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RESEARCH ARTICLE

INFLUENCE OF POSTOPERATIVE ASTIGMATISM ON UNCORRECTED NEAR VISUAL ACUITY IN PSEUDOPHAKIA

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Abstract

Aims: The impact of astigmatism on near visual acuity in pseudophakia patients who underwent manual small incision cataract surgery.

Settings and Design: Randomized, cross-sectional, hospital-based observational study

Methods and Material: 200 eyes of 200 pseudophakic patients with BCVA for distance 6/9 or better was considered. UCNV was recorded at 33 cms by giving only spherical correction used in distance correction without cylindrical correction. Residual astigmatism was noted, near visual acuity pertaining to astigmatism was compared and tabulated. PCIOL in the bag or sulcus was also noted with dilated pupil on slit lamp examination.

Results: 67% were ATR astigmatism 11% were WTR astigmatism, 11% had oblique astigmatism and 12% of them had no astigmatism. In ATR group, 30%, 26%, 15% of patients were able to read N12, N10, N8 vision respectively. In WTR group, 33%, 14%, 19% of patients read N8, N10, N12 respectively. 67% eyes belonged to cylindrical power range of -1.50 D to -0.50 D, 50% of them in this range read N8, N10. 138 patients had in the bag IOL, 62 of them had IOL in sulcus. Among those patients with in the bag IOL, 88 were in range of -0.50 to -1.50, out of which 19 had N8, 25 had N10, patients with IOL in sulcus, 31 were in range of -0.50 to -1.50, out of which 5 had N8, 10 had N10.

Conclusions: Near acuity was relatively poor without astigmatism, and it improved with up to 0.5 to 1.5 D of simple myopic astigmatism. Near acuity deteriorated with hyperopic astigmatism for different meridians. Nearly 50% could read N8, N10 with only distance vision spherical correction. ATR astigmatism produced significantly better reading performance than WTR astigmatism. In the bag IOL had better near visual outcome as compared with in the sulcus IOL.

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Introduction:-

The World health organization (WHO) reported that cataract is one of the major cause of avoidable blindness in the world. [1] Implantation of a monofocal intraocular lens (IOL) is the standard procedure to restore vision clarity in the developed and developing world in most of the cases. [2] Patients consider this procedure highly beneficial, as vision is optimized for a particular distance, usually far distance and clarity for near vision requires refractive correction. Post cataract removal, near vision performance is reduced due to accommodative loss. Some subjects attain good levels of both distance and near vision. [3][4][5]

Postoperative astigmatism is one of the hallmarks of pseudophakia. Two different schools of thought exist about correcting the postoperative astigmatism of pseudophakic eyes. The conventional and currently practiced school of thought advocates full correction of the postoperative astigmatism to maximize distance acuity. Near acuity is improved using bifocals or progressive addition lenses.[6] The alternate school of thought proposes to leave any postoperative myopic astigmatism uncorrected to improve unaided near vision, whereas distance vision is improved using low cost, ready made spherical equivalent spectacles, if required. The pseudophakic eye even with precise correction experiences simple myopic astigmatism for distance and compound hyperopic astigmatism for near.[7][8][9] Astigmatism occurs when the toricity of any refractive surfaces of the optical system produces 2 principal foci delimiting an area of intermediate focus called Sturm's conoid. Despite the distortion induced by astigmatism some astigmatism may be beneficial.[10]

There is some amount of preexisting astigmatism which is present before surgery due to various reasons. Correction of astigmatism at the time of cataract surgery is most commonly achieved through incision placement, creation of peripheral corneal relaxing incisions, toric IOL implantation. In spite of all these measures some amount of residual astigmatism is left post surgery. In clinical studies residual astigmatism is one of the most significant cause for dissatisfaction after multifocal IOL implantation. When the post operative astigmatism is drastically different from the pre operative astigmatism and when all the cause for anterior segment astigmatism are ruled out, it can be concluded that the cause for the residual astigmatism is position or tilt of the IOL. Parameters Causing Residual Astigmatism are Total corneal astigmatism estimation error, Toric IOL calculator error, Surgically induced astigmatism, Rotational error.[11]

Astigmatism induces distortion of images. When the effects of blurring of the image are excluded, the retinal image in an uncorrected astigmatic eye is distorted because of a differential magnification in the two principal meridians. Expressed as a percentage of the differences in these principal meridians the image is distorted by about 0.3% per dioptre of astigmatism. In the corrected astigmatic eye, distortion of the sharp retinal image arises from the unequal spectacle magnification in the two principal meridians, which represents about 1.6% distortion per dioptre cylinder in the correction at the spectacle plane. This unequal magnification is manifest by altered shapes and by tilting of vertical lines (the declination error) that occurs maximally when the correcting cylinder is oblique (that is, 45° or 135°). Although oblique astigmatism only produces 0.4° of tilt per dioptre monocularly, it will produce major alterations in binocular perception. Despite the distortion induced by astigmatism, some astigmatism may be of benefit. Various types of astigmatism have different effects on visual perception. For this reason the concepts of astigmatism “With the rule” (WTR) and “Against the rule” (ATR) are clinically relevant.[12] So determining the visual impact of residual astigmatism post cataract surgery in pseudophakic eye has become necessary.

Aim:-

The impact of astigmatism on near visual acuity in pseudophakia patients who underwent manual small incision cataract surgery.

Objectives:-

To analyse the influence of astigmatism on uncorrected near visual acuity, near vision without cylinder correction, different type of astigmatism, position of IOL and its influence

Subjects and Methods:-

This is a randomized, cross-sectional, hospital-based observational study held from June 2020 to June 2021. The study included 200 eyes of 200 pseudophakic patients visiting OPD at a tertiary care centre in South India, who underwent uncomplicated MSICS with PCIOL (monofocal) implant, with post operative period of more than 6 weeks. Patients with distance BCVA of 6/9 or better were considered under the study.

Methodology:-

Informed and written consent was taken from patients following the precepts of declaration of Helsinki and permission was obtained from ethical committee of the institute to conduct the study. Patient demographic details were noted and a careful detailed history regarding surgery was obtained. After explaining the procedure, patient was seated in a dark room, UCVA (uncorrected visual acuity) was recorded at 6 meters distance using Snellens E chart for illiterate patients and Snellens number or letters chart for literate patients. Refractive error was noted using ACCUREF K-900-Shin-Nippon Auto-Refractometer and full subjective correction was given, patients whose

distance BCVA (best corrected visual acuity) was 6/9 or better were selected. Further, patient was seated in a room illuminated with tube light, both UCNV uncorrected near visual acuity), BCNV (best corrected near visual acuity) was recorded at 33cm distance using Snellens near vision chart. UCNV was recorded at 33 cms by giving only spherical correction used in distance correction without cylindrical correction. Residual astigmatism was noted, near visual acuity pertaining to astigmatism was compared and tabulated. Amount and type of astigmatism was noted. PCIOL in the bag or sulcus was also noted with dilated pupil on slit lamp examination. All the data was tabulated. The type of astigmatism and its influence on near visual acuity was assessed. Results are presented as Mean $\pm$ SD and Range values for continuous data and frequencies as number and percentages. Catogorical data was analysed by Chi-square test. P value of 0.05 or less was considered to be statistically significant. SPSS (Version,18) software was used for data analysis.

Results:-

Among the 200 patients enrolled in the study, the mean age of patients were 64.7 years with standard deviation of 64 ± 7.1 years. Out of the 200 patients 112 (52%) were males and 46 % were female. 133(67%) patients had ATR astigmatism, 22(11%) patients had WTR astigmatism, 22 (11%) patients had oblique astigmatism and 23(12%) had no astigmatism(table 1).

Among ATR (133 patients), 40(30%), 35 (26%), 20(15%) patients were able to read N12, N 10, N8 vision respectively. Among WTR (22 patients), 7 (33%), 3 (14%), 4 (19%) patients could read N8, N10, N12 respectively. Among oblique astigmatism (22 eyes), 2 (9%), 6 (27%), 12 (5%) patients were able to read N8, N10, N12 vision respectively. 20 (15%) out of 133 ATR and 7 (33%) out of 22 WTR patients had near visual acuity of N8. Although ATR group had more number of patients reading N8 vision, higher percentage of WTR group had better near vision showing statistically significant results due to higher sample size of ATR group as compared to WTR group (table 2). Out of 177 astigmatic patients, 119 (67%) patients belonged to cylindrical power range of -1.50 D to -0.50 D, which was the highest among all the astigmatic group. 15(8%) eyes belonged to the range of (> -1.50) cylindrical power. 14 (8%) belonged to range -0.25 to +0.25 astigmatism. 28 (16%) belonged to range +0.50 to +1.50 astigmatism and only 1 patient with $> +1.50$ cylindrical power. 144 of them were myopes and 32 of them were hypermetropes. Overall mean cylindrical power was $(-0.65) \pm (0.92)$ D, range of astigmatism was found to be $(-0.25) - (+1.50)$ D (table 3).

Out of 177 astigmatic patients, 29(16.4%), 44 (24.9%), 93 (52.5%), 11 (6.2%) of them read N8, N10, N12/N18, N24/N36 vision respectively. 15(7.5%) patients were in the range of > -1.50 D of astigmatism, of which 3(20%) could read N8, 5 (33.33%) read N10, 5 (33.33%) read N12/N18, and 2 (13.33%) read N24, N36. 119 (59.5%) belonged to range of (-0.50 to -1.50) astigmatism, of which 24 (20.2%) read N8, 35 (29.4%) read N10, 58 (48.7%) read N12/N18, only 2 (1.7%) read N24/N36. 14 (7.9%) were in the range of -0.25 to +0.25 D, of which 2 of them could read N10, 10 read N12/N18 and 2 read N24/N36.(table 4).

Out of 177 patients, 138 eyes had in the bag IOL, 62 of them had IOL in sulcus. Among those patients with in the bag IOL, 88 were in range of -0.50 to -1.50, out of which 19 had N8, 25 had N10, 42 had N12, N18, 2 had N24, N36 near vision. Among those patients with IOL in sulcus, 31 were in range of -0.50 to -1.50, out of which 5 had N8, 10 had N10, 16 had N12, N18 near vision. (table 5). Out of the 200 patients, 76, 17, 12, 95 patients read dot chart, E-chart, letters chart, Number chart respectively.(table 6).

Discussion:-

This study assessed the impact of astigmatism on near visual acuity in pseudophakes post manual SICS. Among the 200 subjects enrolled in our study, mean age of the subjects was 64.7 years with the standard deviation of 64 ± 7.1 years. Patients who had best corrected distance visual acuity of 6/9 or better were only considered for the study.

Increased prevalence of ATR astigmatism post manual SICS has been reported by many studies.¹³ In our study, 67% of patients showed ATR (table 1), 11% each belonged to no astigmatism, WTR and oblique astigmatism which was in concordance with other studies.

The overall range of cylindrical power obtained in our study was from -2.00D to +2.00D (Table 3), out of which commonest range of astigmatism was found to be -0.50 D to -1.50 D. This was in par with other studies who also found similar range of refraction in the post operative period. Trinidade et al among their study subjects found that

their post operative refractive range was between -1D and -1.5D with different cylindrical axis and concluded that aim of cataract surgery should be to obtain a low, simple, myopic ATR astigmatism which helps patient read without correction.[14]

Among the 119 eyes with cylindrical range of -0.50 to -1.50 (table 4), 59 eyes (50%) were able to read N8 and N 10 vision and 58 (48 %) of them read N12, N18 vision. Individuals with myopic astigmatism (144 patients) had a very good near vision with 48%(69 eyes) distributed in the N8, N10 group which is statistically significant with a p value < 0.001 and among those with hyperopic astigmatism (33 eyes), 14% (4 eyes) were distributed in N8, N10 group, 67 %(22 eyes) were distributed in N12, N18 group and 21 %(7 eyes) in N36 group indicating a poor visual acuity. Patients in the range group of -0.25 to + 0.25 who were considered to have nil astigmatism, 2 read N10, 10 of them read N 12/N18 and 2 of them read N24/N36. These results are in correlation with study by Archana singh et al, who concluded that astigmatic magnitude had a significant effect on near acuity and the interaction between magnitude and axis were not significant. Near acuities with 0.5 D and 1D of induced myopic astigmatism were significantly different from each other, beyond which it was not statistically significant. Near visual acuity deteriorated significantly on 2D hyperopic astigmatism, and also that that near visual acuity was relatively poor without astigmatism and improved upto 1D of induced myopic astigmatism.[10]

According to hypothesis, residual astigmatism post manual SICS would influence patients near visual acuity.[15] Results in our study (table2) showed that UCNV was not in favour of any particular astigmatic group, that is 33% of WTR astigmatism patients had N8 vision when compared to ATR who were 15 %, whereas N10, N12, N18 UCNV was better among ATR patients indicating astigmatism did not make much impact on the near visual acuity among our patients which was not in line with other studies.

Study by Trindade et al concluded that uncorrected near visual acuity between group difference was statistically significant, ATR subjects had much better uncorrected near acuity than those with WTR astigmatism.[14] 90 % of ATR patients read J1 to J2 vision, 80% of WTR patients read J7 J8 vision. In our study 41% of the total ATR patients and 47% of the total WTR patients had near vision of N8, N10 respectively. On comparison of results there was gross difference in the percentage of ATR and WTR astigmatic groups which may be attributed to the small sample size in the above study when compared to a larger sample size in our study, and inclusion of patients with astigmatism of only -1 to -1.50D in the above study as compared to our study which includes different ranges of astigmatic groups. As more than half (41%) of the total 67% of ATR astigmatism patients had better near visual acuity, we would not be wrong in saying that ATR group had good near visual acuity compared to WTR group. Also, the results obtained from table 2 were statistically significant with a p value of 0.001, further strengthening the above conclusion.

Study by Pedro et al found that mean near visual acuity at 0.33 meters was predicted to be equivalent to N7 in eyes with -1.00 D of myopia and they concluded that visual acuity decreased on reduction of chart contrast level with induced spherical and astigmatic blur. Worse vision was found with spherical defocus than compared to both astigmatic conditions. For high contrast letters WTR, ATR astigmatic conditions improved near visual acuity compared to spherical defocus condition by 0.17 ± 0.14 Logmar and 0.20 ± 0.14 logmar respectively which was significantly less than visual acuity provided by +3 spherical lens.[16]

Rhim et al in their study with -1.5 D WTR ATR simple myopic astigmatism , without slit both groups showed best visual acuity at 1.5 m distance , with slit -1.5 D WTR had better vision at 6 m, -1.5 D ATR had good vision at 67 cms .[17]

50% (44 patients) of the total 88 in the bag IOL (table 5) patients in the range group of -0.50 to -1.50 had near vision of N8 , N10 and 48 %(15 patients) of those in sulcus in the same cylindrical power range had N8, N 10 vision . Among the nil astigmatism patients 7 of them whose IOL was in the bag, all of them(100%) had near visual acuity of N12,N18 and 7 patients with IOL in sulcus were distributed in N18,N24, N36. Patients whose IOL was in bag with the astigmatic range of -0.50 to -1.50 had a very good near vision compared to those handful number of patients in sulcus which was statistically significant, therefore we conclude that effective lens position in bag or sulcus would also influence near visual acuity along with astigmatism.

Here in our study patients were made to read one of the 4 types of chart– dot chart, E chart, letter chart, number chart (table 6). Results obtained were distributed in all the near vision groups, as single chart was not used for

evaluation. With respect to near visual acuity, mild differences were found in this study compared to earlier work which may be due to the object detail and its orientation asymmetry as only lower case Roman letters, which have a strong vertical stroke dominance were considered for evaluation in previous reports.

Major drawback of the study was, most of the patients included in the study were patients who were operated under DBCS camps and most of the them were illiterates. Therefore single type of chart was not used to asses visual acuity leading to an underestimation of visual acuity ability when patients read dot chart and number chart, whereas E chart and letter chart could be considered similar as they contain vertical and horizontal lines.

Another drawback of the study was, the diameter of the pupil was not considered as one of the parameters while assessing visual acuity post operatively which could have had an influence on the visual acuity.

The results of the near visual acuity obtained roughly corresponds to the size of a newspaper print, suggesting that pseudophakes may be able to perform their routine near tasks with this range of uncorrected myopic astigmatism. The restoration of near vision with myopic astigmatism is however only partial, as indicated by the fact that the best-corrected near acuity of all participants improved to N6 with full near correction. Tasks requiring very fine near acuity may therefore require additional near-vision correction.

Pedro Serra et al concluded simple myopic astigmatism in its ATR form was associated with the best near vision performance, assessed during a reading task.[16] Its performance at distance was poorer than WTR astigmatism. Meridional blur showed more relevance for visual performance when a time-constrained task was tested. Therefore reading performance may be a sensitive task to predict the performance associated with real-world tasks.

Singh et al concludes that monocular near logMAR acuity of pseudophakes improves with up to 1D of uncorrected myopic astigmatism but only with a proportional loss in distance acuity.[10]The visual experience may be suboptimal beyond this magnitude because of a large loss of distance acuity with no additional benefit to near vision. Leaving myopic astigmatism uncorrected for optimizing near vision of pseudophakic eyes must therefore be considered in the context of the associated loss in distance vision. The beneficial effect of uncorrected myopic astigmatism may be further supplemented in pseudophakes with smaller pupil diameters. Both distance and near acuity deteriorate with uncorrected hyperopic astigmatism, and it should be fully corrected after cataract surgery.

Tables:

Table 1:- Types of astigmatic error and their corresponding number of cases.

Astigmatism	No. of patients	%
ATR	133	67%
WTR	22	11%
Oblique	22	11%
No astigmatism	23	12%
Grand Total	200	100%

Table 2:- Near visual acuity with different types of residual astigmatism after correcting only spherical error of distance visual acuity.

Near vision	No. of patients	ATR		WTR		Oblique	
		No.	%	No.	%	No.	%
N8	29(16%)	20	15%	7	33%	2	9%
N10	44(25%)	35	26%	3	14%	6	27%
N12	56(32%)	40	30%	4	19%	12	55%
N18	36(20%)	30	23%	5	19%	2	9%
N24	9(5%)	8	6%	1	5%	0	0%
N36	2(1%)	0	0%	2	10%	0	0%
Grand Total	177	133	100%	22	100%	22	100%
*23 value are (-)							

Table 3:- Distribution of range of astigmatism among 200 patients.

Cylindrical error	TOTAL	N8	N10	N12,N18	N24,N36
> -1.50	15	3 (20%)	5 (33.33%)	5 (33.33%)	2 (13.33%)
(-0.50) to (-1.50)	119	24 (20.2%)	35 (29.4%)	58 (48.7%)	2 (1.7%)
(0) to (-0.25)	10	0	2 (20%)	8 (80%)	0
(0) to (+0.25)	4	0	0	2 (50%)	2 (50%)
(+0.50) to (+1.50)	28	2(7.1%)	2 (7.1%)	19 (67.9%)	5 (17.9%)
> +1.50	1	0	0	1 (100%)	0
Total	177	29(16.4%)	44(24.9%)	93(52.5%)	11(6.2%)

Table 4:- Range of near vision chart read and different range of cylindrical power.

Cylindrical error	No. of patients	%
> -1.50	15	8%
(-0.50) to (- 1.50)	119	67%
(0) to (-0.25)	10	6%
(0) to (+0.25)	4	2%
(+0.50) to (+1.50)	28	16%
> +1.50	1	1%
Total	177	100.0

Table 5:- Range of near visual acuity read in relation to position of IOL.

Near Vision	Dot		E-chart		Letters		Number		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
N8N10	24	31.6	9	52.9	7	58.3	42	44.2	82	41.0
N12N18	44	57.9	5	29.5	5	41.7	50	52.6	104	52.0
N24N36	8	10.5	3	17.6	0	0.0	3	3.2	14	7.0
Total	76	100	17	100.0	12	100.0	95	100.0	200	100.0
X ² = 12.73, P = 0.048, S										

Table 6:- Near vision range read in relation to type of near vision chart.

	Range of Cylindrical power	TOTAL	N 8	%	N 10	%	N 12 , N18	%	N24, N36	%
BAG	> (-1.50)	8	2	25	4	50	2	25	0	0
SULCUS		7	1	14.3	1	14.3	3	42.8	2	28.6
BAG	(-0.50) to (-1.50)	88	19	22	25	28	42	48	2	2
SULCUS		31	5	16.1	10	32.3	16	51.6	-	0
BAG	(-0.25) to (+0.25)	7	0	0	0	0	7	100	0	0
SULCUS		7	0	0	2	28.6	3	42.8	2	28.6
BAG	(+0.50) to (+1.50)	19	2	10.5	2	10.5	14	73.7	1	5.3
SULCUS		9	0	0	0	0	5	55.6	4	44.4
BAG	> (+1.50)	0	0	0	0	0	0	0	0	0
SULCUS		1	0	0	0	0	1	100	0	0

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Conclusion:-

This study determined the impact of uncorrected astigmatism on monocular near acuity of pseudophakes with monofocal IOL implants. Near acuity was relatively poor without astigmatism, and it improved with up to 0.5 to 1.5 D of simple myopic astigmatism. Near acuity deteriorated with hyperopic astigmatism for different meridians. Nearly 50% could read N8, N10 with only distance vision spherical correction. With optimal near vision correction, 100% of the participants could read N6. ATR astigmatism produced significantly better reading performance than WTR astigmatism. In the bag IOL had better near visual outcome as compared with in the sulcus IOL. Our results show important implications in the management of astigmatism in pseudophakic eyes. It is apparent that uncorrected myopic astigmatism has a beneficial effect on monocular near acuity of pseudophakes implanted with monofocal IOL. Near acuity improved from about N18 line of snellens visual acuity chart in patients without astigmatism to about N8, N10 line with approx – 1 to -1.5D of simple myopic astigmatism.

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