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ORIGINAL RESEARCH

Age related changes in characteristics of corneal astigmatism in Indian cataract patients: A cross-sectional study from foothills of Himalaya

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ABSTRACT

Background: The World Health Organization's 2019 report on vision states that an overwhelming 123.7 million individuals globally suffer from moderate to severe distant vision impairment or blindness owing to uncorrected refractive defects. According to a latest systematic review and meta-analysis, astigmatism is the most widespread refractive defect in adults. Astigmatism affects visual acuity, and cataracts are a common age-related condition necessitating surgical intervention. Understanding these conditions, their implications, and available treatment options is essential for promoting ocular health and enhancing quality of life.**Materials & Methods:**The study aimed at analyzing age related changes in characteristics of corneal astigmatism in patients undergoing cataract surgery. This observational cross-sectional study was conducted at the outpatient eye department of M.M. Institute of Medical Sciences & Research, Mullana, Ambala. Prior to participation, all patients were provided informed consent, and the institutional ethical committee approved the study. 200 eyes of 200 patients that met the inclusion and exclusion criteria were enrolled.**Results:**There was a statistically significant correlation between age and degree of corneal astigmatism (**p value = 0.001**) thus showing increase in prevalence of higher degree of corneal astigmatism with increase in age. We found a significant correlation ($\chi 2 = 18.725$, **p = 0.028**) between different types of astigmatism in different age group categories. It was observed that there is an increase in prevalence of ATR astigmatism with a simultaneous fall in WTR astigmatism as age progresses.**Conclusion:** We conclude in our study, that there was significantly higher value of Astigmatism with increase in age and hence elderly patients can be actively managed on presentation. We can therefore opt for surgical techniques and toric IOLs in elderly patients for correction of pre-operative corneal astigmatism during cataract surgery for achieving desired post-operative results.

Key words: Corneal stigmatism, WTR astigmatism, ATR astigmatism, cataract, toric IOLs, etc.

INTRODUCTION

The World Health Organization's 2019 report on vision states that an overwhelming 123.7 million individuals globally suffer from moderate to severe distant vision impairment or blindness owing to uncorrected refractive defects[1].Refractive errors, such as myopia, hyperopia, & astigmatism, are the most frequently reported visual disorders worldwide, affecting people of all ages[2-3].Refractive errors can have negative social and financial impacts on patients and their family members if they remain untreated[2-4].Globally, unresolved refractive errors and cataract coverage deficit is predicted to cost approximately $24.8 billion in US dollars. These are the extra expenses that would need to be incurred over the value of present healthcare budgets[1].

According to a latest systematic review and meta-analysis, astigmatism is the most widespread refractive defect in adults, with an estimated combined prevalence of 40%[2].Additionally, The estimated prevalence of astigmatism & higher degrees of astigmatism was found to be 57.4% and 4.5%

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respectively in another recent study[5].In fact even in studies conducted across Urban India, under-corrected refractive defects were reported to be among the most frequent causes of reversible blindness. An astonishing 49.3 million people in the nation (ages 15 or older), suffer from refractive defects with the estimated prevalence of astigmatism to be 30% approximately[6].

An eye in humans is sort of an optical system wherein an image is focused onto the retina. However, astigmatism is known to reduce vision quality by warping pictures, creating visual disturbances, and blurring in the eyes[7-9].The progression of astigmatism has been reported to be impacted by extraocular muscle tension, visual input, age, race/ethnicity, genetic variables, environment, and eyelid pressure, however, to point out the exact etiology of astigmatism further research across this domain is required[10-12].Asthenopia, pain, distorted and impaired vision, object elongation, and accommodation issues are some of the frequently presenting symptoms of astigmatism. The signs similarly involve head tilt, partial lid closure, tilted or vertically oval optic disc, and variable power across different meridians[13].On top of that, individuals with unresolved astigmatism experience a negative impact in their standard of living due to vision, a higher risk of falls, face trouble driving at night, and a general decline in overall wellbeing[14-15].Patients also admitted to have suffered financial hardships as a result of less chances for educational and professional pursuits in addition to the necessity of expensive astigmatic correction[14].

On the basis of orientation of the strongest meridian of power, astigmatism can be categorized as majorly: Oblique, With-the-rule, or Against-the-rule[16].It is noted that curvature is steepest in or around the vertical meridian in With-the-rule Corneal Astigmatism, but the vertical meridian is the most myopic in With-the-rule Refractive Astigmatism[16-17].Contrastingly, for corneal and refractive Against-the-rule astigmatism, the opposite is true. Myopia is highest in the oblique meridian or corneal curvature is sharpest in Oblique astigmatism. Corneal and Lenticular astigmatism both combine to produce overall, or refractive, astigmatism[16-18].The most common methods for correcting astigmatism are contact lenses, glasses, toric intraocular lenses, toric implanted collamer lenses & corneal refractive surgery[19].Corneal astigmatism in cataract patients is an important co-morbidity that impairs vision function, lowers quality of life connected to vision, and increases out-of-pocket costs hence requiring appropriate urgent attention[19-21].Refractive cataract surgery, or simply eliminating of cataracts with minimal postoperative spectacle reliance, is a potential strategy for managing such scenarios[22].

There is still a pertaining deficit in our understanding and availability of studies on the prevalence of corneal astigmatism among patients requiring cataract surgery across rural population of the country. And hence, we wish to conduct this study to find out and analyze age related changes in characteristics of corneal astigmatism in patients undergoing cataract surgery.

MATERIALS & METHODS

This observational cross sectional study was conducted at Department of Ophthalmology, Maharishi Markandeshwar Institute of MedicalSciences and Research Center, Mullana, Ambala a tertiary health care center in north India over 14 calendar months (January'23 to March'24**)**after the approval from the institutional ethical committee.This study was carried out including patients of immature or mature senile cataract visiting the OPD of Department of Ophthalmology, M.M.I.M.S.R. Mullana, Ambala that fulfilled the inclusion criteria. The study enrolled **200 eyes** of **200 patients**. This study was performed using convenience sampling and study participants were designated based on availability and willingness to participate in the research.

SELECTION CRITERIA FOR PATIENTS

INCLUSION CRITERIA

1. Patients who are clinically diagnosed cases of immature senile cataract
2. Patients who are clinically diagnosed cases of mature senile cataract.
3. Patients prepared to sign consent to take part in the study.

EXCLUSION CRITERIA

1. Patients having known comorbidities.
2. Patients with history of contact lens usage.
3. Patients with corneal opacities and degenerations.
4. Patients with pterygium encroaching the cornea.
5. Patient presenting with inflammatory diseases of the eye.
6. Patient with history of traumatic cataract, any lid abnormalities or ptosis.
7. Patient with any past history of ocular surgeries.
8. Patients/guardian not willing to be a part of the study.

Each patient/guardian signed a consent in their regional language/best understood language before they were admitted to study. Patients' data was collected using a piloted proforma, hence meeting the objectives of the study by means of personal interview and clinical examination of the patient. Patients were classified according to the data provided. Only the patients that complied with the inclusion and exclusion criteria were involved in the study.

Once the patient was enrolled in the study, a detailed clinical history of the patient was taken. After obtaining detailed history, thorough clinical examination of the patients was carried out in accordance with the department procedures. Visual acuity was measured with Snellen chart (unaided

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visual acuity, Visual acuity with pinhole, best corrected visual acuity). Intraocular pressure was taken with NCT. Patient was examined with torch light followed by Slit lamp examination. Keratometry was performed using Manual Keratometer (Bausch & Lomb type). Posterior segment examination was performed with Indirect Ophthalmoscopy or Direct Ophthalmoscopy. 'A-Scan' of all patients was performed to calculate required power of IOL.

STATISTICAL ANALYSIS

Data was collected in MS excel spreadsheet and Statistical analysis was performed using SPSS Statistics version 28 (SPSS Inc., Chicago, IL). A significance level of $p<0.05$ was deemed statistically significant. We utilized the chi-square test for categorical variables and the t-test for continuous variables along with ANOVA for interpretation of significance between mean values. Results are presented as mean with standard deviation or as percentages where applicable.

OBSERVATIONS & RESULTS

Table 1: Range of Visual Acuity of Patients Presented with Cataract

Visual Acuity Category	Frequency	Percent
6/9-6/18	64	32.0
6/24-6/60	57	28.5
5/60-3/60	12	6.0
< 3/60 or Low	67	33.5
Total	**200**	**100.0**

This table presents data on visual acuity categories within a sample of 200 individuals. In visual acuity 6/9-6/18 category there are 64 (32.0%) cases,in 6/24-6/60 category there were 57 (28.5%) cases, in 5/60-3/60 category 12(6.0%) of the cases and in < 3/60 or Low category 67 (33.5%) cases in the sample. Overall, this data provides insights into the distribution of visual acuity within the sample, highlighting the prevalence of different levels of visual impairment among the individuals surveyed.

Table 2: Categorization of Cataract in Study Sample

Type of Cataract	Frequency	Percent
Cortical	5	2.5
Mixed	115	57.5
M.Sc.	27	13.5
NS	36	18.0
PSC	17	8.5
Total	**200**	**100.0**

Above tabular description of the data on the types of cataract within a sample of 200 cases in our study shows that, 5 (2.5%) cases belongs to cortical cataracts, the most prevalent type of cataract in the sample is mixed cataracts with 115 (57.5%) cases, MSC is 27 (13.5%), NS 36 (18.0%) cases and PSC 17 (8.5%) cases among the total sample. This data provides insights into the distribution of different types of cataracts within the sample population.

Table 3: Distribution of Cases by Age Group

Age Group	Frequency	Percent
50 - 59 Year	81	40.5
60 - 69 Year	80	40.0
70 - 79 Year	30	15.0
> 79 Year	9	4.5
Total	**200**	**100.0**

Overall, this data provides insights into the distribution of individuals across different age groups within the sample population, highlighting the age demographics of the studied cohort.

Above table shows a description of the data on age groups within a sample of 200 cases in our study sample.This data shows that, in 50-59 Year age group there are 81 cases (40.5%), in 60-69 Yearage group there were 80 (40.0%) cases,in 70-79 Yearage group 30 (15.0%) followed by > 79 Year age group wherein, there were 9 (4.5%) cases among the study sample. The mean age of the study participants was 62.13 ± 9.08 years (range 50-90 years).

Table 4:Distribution of Cases by Gender (N = 200)

Gender	Frequency	Percent
Female	113	56.5

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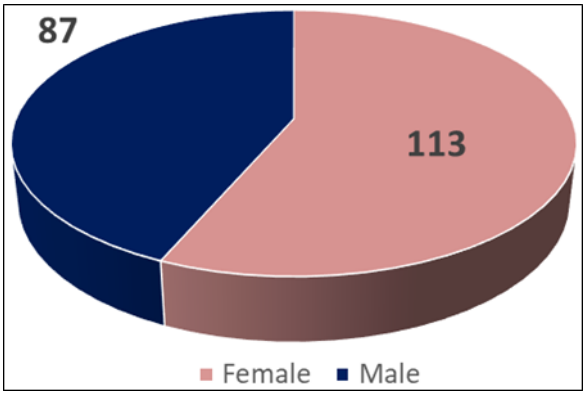
Male	87	43.5
Total	**200**	**100.0**

Above table provided data on gender distribution within a sample of 200 individuals in our study sample. In our study female were 113 individuals (56.5%) and male were 87 (43.5%) of the total sample. This data indicates that there were slightly more females than males in the sample.



Graph 1: Distribution of Cases by Gender (N = 200)

Table 5: Distribution of Corneal Astigmatism among Study Cases

Astigmatism	Frequency	Percent
0	2	1.0
0.01 - 0.99	103	51.5
1.00 - 1.99	56	28.0
2.00 - 2.99	24	12.0
≥ 3.00	15	7.5
Total	**200**	**100.0**

The table presents data on astigmatism frequency and its corresponding percentages across different ranges. It categorizes astigmatism values into five groups: 0, 0.01-0.99, 1.00-1.99, 2.00-2.99, and greater than or equal to 3.00. The highest frequency is observed in the range of 0.01-0.99, with 103 cases, constituting 51.5% of the total. Following this the 1.00-1.99 range accounts for 56 (28.0%) cases, of the total. The frequencies gradually decrease for higher astigmatism values, with 24 cases (12.0%) falling within the 2.00-2.99 range and 15 cases (7.5%) categorized as greater than or equal to 3.00. Additionally, there are 2 cases (1.0%) with astigmatism value of 0. These percentages collectively sum up to 100.0%, representing the distribution of astigmatism values across the entire sample of 200 cases.

Table 6: Cross Tabulation of Corneal Astigmatism Category and Age Category among Study Cases

Astigmatism Category		Age Category				Total
		50-59 Year	60-69 Year	70-79 Year	> 79 Year	
0	**Count**	0	2	0	0	2
	% in Age Category	0.0%	2.5%	0.0%	0.0%	1.0%
0.01-0.99	**Count**	59	29	12	3	103
	% in Age Category	72.8%	36.3%	40.0%	33.3%	51.5%
1.00-1.99	**Count**	16	25	15	0	56
	% in Age Category	19.8%	31.3%	50.0%	0.0%	28.0%
2.00-2.99	**Count**	4	15	2	3	24
	% in Age Category	4.9%	18.8%	6.7%	33.3%	12.0%
≥ 3.00	**Count**	2	9	1	3	15
	% in Age Category	2.5%	11.3%	3.3%	33.3%	7.5%
Total	**Count**	**81**	**80**	**30**	**9**	**200**
	% in Age Category	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

The table presents data on Astigmatism categories cross-tabulated with age categories, depicting the distribution of individuals across different age groups and their corresponding levels of astigmatism. Each cell in the table contains the count of individuals falling into specific categories, along with the

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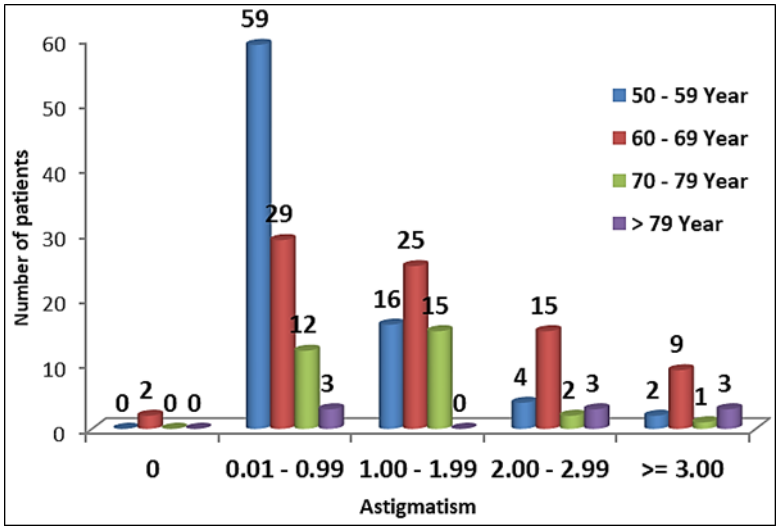
percentage within their respective age categories. For instance, within the 50-59 age group, there are 0 individuals with no astigmatism. Conversely, the majority of individuals within this age group have astigmatism ranging from 0.01 to 0.99, accounting for 72.8% of the total in this age bracket. This pattern varies across different age categories, with fluctuating proportions of astigmatism levels observed. The table concludes with the total count and percentage within each age category, summing up to 100.0% for all age groups, providing a comprehensive depiction of the distribution of astigmatism levels across different age brackets.

The study unveiled a statistically significant correlation between age categories and Astigmatism categories, as evidenced by a chi-square value of 48.561 and a **p-value of 0.001**. This suggests that there is a statistically significant relationship between age and the level of astigmatism.



Graph 2: Graphical representation of Cross Tabulation of Corneal Astigmatism Category and Age Category among Study Cases

Table 7: Distribution of Type of Corneal Astigmatism among Study Cases

Type of Astigmatism	Frequency	Percent
ATR	104	52.0
NO	2	1.0
OBLIQUE	40	20.0
WTR	54	27.0
Total	**200**	**100.0**

The table displays the frequency and percentage distribution of different types of astigmatism. Four types of astigmatism are listed: Against-the-Rule (ATR), No astigmatism (NO), Oblique astigmatism (OBLIQUE), and With-the-Rule astigmatism (WTR). Among these, ATR astigmatism is the most common, with a frequency of 104 cases, representing 52.0% of the total sample. Conversely, the least common type is NO astigmatism, with only 2 cases, accounting for 1.0% of the total. OBLIQUE astigmatism accounts for 40 cases, or 20.0%, while WTR astigmatism is observed in 54 cases, representing 27.0% of the total sample.

Table 8: Cross Tabulation of Type of Corneal Astigmatism According to Age Category among Study Cases

Age Category		Type of Astigmatism				Total
		ATR	NO	Oblique	WTR	
50 - 59 Year	Count	32	0	18	31	81
	% in Age Category	39.5%	0.0%	22.2%	38.3%	100.0%
60 - 69 Year	Count	47	2	14	17	80
	% in Age Category	58.8%	2.5%	17.5%	21.3%	100.0%
70 - 79 Year	Count	21	0	4	5	30
	% in Age Category	70.0%	0.0%	13.3%	16.7%	100.0%
> 79 Year	Count	4	0	4	1	9
	% in Age Category	44.4%	0.0%	44.4%	11.1%	100.0%

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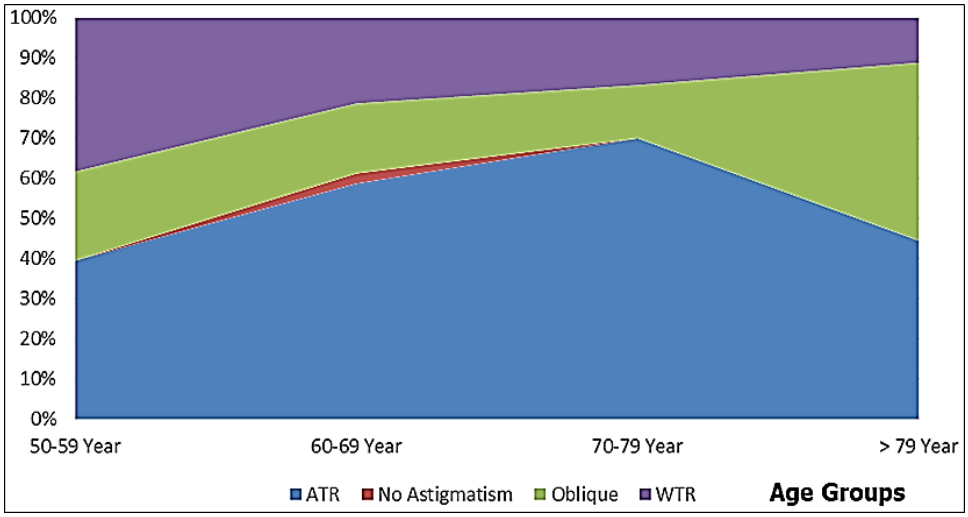
Total	Count	104	2	40	54	200
	% in Age Category	52.0%	1.0%	20.0%	27.0%	100.0%

This table presents data on the distribution of different types of astigmatism across age categories. The age categories are segmented into 50-59 years, 60-69 years, 70-79 years, and over 79 years. Types of astigmatism include ATR, NO astigmatism, OBLIQUE, and WTR.

As illustrated in this table, 39.5% individuals aged 50-59 years exhibit Against-The-Rule (ATR) astigmatism, 22.8% Oblique, and 38.3% With-The-Rule (WTR) astigmatism. Similarly, those aged 60-69 years display a comparable pattern, with ATR astigmatism at 58.8%, No astigmatism at 2.5%, Oblique at 17.5%, and WTR at 21.3%. Again, individuals aged 70-79 years show a higher prevalence of ATR astigmatism at 70.0%, while prevalence of WTR falls to 16.7%. Now those above 79 years demonstrate ATR astigmatism at 44.4% and a further drop of WTR astigmatism to 11.1%. Hence, a trend of increase in ATR astigmatism with a simultaneous fall in WTR astigmatism is observed as age progresses. Our research uncovered a noteworthy correlation ($\chi 2 = 18.725$, **p = 0.028**) between different types of astigmatism in different age group categories.



Graph 3: Graphical representation of Cross Tabulation of Type of Corneal Astigmatism According to Age Category among Study Cases

DISCUSSION

Astigmatism in the eye is primarily influenced by irregularities in the cornea and lens. While cataract surgery can address astigmatism caused by the lens, preexisting corneal astigmatism poses a significant challenge for achieving optimal postoperative vision. This assumes that any astigmatism induced by the surgery itself has been kept to a minimum. Studies from various countries, have examined the prevalence and characteristics of corneal astigmatism in cataract patients prior to surgery[23].With advancements in cataract surgery, from historical methods like couching to modern techniques such as small incision cataract surgery, phacoemulsification, there have been significant improvements in terms of rapid visual recovery, reduced complications, improved visual results, and reduced dependence on glasses. Taking these advancements into consideration, this observational cross-sectional study was conducted at the outpatient eye department of M.M. Institute of Medical Sciences & Research, Mullana, Ambala.

We observed that in our study, 33.5% of participants had a Visual Acuity of <3/60 or Low thus impacting their sight profoundly. This is in consistency with another study by **Chaudhary** *et al*., where the prevalence of VA <3/60 or Low was 36%.[24] Cataract leads to significant visual impairment which explains the high prevalence of low vision in the study population.

Our study showed the distribution of type of cataracts as follows: Mixed (57.5%), NS(18%), MSC(13.5%), PSC(8.5%) and Cortical (2.5%). These findings were similar to those of a study conducted by **Gopal***et al*.,in 2023 where the most common type of cataract observed was Mixed type and Cortical type was least prevalent as well[25].However the distribution was slightly different in the study by **Chaudhary** *et al*.,where most common type of cataract was Nuclear Sclerotic (38.2%). This parity may be attributed to the change in geographical and climate conditions and variation in sunlight and UV exposure[24].

In our study the mean age of the cases were 62.13 ± 9.08 (range 50-90 years). Patients were categorized into four age groups. The largest proportion of patients fell within the fifth and sixth decade, with the next highest numbers in the seventh and above decades. Approximately similar findings were noted in another study, namely a study by **Ferro T** *et al*.,the average age of patients was 60.8 years[27].But this is in reciprocation with other studies, for instance, **Chen W**

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and colleagues (2013) conducted a study on Chinese patients undergoing cataract surgery. The average age of the patients here was 70.56 ± 9.55 years[26].

In our study 113 cases were females (56.5%) compared to male 87 (43.5%) of the total sample. This data indicates that there were more females than males. This observation aligns with findings from other studies. For instance, **Mohammadi M** *et al*.,identified a female predominance in their study on corneal astigmatism (CA) prevalence before cataract surgery in Tehran, Iran[28].Similarly, studies conducted by **Chen W** *et al*., with a majority being female (64%), also observed a higher prevalence of females undergoing cataract surgery, consistent with our findings[26].Contrarily, our study had a different demographic composition compared to that of **Iskayu M** *et al*.,where males accounted for 57.62% and females for 42.38% of the participants[29].In contrast to most previous studies, their research had a higher proportion of male participants, possibly reflecting their greater financial means and thus ability to afford surgery in the study setting.

In previous studies, the occurrence of corneal astigmatism of 1.00 diopter or greater ranged from 31.6% to 45.9%, generally staying below 50%, which is very similar to our study results where we find out that, 47.5% of cases had corneal astigmatism ≥ 1.00 diopter. In a separate study by **Lekhanont K and co-authors** (2011) in Thailand, they investigated senile cataract patients over 40 years of age. They observed pre-existing corneal astigmatism of 1.00 D or greater in 37.8% of eyes[30].The distribution of cases on basis of astigmatism in our study was observed as 51.5% with 0.01-0.99 D, 28% with 1-1.99D, 12% with 2-2.99D and 7.5% with≥3.0 D and 1% with no astigmatism. **Yuan X and co-authors** (2014) investigated the prevalence of Corneal Astigmatism in Northern China. They found that 20.76% of eyes had Corneal Astigmatism of 0.5 D or less, 47.27% had Corneal Astigmatism of 1.0 D or more, 13.16% had Corneal Astigmatism of 2.0 D or more, and 3.75% had Corneal Astigmatism of 3.0 D or more[23].

However, A study in Germany by **Hoffmann PC** *et al*.,reported significantly lower rates of preoperative corneal astigmatism, with only around one third of eyes having astigmatism greater than 1.00 diopter[31].**Lopes MC** *et al*., explain this difference as genetic factors, which play a crucial role in the development and expression of corneal astigmatism[32].

The results of our study also showed that the prevalence of higher values of Corneal Astigmatism increases with increase in age overall **(p value=0.001)**

In our study among the observed types of astigmatism, against-the-rule (ATR) astigmatism stands out as the most prevalent, with 104 (52.0%) of the entire sample of 200 eyes. Simultaneously, the rarest type is NO astigmatism, documented in only 2 cases (1.0%) of the total. Oblique astigmatism is found in 40 (20.0%), while with-the-rule (WTR) astigmatism is present in 54 cases, accounting for 27.0% of the total sample. Similar distributions of astigmatism types were noted in several other studies, including those conducted by **Mohammadi M *et al*.,[28], Chen W *et al*.,[26], Yuan X *et al*.,[23], and Iskayu M *et al*.,[29].** However, in contrast to our findings, **Chaudhary M *et al*.,[24]**reported a higher prevalence of WTR astigmatism (44.4% of eyes) compared to ATR astigmatism (40.04% of eyes), with 12.9% of patients exhibiting oblique astigmatism.

We noted that prevalence of ATR increases significantly with increase in age and simultaneously there is a decrease in the prevalence of WTR **(p value = 0.028).** Similarly, in their study, **Chen W** *et al*., noted that ATR astigmatism was found to increase significantly with older age[26].In another study conducted by **Prasher P and colleagues** in 2016 in India, there was a trend of shifting astigmatism from WTR to ATR with increasing age[33].

CONCLUSION

We conclude from our study thatas the age increases, the degree of astigmatism was found to be significantly higher. Since there was significantly higher value of Astigmatism with increase in age. ATR was the most prevalent type of astigmatism which was found to be significantly increasing with increase in age. Elderly patients can be actively managed on presentation. We can hence opt for surgical techniques and toric IOLs in elderly patients for correction of pre-operative corneal astigmatism during cataract surgery for achieving desired post-operative results.

DISCLOSURE

The authors of this study did not receive any funding for the study and possess no conflicts of interest with respect to this study.

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