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Study on the role of simple myopic against-the-rule astigmatism in visual rehabilitation in monofocal pseudophakic patients

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Abstract

Introduction: Cataract surgery has been viewed as one of the most cost-effective health interventions with salvation of the disability-adjusted life years. The near visual acuity has always been a cause of concern following the cataract surgery as the patient loses accommodating power after it. This loss of reading ability can significantly reduce a patients' quality of life. Another important parameter that affects visual acuity of a person is contrast sensitivity. There is evidence in literature that these two aspects of vision are affected by surgically induced ATR in monofocal pseudophakic patients.

Objective: To compare the visual acuity and contrast sensitivity in monofocal pseudophakic patients with low myopia with and without low ATR astigmatism.

Materials and Methods: The cases selected were divided into study group and control group. Study group included 25 consecutive eyes (cases) with monofocal pseudophakia having spherical power from 0 D to-0.5 D with ATR astigmatism ranging from-0.5 D to-1.25 D. Control group comprised 25 consecutive eyes (controls) with monofocal pseudophakia having spherical power from 0 D to -0.5 D without astigmatism. Comparison was done between the groups based upon uncorrected distance visual acuity, uncorrected near visual acuity and contrast sensitivity.

Conclusion: The mean uncorrected distance visual acuity was almost equal in both the groups, therefore, the difference was not statistically significant with p=0.420. On the other hand, the uncorrected near visual acuity was better in the study group as compared to the control group and the difference was statistically significant with *p* <0.001. The contrast sensitivity was better in the control group than the study group and the difference was statistically significant too.

Keywords: Astigmatism, pseudophakia, contrast sensitivity, myopia

1. Introduction

The visual outcome, in the form of good distance vision and workable near vision is the main expectation of people undergoing cataract surgery. Though the multifocal IOLs, accommodating IOLs and toric IOLs are ideal to meet these expectations, however most patients, especially in developing countries can't afford these technologies The available literature, nevertheless, does mention few studies that have shown that the patients operated for cataract with monofocal IOL placement with post-operative myopia ranging from 0 D to-0.75D, similarly with against-the-rule (ATR) astigmatism ranging from-0.25 D to-1.25 D seem to be enjoying good visual outcome in the form of acceptable distance and near vision. Verzella & Calossi, in 1993 did a study on multifocal effect of against-the- rule myopic astigmatism in pseudophakic eyes. It concluded that with a low against-the-rule simple myopic astigmatism (about-1.50D cyl 90º), we can offer pseudophakic patients a rewarding independence from glasses both for distant and near vision [1-4]. Bradbury *et al* did a study on the optimal postoperative refraction for good unaided near and distance vision with monofocal intraocular lenses. It was found that a pure myopic astigmatism of 1.5 dioptres axis 180 degrees can be considered a desirable goal for postoperative refraction following cataract extraction and monofocal intraocular lens implantation [5]. This gave us enough impetus to study and explore this interrelation between ATR astigmatism and visual acuity, so that an effort can be made in finding a cost-effective alternative for improving visual outcome in post-operative cataract patients. Also there is paucity of literature regarding the relation between ATR astigmatism and contrast sensitivity, and contrast sensitivity being an important aspect of visual acuity, it made it relevant enough to study its affection, if any, caused by low myopia and ATR astigmatism.

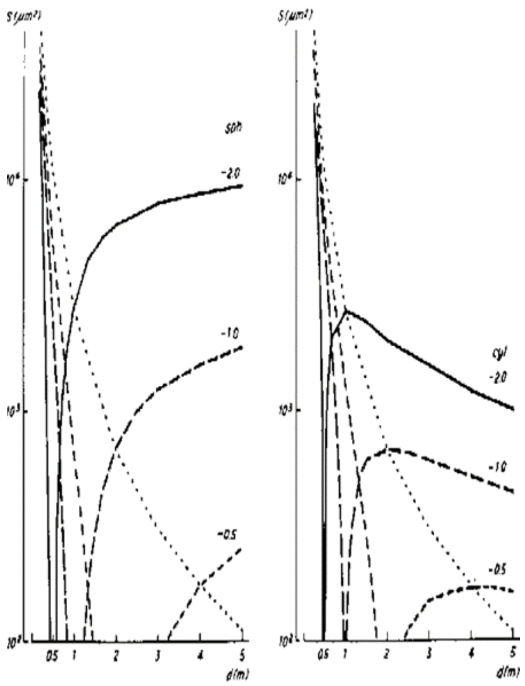

Fig 1: Retinal blur size in ametropia

Figure 1 shows calculated surface of the blurred retinal image in a reduced schematic eye without accommodation, as a function of fixation distance for different amounts of corneal ametropia. The schematic eye has no lens; corneal power is 60 D for the emmetropic eye (dotted line), the length of the schematic eye is 22.26mm, the depth of the anterior chamber is 3.5mm, the pupil size is 3mm. The effect of increasing myopia (left) or increasing myopic astigmatism (right) is calculated for a purely corneal ametropia. The size of the blurred image is plotted in square microns as a function of the fixation distance in meters. The changes in blur size are much less marked in the astigmatic eye than in the myopic eye. If the visual acuity is related to the size of the blurred image, the uncorrected visual acuity will change less over distance in myopic astigmatism than in spherical myopia [13].

2. Material and Methods

The cases selected from the patients attending the eye OPD, Regional Institute of Ophthalmology, PGIMS, Rohtak were divided into study group and control group.

3. Study group: Included 25 consecutive eyes (cases) with monofocal pseudophakia having spherical power from 0 D to-0.5 D with ATR astigmatism ranging from-0.5 D to-1.25 D.

3.1 Control group: Comprised 25 consecutive eyes (controls) with monofocal pseudophakia having spherical power from 0 D to-0.5 D without astigmatism.
Comparison was done between the groups based upon uncorrected distance visual acuity, uncorrected near visual acuity and contrast sensitivity.

3.2 Exclusion Criteria: Patients having history of previous ocular trauma, retinal pathology, visible zonulysis, pseudoexfoliation syndrome, glaucoma, optic atrophy, uveitis, previous refractive surgery, a secondary IOL, sulcus IOL or a decentred IOL were excluded. Further, patients having best corrected visual acuity less than 6/12 were also to be excluded from the study as well as control group.

3.3 Examination

After eliciting the complete ocular and systemic history, each patient was subjected to following examination protocol:

1. Visual acuity was recorded in English language for:
   - Distance (uncorrected and best corrected visual acuity) on Snellen's chart.
   - Near (uncorrected and best corrected visual acuity) on British N system.
2. Contrast sensitivity was recorded on Pelli Robson chart. The patients were made to read the chart from a distance of one meter and assigned a score based on the contrast of the last group in which two or three letters were correctly read. The score, a single number, was taken as a measure of the subject's log contrast sensitivity.
3. Pupil size was measured on Rosenbaum chart by card comparison method. The subjects were instructed to look at a target 8 feet away for far fixation and were given approximately 30 seconds for low-light accommodation. The Rosenbaum card was held horizontally below the pupil diameter, we evaluated the horizontal pupil size with the fellow eye open.
4. Autorefractometry and retinoscopy was performed to note the refractive error.
5. Keratometry was performed using Bausch and Laumb Keratometer. A difference of more than 0.5 between the 2 meridians was defined as corneal astigmatism. ATR astigmatism was to be labelled when the steepest meridian was at 180±15º and WTR astigmatism when the steepest meridian was at 90±15º and the oblique astigmatism when steepest meridian was in between the range of ATR and WTR (45/135±30º).
6. Axial length of eye was measured on Biomedix Optotechnik Ultrasonic A-scan Biometer, Product Code-BOD-10.
7. The IOL centration was evaluated with undilated and dilated pupils. It was considered clinically decentered if the IOL edge was visible through the undilated pupil.
8. Slit lamp examination (detailed examination with both undilated and dilated pupil) was done to rule out previous refractive surgery, decentered IOL, sulcus IOL, visible zonulysis, pseudoexfoliation syndrome and sign of ocular trauma.
9. Goldmann Applanation tonometry was carried out to rule out primary or secondary rise of IOP.
10. Fundus examination (with +78 D and +90 D) was done to rule out any retinal pathology or optic atrophy.

At the end of study, data of both the groups, that is, study group and control group, was tabulated in Microsoft Excel database sheet and analysed using Statistical Process for Social Site (SPSS). Statistical test applied was Unpaired Student's t-test. The data was considered statistically significant at p-value ≤0.05.

4 Results

4.1 Age

Majority of the patients in both the groups were between 55-65 years of age as depicted in and the p-value was statistically insignificant that is 0.552 (Table 1).

Table 1: Distribution of subjects according to age in the two groups

Age (years)	Control (n=25)	Case (n=25)	Total (n=50)	p-value
46-55	04(16%)	03(12%)	07(14%)	0.939
56-65	11(44%)	12(48%)	23 (46%)	
66-75	07(28%)	06(24%)	13 (26%)	
>75	03(12%)	04(16%)	07(14%)	
Mean	63.64±8.43	65.08±8.553		0.552

4.2 Gender

Regarding the gender distribution, the difference among the two groups was not statistically significant, p value being 0.777 (Table 2)

Table 2: Distribution of subjects according to gender in the two groups

Gender	Control(n=25)	Case(n=25)	Total (n=50)	p-value
Female	14 (56%)	13 (52%)	27 (54%)	0.777
Male	11 (44%)	12 (48%)	23 (46%)	

4.3 Laterality of eye

The difference in the two groups regarding the laterality of eyes operated in each group was also not statistically significant with p-value being 0.777 (Table 3).

Table 3: Distribution of subjects in the two groups according to laterality of eye

Laterality of eye	Control (n=25)	Case (n=25)	Total (n=50)	p-value
Right eye	14 (56%)	13 (52%)	27 (54%)	0.777
Left eye	11 (44%)	12 (48%)	23 (46%)	

4.4 Uncorrected distance visual acuity (UCDVA)

The mean UCDVA in logMar, amongst the two groups was also calculated (Table 4). It was found to be 0.341 in controls and 0.381 in cases (Figure 1). The difference being statistically insignificant with p-value 0.420.

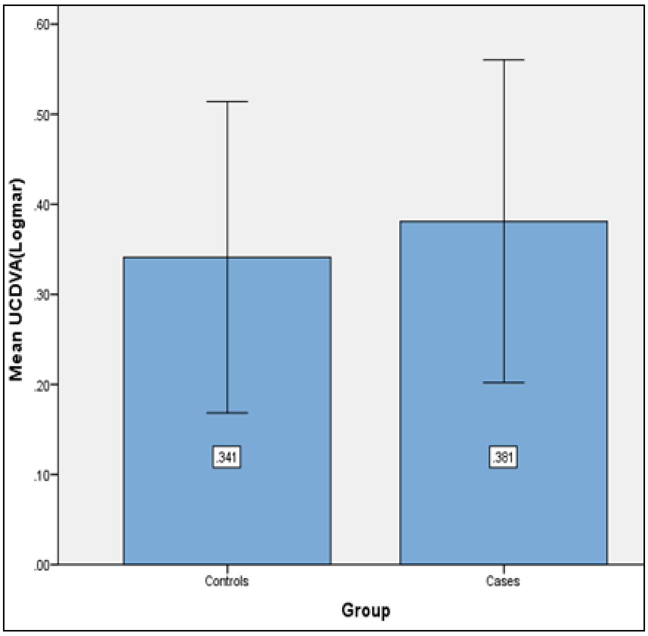

Fig 1: Mean uncorrected distance visual acuity in logMar in both the groups

Table 4: Distribution of subjects in two groups according to uncorrected distance visual acuity in logMar

UCDVA logMar	0.00 (6/6)	0.18 (6/9)	0.30 (6/12)	0.48 (6/18)	0.60 (6/24)	0.78 (6/36)	Mean UCDVA	p-value
Control (n=25)	2(8%)	4(16%)	10(40%)	5(20%)	4(16%)	0	0.341	0.420
Case (n=25)	1(4%)	3(12%)	10(40%)	8 32%)	1 (4%)	2(8%)	0.381	
Total (50)	3 6%)	7(14%)	20(40%)	13(26%)	5(10%)	24%)		

4.5 Spherical distance correction

The spherical distance correction after automated refraction and retinoscopy in the two groups is depicted in Table 5. The mean spherical distance correction equivalent in control group was-0.3800 D ±0.1633 D and in case group was-0.2900 D ±0.15612 D. The difference between the two groups was statistically significant with p-value 0.037.

Table 5: Distribution of subjects in the two groups according to spherical distance correction.

Spherical distance correction (D)	0	-0.25	-0.5	Mean spherical value(D)	p-value
Control(n=25)	2(8%)	8(32%)	15(30%)	-0.3800 ±0.1633	0.037
Case(n=25)	3(12%)	15(30%)	7(14%)	-0.2900 ±0.15612	

4.6 Uncorrected near visual acuity (UCNVA)

Regarding the UCNVA**,** in the control group, 2 patients (8%) had N12, 9 patients (36%) had N18, 6 patients (24%) had N24 and 8 patients (32%) had N36. While in case group, 10 patients (40%) had N10, 8 patients (32%) had N12, 6 patients (24%) had N18 and 1 patient (4%) had N24. The difference between the two groups was statistically significant with p-value less than 0.001 as shown in Table 6.

Table 6: Distribution of subjects in the two groups according to uncorrected near visual acuity.

UCNVA	N10	N12	N18	N24	N36	p-value
Control (n=25)	0	2 (8%)	9 (36%)	6(24%)	8(32%)	<0.001
Case (n=25)	10(40%)	8 (32%)	6 (24%)	1 (4%)	0	
Total (n=50)	10(20%)	10(20%)	15(30%)	7(14%)	8(16%)	

4.7 Absolute value of ATR astigmatism

Table 7 shows the distribution of subjects in case group according to absolute value of ATR astigmatism. 6 subjects (24%) had-0.5 D cyl 90°, 12 had(48%)-0.75 D cyl 90°, 4 had (16%)-1 D cyl 90°, while 3 had(12%)-1.25 D cyl 90°. Figure 2 shows the trend of UCNVA in case group with the degree of ATR astigmatism, showing that subjects with N10 had the mean ATR of 0.775 D, subjects with N12 had mean ATR of 0.781D, subjects with N18 had mean ATR of 0.833D, while those having N24 had mean ATR of 0.750 D. We can see that the UCNVA is decreasing as we move away from the range of 0.775 D to 0.781 D that is from N10 to N12. Further the patients with high mean ATR of 0.833 D have N18 near vision, while those with 0.750 D ATR have N24 vision.

Table 7: Distribution of subjects in case group according to absolute value of ATR astigmatism

ATR Astigmatism (D) (absolute value)	0.5 D	0.75 D	1 D	1.25 D
Control (n=25)	0	0	0	0
Case (n=25)	6(24%)	12(48%)	4(16%)	3(12%)

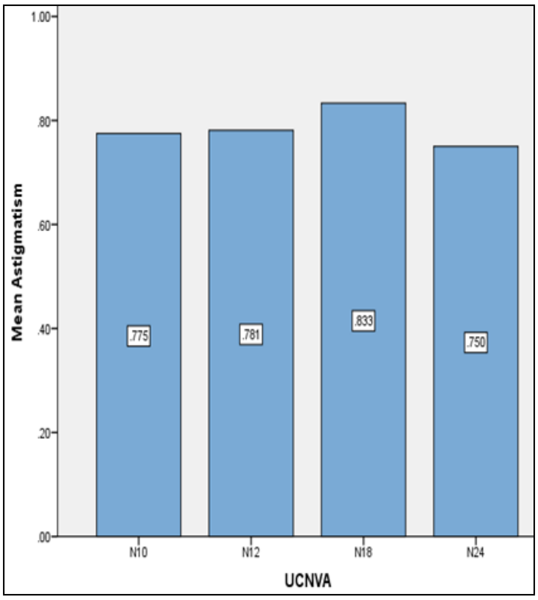

Fig 2: Trend of uncorrected near visual acuity in case group with ATR astigmatism.

4.8 Contrast sensitivity

Distribution of subjects according to their contrast sensitivity values (in log units) is shown in Table 8. It shows that 9 subjects (36%) in control group had 2.1 and 16 (64%) had 2.25. In the case group 4 subjects (16%) had 1.95, 13 (52%) had 2.1, while 8 (32%) had 2.25.The mean contrast sensitivity in the two groups is shown in Figure 3. In control group, it was 2.190±0.1061 and that in case group was 2.130±0.750. The difference between the two groups was statistically significant with p-value being 0.025, with contrast sensitivity better in control group than case group. Figure 4 shows the linear trend between contrast sensitivity and degree of ATR astigmatism, that is, contrast sensitivity linearly decreases as the ATR astigmatism increases.

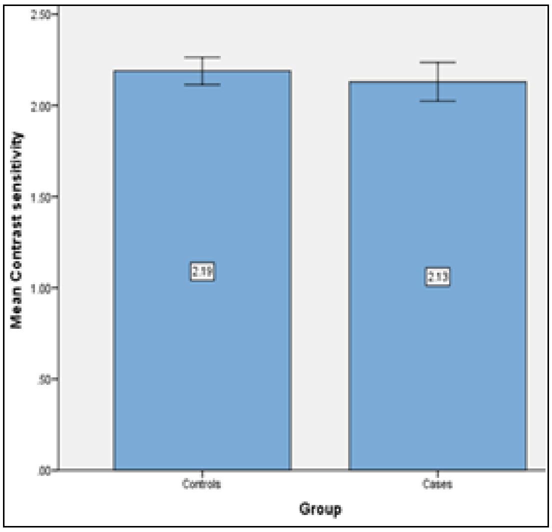

Fig 3: Comparison of the mean contrast sensitivity between the two groups

Table 8: Distribution of subjects in the two groups according to contrast sensitivity

Contrast sensitivity (log units)	1.95	2.1	2.25	Mean	p-value
Control (n=25)	0	9(36%)	16(64%)	2.190 ±0.1061	0.025
Case (n=25)	4(16%)	13(52%)	8(32%)	2.130±0.0750	

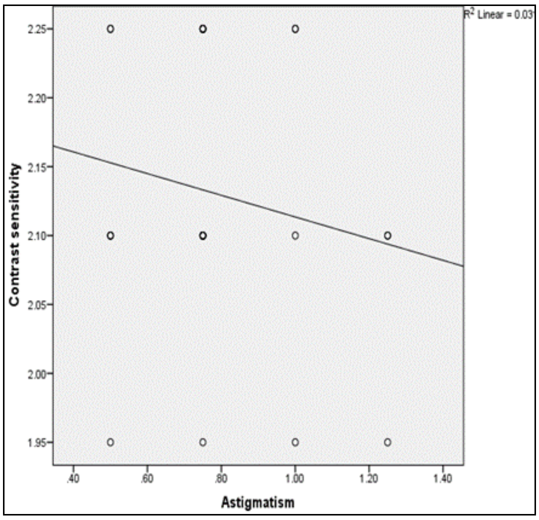

Fig 4: Trend between contrast sensitivity and degree of ATR astigmatism

5. Discussion

One of the most practically supporting study to advocate the role of surgically induced simple myopic against-the-rule astigmatism in facilitating good uncorrected near vision after cataract surgery, was done by Huber[13], in which, planned myopic astigmatism was studied as a substitute for accommodation in pseudophakia. In the study, postoperative measurements of visual acuity at different distances showed an increased depth of focus in patients with myopic astigmatism after lens implantation. Visual acuity showed the trend of becoming more constant over distance as myopic astigmatism increases. The same was found to be true for cases with a mixed astigmatism. However, the best acuities and depth of focus were found in subjects with about-0.75 D to-3 D of simple myopic astigmatism, but with a compromise in distance visual acuity. The current study was planned to compare the visual acuities between two groups of monofocal pseudophakic patients, with the control group having no astigmatism and study group having against the rule astigmatism, while both the groups' subjects were having low myopia or absence of any spherical refractive error. The mean UCDVA in control group was 0.3410 and in study group was 0.3810. The difference was not statistically significant with p=0.420, which is comparable to the result of various studies[14-22] one of which was done by Trindade *et al* in 1997 which concluded that there was no statistically significant difference in uncorrected distance visual acuity between control group with WTR astigmatism and case group with ATR astigmatism [14] Also, it can be seen that there were two emmetropic subjects in control group. Both had (0.0) 6/6 UCDVA, N18 UCNVA, 2.25 contrast sensitivity and no astigmatic correction. The mean UCDVA in the low myopic subjects in control group was 0.341, UCNVA was N18, maximally and mean contrast sensitivity was 2.190± 0.1061. So it was observed that the emmetropic patients had better

UCDVA and contrast sensitivity, and similar UCNVA. In our study the mean spherical equivalent in control group was-0.3800 D ±0.1633 D (range 0 to-0.5 D) and in study group was -0.2900 D ± 0.15612 D (range 0 to-0.5D), with p=0.037, which was statistically significant. This may have been because we had specifically included subjects with 0 to-0.5 D of spherical power in both the groups, while the comparative study done by Nanavaty *et al*, had subjects with a broader range of spherical power in cases (0.75 D to-1.75 D) and in controls (1.75 D to-2.5 D) [18]. So it is only due the difference in inclusion criteria between the studies that a incongruence of mean spherical power is there. Regarding UCNVA, the difference between the two groups is significant with p-value less than 0.001. The subjects with N10 had the mean ATR of 0.775 D, subjects with N12 had mean ATR of 0.781 D, and subjects with N18 had mean ATR of 0.833 D, while those having N24 had mean ATR of 0.750 D. The mean ATR was 0.79 D ±0.235 D. Singh *et al*, in 2014 conducted a study that determined the impact of induced astigmatism and pupil size on the distance and near acuity of otherwise emmetropic pseudophakic eyes implanted with monofocal intraocular lenses. It showed that near acuity with all magnitudes of induced myopic astigmatism upto 1 D was significantly better than the acuity without astigmatism (p=0.001) [20]. In our study, 0.79 D ±0.235 D was the mean ATR responsible for better UCNVA in study group. Beyond the small range of 0.775 D to 0.781 D, on either side, the UCNVA seemed to decrease in the study group and results for UCNVA are found to be statistically comparable as well as significant with p value less than 0.001. The mean contrast sensitivity in control group was 2.190 ±0.1061 and that in study group was 2.130 ±0.750. The difference between the two groups was statistically significant with p-value less than 0.05, with contrast sensitivity being better in control group than study group. It was comparable to the study done by Hasegawa in 2018, to determine the effects of astigmatism on contrast sensitivity. It was concluded that ATR astigmatism reduces contrast sensitivity more than WTR astigmatism does [23]. In another study done by Stoimenova in 2007, it was concluded that at all background luminance levels, contrast thresholds of myopic subjects increased systematically with a higher spherical equivalent refractive error [24]. This goes in congruence with our study, where better contrast sensitivity (2.25) was observed in the emmetropic subjects in the control group, compared to their counterparts (2.190 ±0.1061) with low myopia.

6. Conclusion

The visual performance of monofocal pseudophakic subjects having residual low myopia without astigmatism was compared with those having low myopia with low ATR. The mean uncorrected distance visual acuity was almost equal in both the groups, therefore, the difference was not statistically significant with p=0.420. On the other hand, the uncorrected near visual acuity was better in the study group as compared to the control group and the difference was statistically significant with p <0.001. The contrast sensitivity was better in the control group than the study group and the difference was statistically significant too. Thus, our results demonstrate that monofocal pseudophakic patients having low myopic correction with low ATR had a better uncorrected near visual acuity but almost equal uncorrected distance visual acuity when compared to a similar group of patients without any astigmatism. The contrast sensitivity was, however slightly better in patients having low myopic correction without astigmatism. Overall the study group patients reported more satisfactory visual outcome as compared to the control group patients. Thus, it can be concluded that low degree (-0.5 D to-1.25 D) of residual ATR astigmatism is useful in providing satisfactory distance as well as near visual acuity for routine working.

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