

# Prevalence of Pre-Operative Corneal Astigmatism in Cataract Surgery Patients of Western U.P.

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**Abstract:** This study helps us to plan the surgery in a way which provides the patient with a spectacle free cataract surgery. The pre-operative K readings of all patients were taken and tabulated age and gender wise. Patients were classified as having WTR and ATR astigmatism. At the end of the study, 98.4% patients (492/500) showed astigmatism and a mean astigmatism of 1.06 $\pm$ 0.93 was found in our patients. ATR astigmatism showed a higher prevalence and that too in women. Hence we concluded that evaluating astigmatism pre-operatively is important to plan toric IOLs or LRIs during surgery to render the patient spectacle free post surgery.

**Keywords:** Sturm's conoid, with the rule, against the rule, K readings, corneal curvature

## 1. Introduction

Astigmatism is a type of refractive error, wherein a point focus of light cannot be formed upon the retina. Theoretically, no eye is "stigmatic", and in practice we include those anomalies in the optical mechanism wherein an appreciable error is caused by the unequal refraction of light in different meridians. Astigmatism is a commonly encountered refractive error, accounting for about 13% of the refractive errors of the human eye [1]. **Refractive astigmatism of an eye mainly comprises of anterior corneal astigmatism (CA) and lenticular astigmatism (LA). The LA does not play any role once the patient undergoes cataract surgery.** Cataract surgery is one of the most commonly performed procedures in ophthalmology. Recent advances in cataract and intraocular lens (IOL) implant surgery have led to a new concept of "Refractive cataract surgery". Refractive cataract surgery refers to the uncomplicated removal of cataract while minimizing post-operative spectacle dependence. Most patients now desire that all refractive errors, including astigmatism, be addressed at the time of surgery. Cataract surgery provides a unique opportunity for the surgeon to address the issue of pre-operative corneal astigmatism in the pursuit of achieving the intended post-operative refraction as per the patient's visual needs and lifestyle. There exist a variety of surgical techniques to reduce or eliminate the CA including **corneal relaxing incisions (CCIs), limbal relaxing incisions (LRIs), opposite clear corneal incisions, femtosecond laser-assisted astigmatic keratotomy, excimer laser keratectomy, and toric IOL implantation.** Hence, knowledge about the prevalence of astigmatism and thus the demand for toric IOLs in any population group would be important for the ophthalmologists, hospital administrators as well as the IOL manufacturers to ensure their availability for the patients

## 2. Literature Review

Astigmatism means "without a point". **Miller Stephen J** defined astigmatism as a condition of refraction in which a point of light cannot be made to produce a punctate image upon the retina by a correcting spherical lens.

### Classification of Astigmatism

Astigmatism can be broadly classified as

- Regular Astigmatism (RA)
- Irregular Astigmatism (IA)

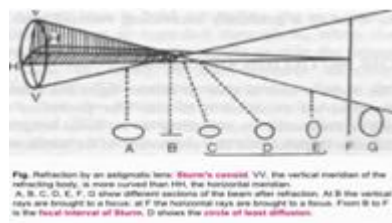
### Optics of Regular Astigmatism

In RA, the parallel rays of light are not focused on a point but form two focal lines. **The configuration of rays refracted through the astigmatic surface is called the Sturm's Conoid** and the distance between the two focal lines is known as **focal interval of Sturm**. The length of this focal interval is a measure of the degree of astigmatism.

### Refractive Types of Regular Astigmatism

Depending upon the position of two focal lines **in relation to retina**, the regular astigmatism is further classified into three types

- 1) **Simple astigmatism** – Wherein the rays are focused on the retina in one meridian and either in front (simple myopic astigmatism) or behind the retina (simple hypermetropic astigmatism) in the other meridian.
- 2) **Compound astigmatism** – In this type the rays of light in both meridians are focused either in front (compound myopic) or behind the retina (compound hypermetropic).
- 3) **Mixed astigmatism** – Refers to a condition wherein the light rays in one meridian are focused in front and in the other meridian behind the retina. Thus in one meridian, the eye is myopic and in another hypermetropic.



**Figure 1: Sturm's Conoid**

**Mohammadi M et al** [2] in 2016 described and analyzed the prevalence and pattern of CA in 2156 eyes of 1317 cataract surgery candidates. The mean of CA was 1.12  $\pm$  1.10 D (range 0.0–7.00), in all patients. Furthermore, the mean of flat and steep K readings were 43.70  $\pm$  1.70 and 44.83  $\pm$  1.79 D, respectively. CA was 1.50 D or less in 1590 eyes (73.7 %), more than 1.50 D in 566 eyes (26.2 %), 3.00 D or more in 161 eyes (7.4 %), WTR in 796 eyes (36.9 %), ATR in 1010 eyes (46.8 %), and oblique in 350 eyes (16.2 %). ATR

astigmatism axis significantly increased with the increase in age. CA of most cataract surgery candidates fell between 0.50 and 1.50 D.

**Blasco TF et al** <sup>[3]</sup> in 2009 recorded prevalence of CA before cataract surgery in Spain. 4540 eyes of 2415 patients, between 30 – 90 yrs of age and having cataract were included in the study. In 13.2% of eyes, no CA was present; in 64.4%, corneal astigmatism was between 0.25 and 1.25 diopters (D) and in 22.2%, it was 1.50 D or higher.

**Lekhanont K et al** <sup>[4]</sup> in 2011 recorded prevalence of CA in cataract surgery patients in Thailand. The study comprised of 1005 consecutive senile cataract patients, >40 yrs of age, (mean age – 68.21 +/- 9.19 yrs) scheduled for simple cataract surgery. Pre existing corneal cylinder  $\geq$  1.00 D was seen in 37.8 % eyes. Astigmatism axis was mainly ATR in 62.25 % eyes, whereas 26.05 % patients had WTR astigmatism. Also prevalence of ATR astigmatism increased with age.

**Chen W et al** <sup>[5]</sup> in 2013 recorded prevalence of CA before cataract surgery in 2849 Chinese patients. (4831eyes). The mean age of the patients was 70.56 +/- 9.55 years along with a female predominance (64 %). The mean CA in this cohort was 1.01 D (range 0.05 to 6.59 D). CA was between 0.25 D and 1.25 D in 67.7% of eyes, 1.25 D or higher in 27.5% eyes, and less than 0.25 D in 4.8% of eyes. Astigmatism was WTR in 25.1% of eyes, ATR in 58.2% of eyes, and OBL in 16.7% of eyes. The mean steep keratometry measurement was  $44.76 \pm 1.56$  D. ATR astigmatism increased significantly with older age.

**Yuan X et al** <sup>[6]</sup> in 2014 recorded prevalence of CA before cataract surgery in Northern China . The study evaluated 12, 449 eyes from 6, 908 patients with a mean age of  $69.80 \pm 11.15$ (SD) years. The CA was 0.5 D or less in 20.76% of eyes, 1.0 D or more in 47.27% of eyes, 2.0 D or more in 13.16% of eyes, and 3.0 D or more in 3.75 % of eyes. WTR astigmatism was found in 30.36% of eyes, while ATR was found in 52.41% of eyes. The percentage of ATR astigmatism increased with age. They concluded that almost one-half of pre-operative eyes (47.27%) in Northern China have a CA of 1.0 D or more.

**Iyaku M et al** <sup>[7]</sup> in 2014 documented astigmatism in cataract patients in Northern Nigeria. There were 3, 169 patients (3286 eyes) aged between 16 and 110 years, with a Male to female ratio of 1.4:1. Mean keratometry in dioptres was  $K1 = 43.99$  and  $K2 = 43.80$ . Astigmatism ranged from 0.25 – 6 D with a mean CA of 1.16 D. Astigmatism was WTR in 1373 eyes (41.78 %), ATR in 1862 eyes (56.66 %) and there was no astigmatism in 51 eyes (1.55 %). A majority (45.92%) of eyes had astigmatism between 1.00 and 1.99 D. Two-thirds of the eyes (66.9%) in this study had pre-operative CA equal to or above 1.00 D, 6.12 % had astigmatism  $>3$  D.

An Indian study conducted in 2016 by **Prasher P et al** <sup>[8]</sup> recorded prevalence of CA before cataract surgery. The mean age of 2316 patients (2502 eyes) was  $59.54 \pm 10.96$  years. The CA was less than 1.0 D in 796 eyes (59.37 %), 1.0–1.99 D in 716 eyes (28.62 %), 2.0–2.99 D in 187 eyes

(7.47 %) and more than 3.0 D in 114 eyes (4.56 %). The mean CA was  $1.04 \pm 1.04$  D and showed a gradual increase with age after the fourth decade. The astigmatism was WTR in 709 (28.34 %), ATR in 1298 (51.88 %), and OBL in 598 (23.9 %) eyes. There was a shift in astigmatism from WTR to ATR with increase in age. Over 40 % of the Indian patients undergoing cataract surgery had more than 1.0 D of CA and may benefit from the use of toric IOLs.

**Ji-guo Yu et al** <sup>[9]</sup> in 2017 evaluated 3209 eyes of 2821 cataract patients and found out a CA of 0.5-1D . A total of 10.56% patients exhibited CA greater than 2.0 D. Proportion of ATR astigmatism increased with age and that of WTR astigmatism decreased with age.

**Curragh DS et al** <sup>[10]</sup> in 2017 evaluated 2080 eyes of 1788 patients in Northern Ireland. The mean CA was  $1.09 \pm 0.83$ . CA was 1.50 D or less in 1621 eyes (78%). It was more than 2.0 D in 242 eyes (11.6 %), more than 2.5 D in 127 eyes (6.1 %), more than 3 D in 68 eyes (3.27 %) and more than 3.5 D in 45 eyes.(2.16 %).

**Chaudhary M et al** <sup>[11]</sup> in 2017 carried out a study to investigate the prevalence and pattern of pre-existing CA in patients undergoing cataract surgery at B.P. Koirala Lions Center for Ophthalmic Studies, T.U. Teaching Hospital. Study included 225 eyes of 185 subjects. Mean amount of CA was  $0.84 \pm 0.80$  D. 16.9% had no significant CA while 65.3% had CA between 0.25 and 1.50 D and 17.8% had CA of 1.50 D or higher. WTR astigmatism (axis of correcting cylinder  $180 \pm 30$  degrees) was present in 44.4% eyes, 40.04% of the eyes had ATR astigmatism, and 12.9% of the eyes had OBL astigmatism.

**Moulick BPS et al** <sup>[12]</sup> in 2018 studied the prevalence of CA before cataract surgery in 223 eyes of western Indian population. Mean CA was  $0.88 \pm 0.61$ . 27.8% patients had WTR astigmatism, 51.1% patients had ATR astigmatism and 21.1 % patients had OBL astigmatism. They found out that ATR exceeds WTR and reaches 100% by 80 years. CA was below 0.25 D in 17.5% eyes, between 0.25-1.25 D in 63.7 % patients and  $>1.50$  D in 18.8 % eyes.

### 3. Methods

This prospective observational study was conducted in the Department of Ophthalmology, Subharti Medical College, Meerut on 500 eyes of 500 patients undergoing routine elective cataract surgery. This study examines the prevalence of pre –operative CA in cataract surgery patients of western U.P. All the K values were taken by a single person, thus eliminating examiner bias. Using the K1 and K2 values, the astigmatism was calculated and its prevalence was noted. Keratometry with Topcon Automated keratometer KR 8800 Version 1.25 (Topcon, Tokyo, Japan) was done and refractive power of the cornea in the vertical and horizontal meridian was recorded. A minimum of three measurements were performed for each eye.

The astigmatism axis was classified as **With-The-Rule (WTR)** if the flatter axis was between  $150^\circ$  and  $180^\circ$  or between  $0^\circ$  and  $30^\circ$ , **Against-the- Rule (ATR)** if the flatter

axis was between 60° and 120° and **oblique (OBL)** if was at any other meridian.

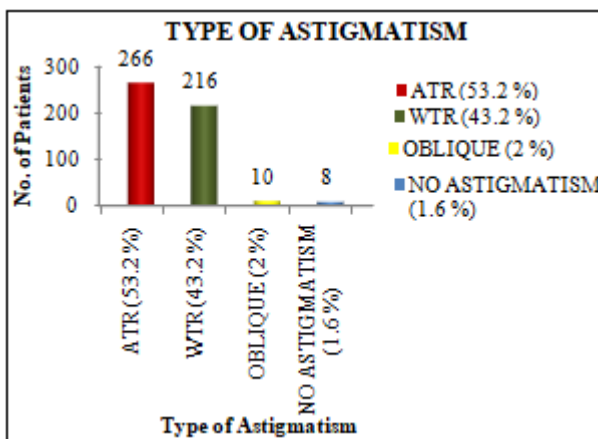
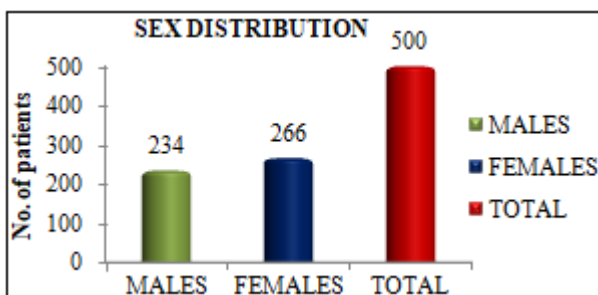
Following the K readings, the astigmatism was calculated and accordingly techniques like limbal relaxing incisions, toric IOLs etc were planned for patients.



**Figure 2:** Topcon Automated keratometer KR 8800 version 1.25 (Topcon, Tokyo, Japan)

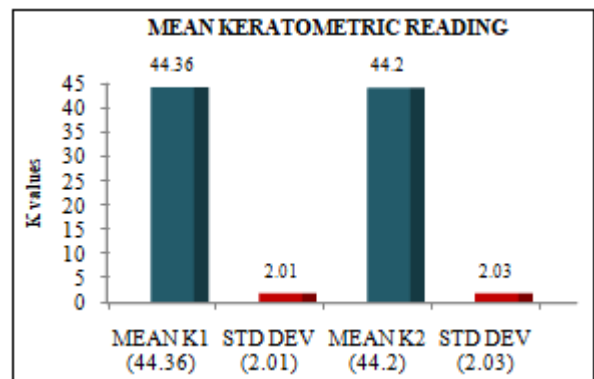
#### 4. Results

Our study comprised of a total of 500 patients. 46.8 % patients in our study were males and 53.2 % patients were females. There was a clear female preponderance in our study. Out of 500 patients who were included in our study, only 8 patients i.e. 1.6 % patients had no astigmatic error in their eye, only 10 of them had oblique astigmatism (i.e. 2%). 266 patients had ATR astigmatism i.e 53.2 % patients, 216 i.e. 43.2 % of them showed WTR astigmatism in their eye.

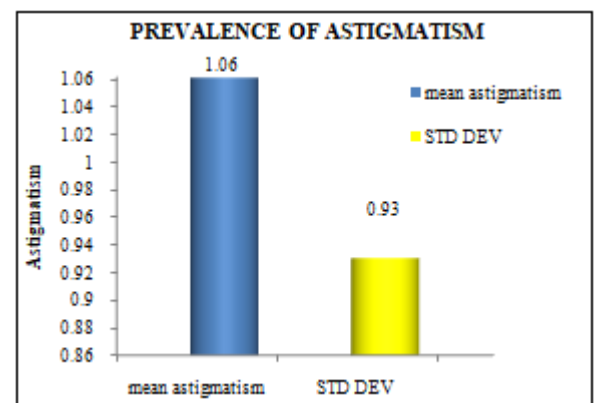


The mean of the K1 readings is 44.36 +/- 2.01 D. The mean of the K2 readings is 44.2 +/- 2.03 D.

A mean astigmatism of 1.06 +/- 0.93 D is present in the pre-operative patients who came up for cataract surgery in our hospital.



Keeping aside the patients with no astigmatism, majority of the patients had an astigmatism of <1 D (53.2 %). Prevalence of an astigmatism of 1 – 2 D was 35.4 % and the least number of patients had an astigmatism of >2 D (9.8 %).



#### 5. Discussion

Cataract surgery has undergone remarkable changes in the recent times, evolving through the years from couching to current day small incision phacoemulsification with quick visual rehabilitation, minimal morbidity, better visual outcomes, and freedom from spectacles.

Keeping this in mind, the present prospective observational study was undertaken in the out patient eye department of Chhatrapati Shivaji Subharti Hospital, Meerut.

In our hospital more number of females (53.2%) were operated for cataract as compare to males (46.8%) and that there was a clear female preponderance.

A **similar** female preponderance was found out in the study conducted by **Mohammadi M et al** [2], who found out the prevalence of CA before cataract surgery in 2156 eyes of 1317 patients (609 males and 708 females) in Tehrn, Iran.

**Blasco TF et al** [3] also reported a **similar** female preponderance when they found out the prevalence of pre-operative CA before cataract surgery in 4540 eyes of 2415 patients (768 males and 1647 females), in Valencia, Spain. Studies by **Lekhanont K et al** [4], **Chen W et al** [5], **Yuan X et al** [6], also had a female preponderance, similar to ours.

Our study differed from that of **Iskayu M et al** <sup>[7]</sup> whose study had 57.62 % males and 42.38 % females.

In our study, the mean of the K1 and k2 readings is 44.36 +/- 2.01 and 44.2 +/- 2.03 respectively. (K1 being slightly higher than K2). **On the contrary**, the mean K readings (K1 and K2) observed by **Chen W et al** <sup>[5]</sup> who found out prevalence of CA in Chinese cataract surgery patients, were 43.76 +/-1.53 and 44.76 +/-1.56 respectively (K2 being higher than K1).

Also in the study conducted by **Blasco TF et al** <sup>[3]</sup> the mean K1 and K2 were 43.48+/-1.61 and 44.08+/-1.59 respectively (K2 >K1). Similar to our study, the mean K1 and K2 in the study carried out by **Iskayu M et al** <sup>[7]</sup> were 43.99 and 43.80 respectively. (K1 slightly higher than K2).

Majority of the studies including **YuanX et al** <sup>[6]</sup>, **Mohammadi M et al** <sup>[2]</sup>, **Prasher P et al** <sup>[8]</sup>, **Yu JG et al** <sup>[9]</sup>, **Curragh DS et al** <sup>[10]</sup>, **unlike our study** had a mean K1 less than K2.

A mean astigmatism of 1.06 +/- 0.93 (minimum – 0.25 D and maximum – 9 D) is present in the pre-operative patients who came up for cataract surgery in our hospital. The study by **Lekhanont K et al** <sup>[4]</sup>, also found out a **similar** mean astigmatism of 1.05 +/- 0.62.

Mean astigmatism in the study by **Curragh DS et al** <sup>[10]</sup> was also **similar** to our study (1.09 +/- 0.83). The mean astigmatism in the study by **Chaudhary M et al** <sup>[11]</sup> was also lower than our study (0.84 +/- 0.80). The study by **Moulick PS et al** <sup>[12]</sup> however showed a comparatively lower mean astigmatism than our study (0.87+/-0.61).

Similar mean CA was seen in studies by **Chen W et al** <sup>[5]</sup>, **Iskayu M et al** <sup>[7]</sup>, **Mohammadi M et al** <sup>[2]</sup>, and **Prasher P et al** <sup>[8]</sup>.

ATR astigmatism is the more prevalent type of astigmatism in our study i.e. 266 patients out of 500 had ATR astigmatism (53.2%). This was followed by WTR astigmatism which was present in 216 out of 500 patients (43.2%).

Oblique astigmatism was present in only 10 out of 500 patients (2%). **Similar** distribution of the type of astigmatism was seen in majority of the studies, in which ATR astigmatism showed the highest prevalence followed by WTR astigmatism, oblique astigmatism and no astigmatism.

These studies included studies by **Mohammadi M et al** <sup>[2]</sup>, **Chen W et al** <sup>[5]</sup>, **Yuan X et al** <sup>[6]</sup>, **Iskayu M et al** <sup>[7]</sup>, and **Prasher P et al** <sup>[8]</sup>. **Contrary** to our study, a higher prevalence of WTR astigmatism was found in the study by **Chaudhary M et al** <sup>[11]</sup>. They found out that WTR astigmatism was present in 44.4 % eyes as compared to ATR astigmatism which was present in 40.04 % eyes, and 12.9 % patients had oblique astigmatism.

We found out that in our study, majority of the patients had an astigmatism of less than 1 D ( 53.2 %). 1 – 2 D of

astigmatism was seen in 35.4 % patients and only 9.8 % patients had an astigmatic value of more than 2 D.

The Indian study by **Prasher P et al** <sup>[8]</sup>, showed similar results as our study, less than 1 D astigmatism having the largest proportion (59.37 %) and more than 2 D astigmatism having the least number of patients (7.47 %).

**Contrary** to our study, the study by **Curragh DS et al** <sup>[10]</sup>, showed a higher proportion of more than 2 D of astigmatism (23.2%).

## 6. Conclusion

Modern cataract surgery, in its quest for providing the best uncorrected VA to the patient and minimizing SIA has become a refractive surgery today.

We hence decided to perform this study in our set up to get an approximate idea about the prevalence of astigmatism and its type so as to plan our surgery accordingly which rendered the patient emmetropic.

A mean astigmatism of 1.06 +/- 0.93 is present in the pre-operative patients who came up for cataract surgery in our hospital.

ATR astigmatism is the most prevalent type of astigmatism in our study i.e. 266 patients out of 500 had ATR astigmatism (53.2 %). This was followed by WTR astigmatism which was present in 216 out of 500 patients (43.2 %). OBL astigmatism was present in only 10 out of 500 patients (2 %).

An increase in the prevalence of ATR astigmatism was seen as the age advanced.

There was a higher prevalence of ATR astigmatism in females whereas males showed a higher prevalence of WTR astigmatism.

We hence conclude that in a developing and over-populated country like India, especially in a set up like ours, where patients belong mostly to the rural population, and usually do not turn up for regular follow ups, it is necessary to try and leave the patients emmetropic, and hence, reduce the need for spectacles after cataract surgery.

Hence estimation of pre operative corneal astigmatism helps us to decide the various surgical interventions which can be taken up during surgery to eliminate post-operative refractive error.

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