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Original Research Article

STEROACUITY IN MONOCULARLY INDUCED ASTIMATISM IN EMMETROPES AND AMMETROPES: A COMPARATIVE CROSS-SECTIONAL STUDY

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ABSTRACT

Objective: This study aims to find the effect of monocularly induced myopic and hypermetropic astigmatism on stereopsis among ammetropes and emmetropes.

Methods: This comparative cross-sectional study was conducted at the General outdoor patient department (OPD) of Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan from October 2018 to January 2019. The study was conducted on 430 individuals aged between 10 to 35 years, emmetropic and with astigmatic refractive error of <4D at the axis of 90°, 180°, 45°, 135°, and <6D spherical refractive error. Subjects were divided into two groups of 215 individuals each. Both groups were induced with myopic and hypermetropic astigmatism using ± 1 Dc and ± 2 Dc at three axes; 45°, 90°, and 180°. Stereoacuity was measured by the Titmus Fly Stereo Test at the baseline and varying at degrees after induced astigmatism. ANOVA and paired t-tests were used for statistical analysis.

Results: The mean stereoacuity in emmetropes and ammetropes was respectively. On average, there was a significant decrease in stereoacuity with increased dioptric astigmatism power ($p < 0.0001$). Stereoacuity was affected the most at 45° whilst least at 180° among both emmetropes and ammetropes. However, monocularly-induced hypermetropic astigmatism caused more deterioration in stereoacuity than monocularly induced myopic astigmatism.

Conclusions: This study illustrates that monocularly induced myopic and hypermetropic astigmatism affects stereoacuity in emmetropes as well as ammetropes at all given degrees.

Keywords: Stereoacuity, emmetropia, ametropia, amblyopia, astigmatism

INTRODUCTION

Stereopsis is a binocular phenomenon of perceiving depth caused by horizontal retinal image disparity and represents the highest level of single binocular vision¹. The minimal disparity of image detected by the individual is stereoscopic vision. There are three prime requirements of stereoscopic vision binocular overlap of visual fields, partial decussating of the afferent visual fibers, and conjugated eye movements². The stereoscopic vision may be measured by stereoscope or various stereopsis tests^{3,4}. Distance and near Stereoacuity reach the adult level at five years^{5,6}. Stereoacuity is essential for daily activities as it enhances the quality of the vision and is most important in some professions. Stereopsis is affected by both factors' clinical testing environment such as illumination, color, and contrast of the test, and ocular conditions like refractive errors, misalignment of axis, amblyopia, and anisometropia strabismus⁷.

Among the refractive errors, Stereopsis is mainly affected by binocular and monocular astigmatism, and it is affected more severely due to with-the-rule astigmatism than against-the-rule astigmatism^{8,9}. One diopter of cylindrical anisometropia could reduce the Stereoacuity to an average of 51-56 seconds of arc. Astigmatism is the refractive error present at different ages of the patients.

It may be induced even after surgical procedures such as cataract extraction, pterygium, and even refractive surgery among adults and children worsen the Stereopsis. So it is essential to find the effect of astigmatism on Stereopsis because it is an important parameter that enhances the prognosis and treatment of various binocular anomalies. According to the best of our knowledge, there is little knowledge of the effect of astigmatism on Stereopsis. The current study evaluated the effect of astigmatism on Stereopsis experimentally, reflecting the patients' stereopsis after the corneal and lenticular surgical interventions.

MATERIAL AND METHODOLOGY

This study was conducted at the General outdoor patient department (OPD) of Al-Shifa Trust Eye Hospital, Rawalpindi. Al-Shifa Trust Eye Hospital is a tertiary healthcare facility present in Rawalpindi and is the apex of ocular health in the country. It has the state of the art technology relating to the diagnosis, investigations, and management of all eye diseases. This cross-sectional study included patients aged between 10 to 35 years, emmetropic, and ametropic with astigmatic refractive error of <4Dc at the axis of 90°, 180°, 45°, 135°, and <6Ds spherical refractive error with best-corrected visual acuity of better than 6/9. The patients having irregular astigmatism, squint, amblyopia, trauma, and having undergone ocular surgery were excluded. Using a non-probability sampling technique, data was collected from 430 participants over six months from October 2018 to January 2019. This was done to ensure all participants fulfilled the study criteria during the duration. It allows a more accurate analysis of the astigmatism and Stereopsis of the participants. Data was collected by using structured clinical Performa. The first part of the Performa collected information about the socio-demographic variables. In contrast, the second part contained information on ocular examination such as visual acuity, autokeratorefractometry, and subjective refraction. The third part collects the data on the Stereopsis of the patients using the Titmus fly test. Permission was taken from the Ethical committee of Al-Shifa Trust eye hospital (Reference number: ERC-64/AST-18) and verbal informed consent was taken from each participant before inclusion in the study. The primary researcher itself collected all the data under the supervision of experts. The total sample size was divided into two groups, Group A is emmetropes, and Group B is ammetropes fulfilling the study criteria. In group A, monocular myopic astigmatism of -1D and -2D was induced in fifty percent of the participants, and monocular hyperopic astigmatism of +1D and +2D was induced in the other fifty percent of subjects. The same strategy was followed with group B as well. Confidentiality of the patient's data was maintained, and the ethical value of research was considered correctly and tracked at every step of the study. The data recorded were entered and analyzed using SPSS version 21. The descriptive analysis was done on the categorical and continuous variables. Percentages and frequencies were reported for categorical variables and

mean standard deviation, minimum and maximum values were reported for continuous variables. ANOVA and paired sample t-tests were used for inferential analysis. A p-value of <0.05 was considered significant.

RESULT

A total of 432 subjects with an average age of 22.46 ± 4.56 years participated in this study. Among 432 participants, 49.1 % (n=212) were males and 50.9 % (n=220) were females. The demographic characteristics of the subjects are given in Table 1.

Table 1: Demographic data of participants

Subjects (n=430)	Mean SD	Range
Age (years)	22.10 ± 4.76	13-33
Sphere Power (DS)	-0.25 ± 0.25	-0.00-1.00
Cylindrical power (DC)	-0.27 ± 0.18	-0.00-0.50
Spherical equivalent (D)	0.4 ± 0.1	-0.00-0.50

Stereopsis among emmetropes:

Table 2 shows that monocularly induced myopia astigmatism with + 1 D cylinder and + 2 D cylinder stereoacuity was affected significantly at 45° and there is a minimum change in stereoacuity at 180° (p = 0.002).

Table 2 : Stereopsis in monocularly induced Myopia Astigmatism among emmetropes

	Mean Stereopsis in monocularly induced Myopia Astigmatism (+1.00 D)	Mean Stereopsis in monocularly induced Myopia Astigmatism (+2.00 D)	p-value
Baseline (Sec of arc)	24.85 ± 4.85	24.85 ± 4.76	
180°	45.70 ± 6.89	88.68 ± 19.22	0.002*
90°	59.48 ± 7.35	98.44 ± 26.54	0.004*
45°	70.21 ± 8.55	100.58 ± 29.48	0.005*

*Statistically Significant

Table 3 shows a similar trend and indicated monocularly induced hypermetropic astigmatism with - 1 D cylinder and - 2 D cylinder stereoacuity was affected significantly at 45°, and stereoacuity was least affected at 180° (p = 0.0001).

Table 3. Stereopsis in monocularly induced Hypermetropic Astigmatism among emmetropes

	Mean Stereopsis in monocularly induced Hypermetropic Astigmatism (-1.00 D)	Mean Stereopsis in monocularly induced Hypermetropic Astigmatism (-2.00 D)	p-value
Baseline (Sec of arc)	29.75 ± 3.58	28.76 ± 4.21	
180°	68.75 ± 7.47	100.05 ± 19.72	0.0012*
90°	75.89 ± 11.96	120.85 ± 29.58	0.003*
45°	86.78 ± 10.05	160.25 ± 33.25	0.0001*

Figure 1 shows that monocularly-induced hypermetropic astigmatism caused a higher reduction in stereoacuity than monocularly-induced myopic astigmatism. On average, induced astigmatism affected the stereoacuity at all given angles.

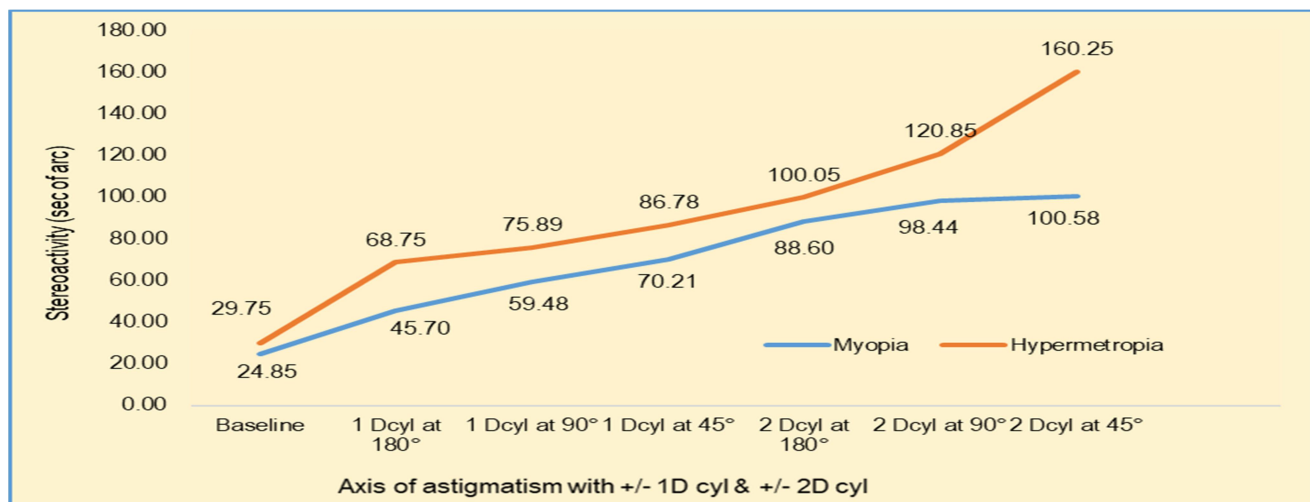


Figure 1 Comparison between stereoacuity in Monocular Myopic Astigmatism & Monocular Hyperopic Astigmatism among emmetropes

Stereopsis among ammetropes

In group B, monocularly induced myopic astigmatism with both the +1 D cylinder and + 2 D cylinder caused a significant reduction in stereoacuity at 45° and minimum change at 180° (Table 4). It is a significant difference in stereoacuity at all given degrees ($p < 0.001$).

Table 4. Stereopsis in monocularly induced Myopia Astigmatism among ammetropes

	Mean Stereopsis in monocularly induced Myopia Astigmatism (+1.00 D)	Mean Stereopsis in monocularly induced Myopia Astigmatism (+2.00 D)	p-value
Baseline (Sec of arc)	28.46 ± 5.26	28.85 ± 4.96	
180°	30.65 ± 8.52	96.23 ± 19.22	0.002
90°	68.21 ± 10.65	110.65 ± 28.45	0.004
45°	85.56 ± 12.55	120.23 ± 35.05	0.005

Table 5 shows a similar trend among ammetropes with the induction of hypermetropic astigmatism at given degrees. There was a significant reduction of stereoacuity at 45° (p=0.0001). At each degree, there was a change of 20 sec of arc stereoacuity

Table 5: Stereopsis in monocularly induced Hypermetropic Astigmatism among ammetropes

	Mean Stereopsis in monocularly induced Hypermetropia Astigmatism (-1.00 D)	Mean Stereopsis in monocularly induced Hypermetropia Astigmatism (-2.00 D)	p-value
Baseline (Sec of arc)	32.65 ± 4.68	29.85 ± 5.85	
180°	78.67 ± 7.45	120.21 ± 20.68	0.0006
90°	85.21 ± 10.55	130.53 ± 30.85	0.0002
45°	91.25 ± 9.25	168.95 ± 35.68	0.0001

Figure 2 shows a trend in ammetropes similar to emmetropes. The line graph indicates that monocularly induced hypermetropic astigmatism affected stereoacuity significantly more than monocularly induced myopic astigmatism. On average, induced astigmatism affected the stereoacuity at all given angles.

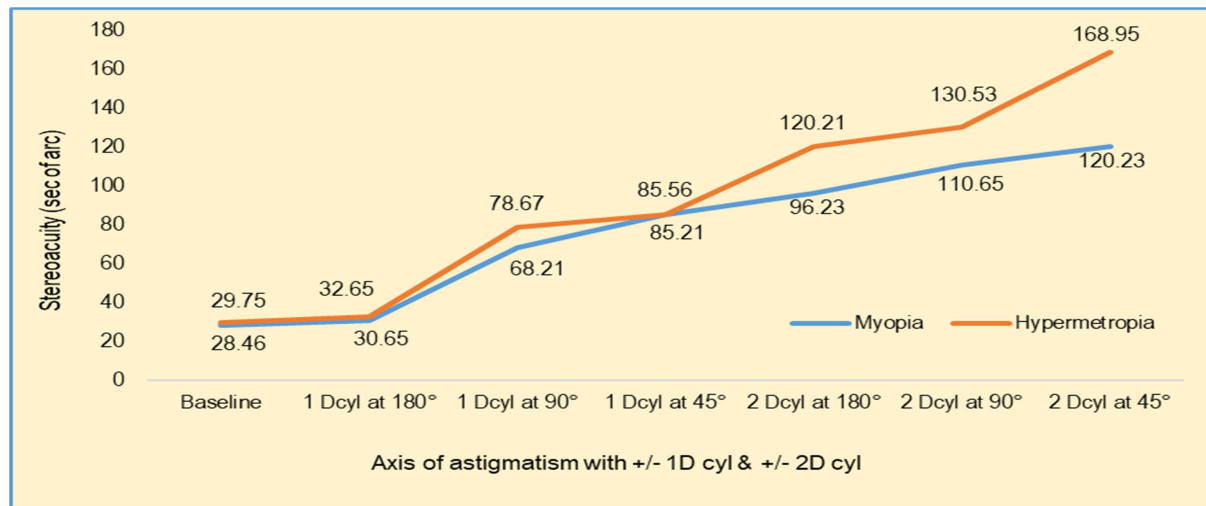


Figure 2: Comparison between stereoacuity in Monocular Myopic Astigmatism & Monocular Hyperopic Astigmatism among ammetropes

DISCUSSION

The present study aimed to evaluate the effect of induced astigmatism on stereoacuity. This study included 432 patients which were equally divided into emmetropes and ammetropes. In the present study mean age of the respondents was 22.10 ± 4.76 ranging from 13 to 33 years. It is stated in the current study that the monocularly induced astigmatism of 1Dc and 2Dc caused a decrease in stereoacuity and this downfall in stereoacuity is more as the power of the cylindrical lens is increased. This decrease in stereoacuity is also associated with the meridional variations which are affected maximally at the oblique axis (45°) than the vertical axis (90°) and least affected at the horizontal axis (180°). Moreover, another interesting finding is that monocularly-induced hypermetropic astigmatism caused more deterioration in stereoacuity than monocularly-induced myopic astigmatism. Varsha Kulkarni et al. stated in their results that even a small degree of monocular or binocular astigmatism is responsible for the reduction in stereoacuity and this demotion is found to be more as the power of induced astigmatism is increased¹⁰

Hanan Al-Qahtani et al. found in their results that the increase in cylindrical dioptric power is the basis for the decrease in stereoacuity and this relation is statistically significant ($p < 0.05$)¹¹. They also stated that monocular or binocular-induced hypermetropic astigmatism has a more deteriorating effect than induced myopic astigmatism, but the difference was not of statistical significance. This difference may be due to the limited number of participants. Varsha Kulkarni et al results are also supported by the results of Maki Shindo et al, Gagal et al, Chen et al, and the results of the current study^{12, 13, 14}.

However, David A. Atchinson et al found that positive or negative lens i.e., simulated myopic or hypermetropic blur, has the same detrimental effect on the stereoacuity which contradicts previous studies. The contradiction may be due to the very small sample size which may explain this variation or the test used for stereoacuity. Most of the studies used Titmus Fly Stereo Test but this study used McGill Vision Research Modified Random Dot Stereogram. No other study has found a similar effect of induced hypermetropic and myopic astigmatism on stereoacuity¹⁵.

Now, when the effect of the axis was noted, all the above-mentioned studies support the results of the current study i.e. oblique astigmatism affects the stereoacuity most followed by vertical astigmatism and then horizontal astigmatism. Even when different stereo tests were used in these studies the results were the same concerning the axis. But Oguz et al. found in their study that induced vertical astigmatism has the greatest deteriorating effect

than induced orthogonal oblique astigmatism (45° & 135°).¹⁶ This deviation from other studies may be due to the limited number of testing levels used, and small sample size or may even be due to the shortcoming of testing stereoacuity at the threshold level. Only one other study supports this finding, but their age group is very broad and participants are very limited.¹⁶

CONCLUSION

In conclusion, most of the studies are in favor of this finding that monocular, as well as binocular-induced astigmatism, is responsible for the deterioration in stereoacuity, and this decline is more as the power of astigmatism increases. In addition to that induced hypermetropic astigmatism (monocular as well as binocular) has a more detrimental effect than induced myopic astigmatism. Moreover, oblique astigmatism has the most degrading effect on the stereoacuity. This data indicates that the astigmatic effect on stereoacuity should be considered in the empirical correction of refractive error. However, the practical knowledge gap cannot be ignored as fewer studies have been done in this area and more should be done so that strong grounds can be established in the future

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