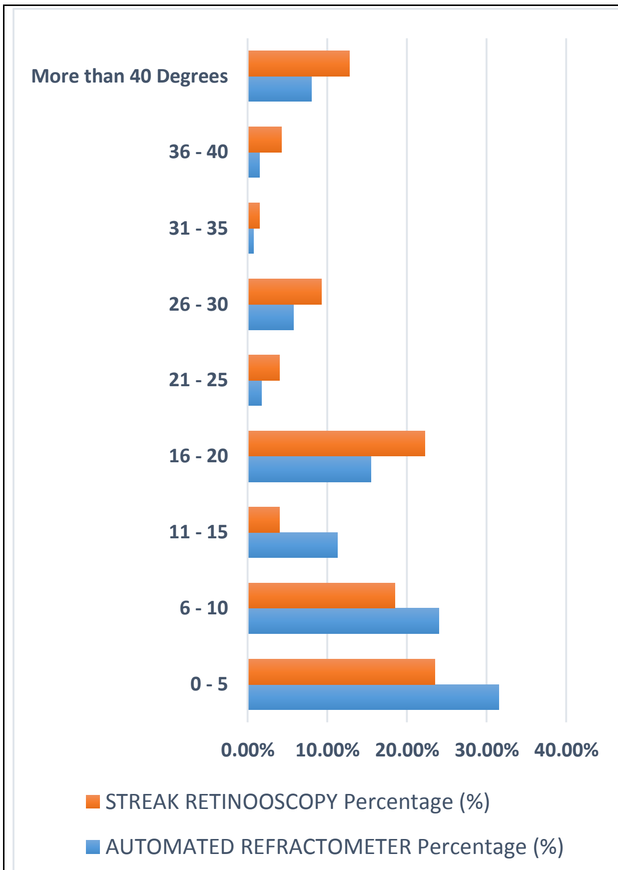

Figure 3. Graph Showing the Difference in the Cylindrical Axis of 400 Eyes between Automated Refractometer and Streak Retinoscope with Subjective Correction

SPHERICAL POWER				
POWER IN DIOPTER (D)	AUTOMATED REFRACTOMETER		STREAK RETINOSCOPE	
	Number	Percentage (%)	Number	Percentage (%)
Zero Diopter Difference	50	12.50%	116	29.00%
0.25 D	90	22.50%	129	32.25%
0.50 D	68	17.00%	97	24.25%
0.75 D	122	30.50%	36	9.00%
1.00 D	56	14.00%	12	3.00%
More than 1.00 D	14	3.50%	10	2.50%
TOTAL	400	100	400	100

CYLINDRICAL POWER				
POWER IN DIOPTER (D)	AUTOMATED REFRACTOMETER		STREAK RETINOSCOPE	
	Number	Percentage (%)	Number	Percentage (%)
Zero Diopter Difference	59	14.75%	101	25.25%
0.25 D	86	21.50%	166	41.50%
0.50 D	126	31.50%	99	24.75%
0.75 D	65	16.25%	13	3.25%
1.00 D	24	6.00%	15	3.75%
1.25 D	21	5.25%	3	0.75%
More than 1.25 D	19	4.75%	3	0.75%
TOTAL	400	100	400	100

CYLINDRICAL POWER AXIS				
AXIS IN DEGREE	AUTOMATED REFRACTOMETER		STREAK RETINOSCOPE	
	Number	Percentage (%)	Number	Percentage (%)
0 - 5	126	31.50%	94	23.50%
6 - 10	96	24.00%	74	18.50%
11 - 15	45	11.25%	16	4.00%
16 - 20	62	15.50%	89	22.25%
21 - 25	7	1.75%	16	4.00%
26 - 30	23	5.75%	37	9.25%
31 - 35	3	0.75%	6	1.50%
36 - 40	6	1.50%	17	4.25%
More than 40 Degrees	32	8.00%	51	12.75%
TOTAL	400	100	400	100

Table 2. Difference in Spherical Power, Cylindrical Power and Cylindrical Axis of 400 Eyes between Automated Refractometer and Streak Retinoscope Compared with Subjective Correction

Figure 1 shows the difference in spherical power as measured by automated refractometer and streak retinoscope compared with subjective correction in this study. The graph clearly shows that the magnitude of the spherical power measured by the AR is larger than the values obtained by the SR. In other words, the SR gives values closer to the values accepted by the patient.

Statistically, the mean standard deviation of the spherical power as measured that of automated refractometer is 0.56 ± 0.357 D and that of the streak retinoscope is 0.36 ± 0.268 D. Comparing these two modalities gives us a chi-square value of 49.384 and gives a statistically significant p-value of < 0.001.

The difference in cylindrical power as measured by automated refractometer and streak retinoscope compared with subjective correction is shown in Figure 2. It is observed that the value of the cylindrical power measured by the AR is larger than the values obtained by the SR. Therefore, the SR gives values closer to the values accepted by the patient in this study.

On applying statistical analysis, the mean standard deviation of the cylindrical power as measured of the automated refractometer is 0.526 ± 0.391D and that of the streak retinoscope is 0.31 ± 0.276 D. Comparing these two modalities gives us a chi-square value of 51.876 and gives a p-value of < 0.001 which is statistically significant.

Figure 3 shows the difference in cylindrical power axis as measured by automated refractometer and streak retinoscope compared with subjective correction. It is observed that the value of the cylindrical power axis measured by the SR (mean 17.628 degrees with ± 17. 684) varies more than the degree of the axis by the AR (15.647 ± 10.346). Hence, this study shows that the AR gives a better estimation of the cylindrical axis.

Upon calculations, this gives us a chi-square value of 641.23 and a p-value of < 0.001 which is statistically significant.

DISCUSSION

In our study, a total of 200 patients, that is 400 eyes, were evaluated for refractive error (Astigmatism). Patients who met the inclusion-exclusion criteria and those who consented to partake in this study were chosen.

All these patients underwent objective refraction by automated refractometer and streak retinoscope (following full pupillary dilation).

Following this, they underwent subjective correction to attain the best-corrected visual acuity.

The values accepted by the patient were then compared with the values obtained by the AR and the SR to see which modality gave the closest estimation of the refractive error value accepted by the patient.

The age group selected in this study was 15 – 40 years.

Patients over the age of 40 years were excluded as they had a higher incidence of lens-induced refractive errors and presbyopia.

In this study, the predominant number of cases (82 cases/ 41 %) were in the age group of 20 – 25 years.

A study done by Hashemi et al. on the regional prevalence of refractive error showed that the highest prevalence of refractive error was between the age of 25 and 35 years which is par with the results obtained in this study. [11]

The predominant number of cases (143 cases / 72%) were females.

A study by Wen et al. on refractive error prevalence among Asian children showed a higher prevalence of refractive error in girls (51.8 %) than in boys. In comparison to this, the values obtained in our study were higher.[12]

In another study by Raju et al. also there was a female predominance of refractive error (67.23 %) which is consistent with our study.[13]

Our study showed that 22 % (44 patients) were hypermetropic and the rest were myopic considering the refractive error population only.

A study by Harrington et al. on refractive error and visual impairment showed that 19.9 % were myopic and 8.9 % were hypermetropic in the overall population. Our study shows a slightly lower prevalence of hypermetropia in comparison to their study. [14]

In another study by Hyams et al. on the prevalence of refractive errors in an adult rural population of 8102 eyes, 18.4 % were myopic, 57.1 % were emmetropic, and 24.5 % were hypermetropic. Myopia was commoner in males than in females, and hypermetropia was commoner in females than in males, our study shows values consistent with their study.[15]

In our study, first taking the spherical power estimated objectively in the 400 eyes, a zero diopter variation was seen in 12.50 % of the eyes in AR and 29.00 % in SR.

A 0.25 – 0.50 D i.e.; a smaller variation, was seen in 22.50 % of the eyes in AR and 32.25 % of the eyes in SR whereas greater than 1.00 D was seen in 3.50 % of the patients by AR and 2.50 % of the patients by SR.

A P-value of < 0.00001 was obtained, hence a statistically significant difference existed between the two modalities and the study showed that the spherical power estimation was more accurate by streak retinoscope than the automated refractometer.

The cylindrical power estimated by the two modalities showed, a zero diopter variation seen in 14.75 % of the eyes in AR and 25.25 % in SR. A 0.25 – 0.50 D difference was seen in 21.50 % of the eyes in AR and 41.50 % of the eyes in SR, whereas, a greater than 1.00 D was seen in 6.00 % of the patients by AR and 3.75 % of the patients by SR.

There was a statistically significant difference between the two modalities with a p-value of < 0.00001. Therefore, the study showed that the spherical power estimation was more accurate by streak retinoscope than the automated refractometer.

The cylindrical axis estimated for these eyes showed that the axis estimated had zero to five-degree variation in 31.50 % of the eyes in AR and 23.50 % in SR.

Six to ten-degree difference was seen in 24.00 % of the eyes in AR and 18.50 % of the eyes in SR.

A greater than 40-degree difference was seen in 8.00 % of the patients by AR and 12.75 % of the patients by SR.

A P-value of < 0.00001 was obtained hence a statistically significant difference exists, showing that the cylindrical axis was better estimated by the automated refractometer than the streak retinoscope.

A study by Rotsos et al. showed that of the 69 eyes with a negative sphere, they observed that the sphere power was significantly higher (more than 0.5 diopters) in automated refractometer than in retinoscope (P = 0.0001) which is similar to our study.[16]

Another study by Vilaseca et al. showed that significant correlations could be established between retinoscopy which gave more hyperopic values while more myopic values were achieved using an autorefraction 0.24 ± 0.49D, which is similar to our study.[17]

In a study by Guha S et al. comparing the sphere, cylinder, spherical equivalent, and length of power vector values gained by autorefraction and retinoscopy, no statistically significant differences were found in any group, which is unlike our study.[18]

A study by Prabhakaran S et al. on the effectiveness of automated refractometers and retinoscope in estimating refractive errors showed that astigmatism measured using the handheld (-0.89 ± 0.51 D) and table-mounted autorefractor (-0.83 ± 0.61 D) was significantly greater than that obtained with streak retinoscopy (-0.58 ± 0.56, p = 0.0003) which is similar to this study where higher values were obtained for the cylinder component using the automated refractometer.[19]

CONCLUSIONS

Astigmatism, a refractive error that produces very troubling asthenopic symptoms when uncorrected and also when corrected improperly, requires efficient assessment and adequate correction to provide trouble-free and clear vision.

With the advent of new technologies every day, automated refractometers are becoming more and more accurate and reliable in day to day to clinical practice. Added to this benefit they are easy to use, do not require additional skills, and are not time-consuming.

But they are expensive and are not portable. Hence these serve as an inconvenience in a rural and camp clinical setup. Automated refractometers are very reliable for estimating the axis for cylindrical correction. One should be aware of inaccuracies induced by accommodation as the instrument is placed close to the eye and take suitable corrective measures by performing a subjective verification of the result.

Streak retinoscope, an age-old device, is widely used. It is cheap, portable and very reliable. The drawback of the retinoscope is that it is skill-based and the axis determination of astigmatism can prove to be quite difficult. It is also time-consuming and requires cycloplegia.

A higher agreement was shown for the spherical and cylindrical power as estimated by the streak retinoscope when compared with the automated refractometer and a more accurate axis was achieved by the automated refractometer in this study.

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