Original Article

Prevalence and types of corneal astigmatism in patients undergoing cataract surgery

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Abstract

Introduction: Cataract surgery is one of the most commonly performed ophthalmic surgical procedures worldwide, with a high rate of successful and rapid anatomical and functional visual recovery. Goal of cataract surgery is to achieve a desirable induction of refractive outcome with minimal astigmatism after surgery. This brings to interest the question of influence of preoperative and surgically induced corneal astigmatism on the final postoperative unaided visual acuity. Pre-existing corneal astigmatism is an important limiting factor for optimal results of cataract surgery in a significant number of patients. It has been estimated that 15% to 29% of patients with cataract have more than 1.50 dioptres (D) of pre-existing astigmatism.

Methods: Prospective study was carried out to investigate the prevalence and pattern of pre-existing corneal astigmatism in patients undergoing cataract surgery at B.P. Koirala Lions Center for Ophthalmic Studies, T.U. Teaching Hospital for a period of 2 years. All patients underwent complete ophthalmic examination including visual acuity, refraction, slit lamp examination, applanation tonometry and dilated fundus evaluation, biometry and ultrasound B-scan examination. Corneal astigmatism was measured by Keratometer at least two times for each patient. Astigmatism was calculated from dioptric difference between vertical reading and horizontal reading. With the rule (WTR) astigmatism was considered when steep meridian was at $90^0 \pm 30^0$. Against the rule (ATR) astigmatism was considered when steep meridian was at $180^0 \pm 30^0$.

Results: Study included 225 eyes of 185 subjects, out of which 38.7% were male eyes and 61.3% were female eyes. The mean age of the subjects was 64.45±12.89 years. Mean amount of corneal astigmatism in our study was 0.84±0.80 D. 16.9% had no significant corneal astigmatism while 65.3% had corneal astigmatism between 0.25 and 1.50 diopter and 17.8% had corneal astigmatism of 1.50D or higher. With-the-rule astigmatism (axis of correcting cylinder 180±30 degrees) was present in 44.4% eyes, 40.04% of the eyes had against-the-rule (ATR) astigmatism (correcting minus cylinder 90±30 degrees), and 12.9% of the eyes had oblique astigmatism.

Conclusion: Approximately two thirds of pre-operative cataract patients had 1D or less astigmatism**.** Corneal astigmatism increases with age. Hence, it is important to analyze the magnitude and pattern of pre-existing corneal astigmatism in aging population due to higher demand for improved vision and use of suitable methods for best visual results.

Keywords: Cataract, corneal astigmatism, Keratometer, with the rule, against the rule.

Introduction

Cataract is the main cause of reversible blindness in the world accounting for about three quarters of blindness. Significant efforts are being undertaken to increase the output of vision through safe cataract services. Cataract surgery has undergone great refinement in recent years.[1] with improvements and advances in operating techniques, instruments and technical aids, the patients' as well as the surgeons' demands and expectations are continuously increasing. The main aim of cataract surgery today is rapid visual rehabilitation, the best possible uncorrected visual acuity, and minimal postoperative astigmatism.[2] Some of the factors affecting the Surgically Induced Astigmatism (SIA) are the architecture and site of incision, surgical skill, and to a great extent of pre-existing corneal astigmatism.[3] It has been documented that approximately 15% of cataract patients have more than 1.5 diopter of pre-existing keratometric astigmatism.[4]

Phacoemulsification is one of the most successfully and commonly performed cataract surgeries worldwide. Phacoemulsification with nontoric intraocular lens (IOL) implantation eliminates astigmatism attributable to the lens, but has no effect on corneal astigmatism. Correcting preexisting corneal astigmatism is commonly carried out at the time of cataract surgery by making limbal or corneal relaxing incisions or by the implantation of toric IOLs.[5] Advances in the calculation of IOL power have significantly reduced the incidence of spherical refractive errors, while residual astigmatism after surgery is a concern for both ophthalmologists and patients and can leave patients with symptomatic decreased visual function[6,7,8]. Prevalence and types of corneal astigmatism in patients undergoing cataract surgery has been reported from different countries but not from Nepal till date. Nepal has a huge burden of cataract with increasing visual demand of patients. The estimated incidence of blindness due to cataract in Nepal is 62.2%.[9] Hence, this study was undertaken to estimate the prevalence of corneal astigmatism in Nepalese population.

Methodology

A prospective observational study was carried out at B.P. Koirala Lions Centre for Ophthalmic Studies, T.U. Teaching hospital for a period of 2 years in patients with cataract. In our study we included 225 eyes of 185 subjects with cataract. Informed consent was taken. The preoperative evaluation included assessment of best corrected visual acuity, slit lamp examination, applanation tonometry, fundoscopy. Cataract patients with a history of prior ocular surgery, corneal disease, and inflammation were excluded. The amount of corneal astigmatism was determined by manual keratometry (Topcon) .The measurement was carried out at least two times for each patient. Astigmatism was calculated from dioptric difference of vertical reading from horizontal reading. With the rule (WTR) astigmatism was considered when steep meridian was at $90^0 \pm 30^0$. Against the rule (ATR) astigmatism was considered when steep meridian was at $180^0 \pm 30^0$. Astigmatism in other direction was defined as oblique. On keratometry, when vertical reading (k1) was found steeper than horizontal (k2) was considered WTR astigmatism and the reverse reading for ATR astigmatism.

Statistical analysis was performed by the SPSS program for Windows, version 20.0. Continuous variables were expressed as mean ± SD, and categorical variables are presented as absolute numbers and percentage. One-way analysis of variance and the Kruskal-Wallis test were applied for the comparison of variance for normally and non- normally distributed data among different age groups, respectively. A p value less than 0.05 was considered statistically significant.

Results

A total of 225 eyes of 185 subjects undergoing cataract surgery were included in the study out of which 38.7% (n=87) were males and 61.3% (n=138) were females. The mean age of the subjects in the study was 64.45±12.89 years (range 16 years to 90 years). Table 1 describes the range of visual acuity with which the cataract patient presented to the outpatient department.

Table 1: Preoperative visual status of the operated eye

Visual acuity	Numbers (n)	Percentage (%)
6/6-6/18	15	6.7
6/24-6/60	89	39.6
5/60-3/60	40	17.8
<3/60-PL	81	36.0

Eyes with cataract were categorized on basis of having opacification at different sites of lens, as shown in Table 2. Nuclear sclerosis was present in 38.2% (n=86) eyes. 37.3% (n=84) eyes had both nuclear sclerosis and posterior subcapsular opacification

Table 2: Different types of cataract

Types of cataract	Numbers (n)	Percentage (%)
Developmental cataract	1	0.4
Cortical cataract	2	0.9
Nuclear sclerosis	86	38.2
Posterior sub capsular opacification	15	6.7
Mixed type	84	37.3
Mature cataract	15	16.4

Table 3: Demographic characteristics of subjects (descriptive values of the study).

Characteristics	Value
Number of eyes/subjects	225/185
Mean age (Y) ± SD	64.45±12.89
Range of age (Y)	16 to 90
Gender (male/female)	87/138
Mean corneal astigmatism (D) ± SD	0.84±0.80
Range of corneal astigmatism (D)	0 to 5.71
Range of Keratometry	38 to 50
Mean sphere (D) ± SD	-1.38±2.00
Mean cylinder (D) ± SD	0.41±0.64
Range of cylinder (D)	0 to 2.25

Table 3 shows the Mean amount of corneal astigmatism in our study which was 0.84±0.80 D (minimum 0, maximum 5.71) with a slight difference between right eyes (0.90D) and left eyes (0.76D) but was not statistically significant (p=0.198).

Figure 1 represents the histogram showing distribution of corneal astigmatism for the entire study sample, 16.9% subjects had no significant corneal astigmatism, 65.3% of the subjects had corneal astigmatism between 0.25 and 1.50 diopter and 17.8% of the subjects had corneal astigmatism of 1.50D or higher.

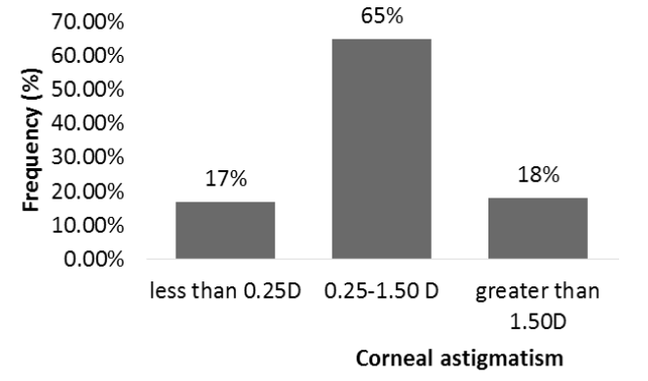

Fig1: Histogram of distribution of amount of corneal astigmatism

Regarding the distribution of corneal astigmatism as seen in Table 4, with-the-rule (WTR) astigmatism (axis of correcting cylinder 180±30 degrees) was present in 44.4% (n=100) eyes, 40.04% (n=91) of the eyes had against-the-rule (ATR) astigmatism (correcting minus cylinder 90±30 degrees), 12.9% (n=29) of the eyes had oblique astigmatism and 2.2% (n=5) of the corneas were spherical (no astigmatism) .

Table 4: Distribution of different types of corneal astigmatism

Types of astigmatism	Numbers (n)	Percentage (%)
With the rule	100	44.4
Against the rule	91	40.4
Oblique astigmatism	29	12.9
No astigmatism	5	2.2

Patients were distributed into five categories made on basis of distribution of age as follows: 15 to 30 years, 5 eyes; 31 to 45 years, 13 eyes; 46 to 60 years, 59 eyes; 61 to 75 years, 110 eyes and 76 to 90 years, 38 eyes. Figure 2 and table 5 show distribution of amount of astigmatism for different age groups. Corneal astigmatism showed significant changes between different age groups (p=0.007, Kruskal-Wallis).

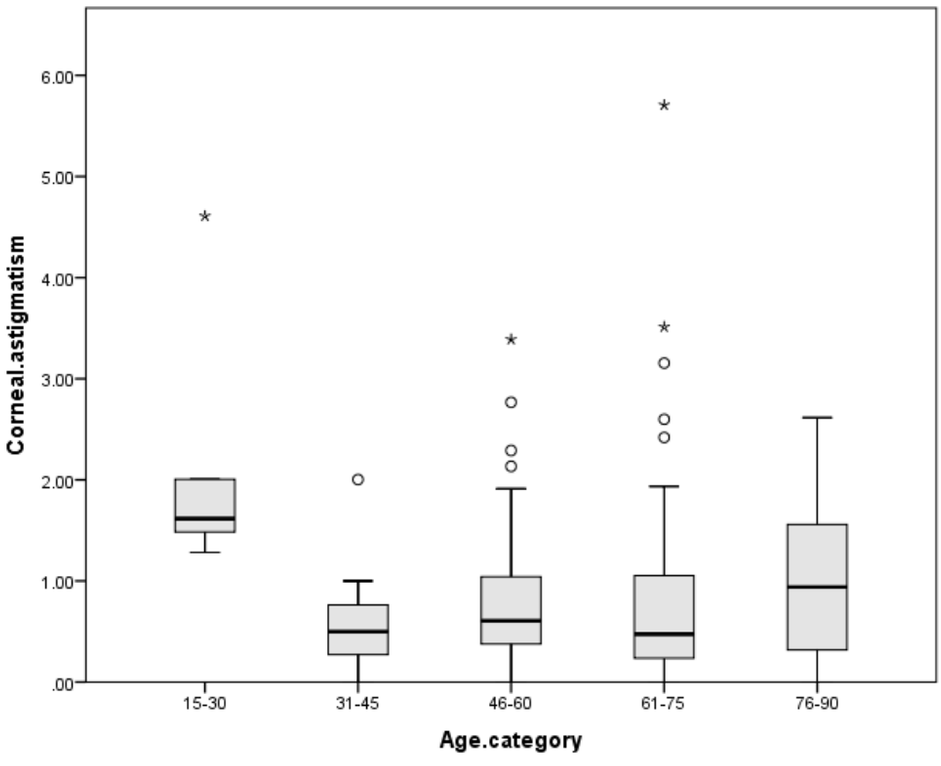

Figure 2: Box plots for values of corneal cylinder in age groups

Table 5: Amount of corneal astigmatism in relation to age groups

Age category (yrs.)	Mean amount of astigmatism (D)	Median (D)
15-30	2.19 ±1.37	1.62
31-45	0.62 ±0.51	0.49
46-60	0.81 ±0.67	0.61
61-75	0.77 ±0.83	0.47
76-90	0.99 ±0.72	0.94

The astigmatism was found to be higher in the extremes of ages.

Refractive astigmatism which includes astigmatism due to lens and cornea was seen to be higher in older age groups ie. 0.54±0.85D. Mean amount of refractive astigmatism was 0.41±0.64D (range: minimum 0, maximum 2.25). ATR was more common n=98, 43.6% cases because of advancing age as ATR astigmatism increases as the age increases. (As shown in table 6 &7)

Table 6: Prevalence of mean amount of refractive astigmatism

Age groups (yrs.)	Mean amount of refractive astigmatism
15-30	-
31-45	0.50±1.00
46-60	0.46±0.45
61-75	0.28±0.53
76-90	0.54±0.85

Table 7: Distribution of different types of refractive astigmatism

Types of Astigmatism	Numbers (n)	Percentage (%)
With the rule	60	26.7
Against the rule	98	43.6
Oblique astigmatism	32	14.2
No astigmatism	35	15.6

Discussion

The cornea and lens are the main contributors to ocular astigmatism. For patients undergoing uncomplicated cataract surgery (which eliminates lenticular astigmatism), significant preoperative corneal astigmatism remains the major obstacle to obtain satisfactory postoperative visual outcome. This presumes that surgically induced astigmatism has been minimized. The preoperative corneal astigmatism is often overlooked and this leads to patient dissatisfaction. Prevalence and type of preoperative corneal astigmatism in patients with cataract has been reported from several countries. [8,10,11,12] and has been taken into account during surgery. Nepal has huge burden of cataract with number of cataract surgery increasing each year, but this type of study has not been documented from Nepal till date.

Our study included 225 eyes of 185 subjects with mean age of 64.45±12.89 years which is very similar to a study done by Ante Ercegović etal in Croatia which included 392 eyes of 202 cataract patients with median age of 77 years.[13] The mean age in MA Rashid etal study was 61.9±8.1 (40 to 70) years .[1] The age range of our study population was from 16 to 90 years which is similar to Mohammed Isyaku etal study[14] which included age range of 16 to 110 years. This is different from studies conducted by MA Rashid etal, Ante Ercegović etal and Xiaoyong Yuan etal who included cataract patients with age range of 40 - 70 years, age 50 years and more and 30 – 97 years respectively.[1,13,15] The number of males in our study were 38.7% (n= 87) compared to 61.3% (n= 138) females which is nearest to a study done by De Bernardo et al. which had male / female as 176/204 .[12]

The mean corneal astigmatism in our study was 0.84±0.80 D (range being 0 - 5.71 D) with a slight difference between right eyes (0.90D) and left eyes (0.76D) but not statistically significant (p=0.198). MA Rashid[1] showed the mean astigmatism to be 1.17±0.75 diopter and M Isyaku etal[14] showed a mean of 1.16 diopters in their studies which was higher compared to our study. Miyake et al. observed that the mean corneal astigmatism was 1.02+/- 0.81 D.[16] Range of astigmatism in our study was similar to M Isyaku etal study (0.25 diopters to 6.00 diopters) done in Nigerian population.[14]. The range of corneal astigmatism has been reported by different studies as follows**:** up to 4.50 DCyl in the study by Riley et al. , up to 6.12 DCyl in Ante Ercegović etal study and up to 6.75 DCyl in the study by Ferrer-Blasco et al.[13,17,18]. The astigmatism may be less in our study because of small sample size compared to other studies.

In our study 16.9% subjects had no significant corneal astigmatism, 65.3% of the subjects had corneal astigmatism between 0.25 and 1.25 diopter and 17.8% of the subjects had corneal astigmatism of 1.50D or higher as seen in figure 1. Miyake etal[16] study observed the percentage of 1 D or less of corneal astigmatism in 63.6%, that of more than 1 D and 1.5 D or less in 20.9%, that of more than 1.5 D and 2 D or less in 7.4%, that of more than 2 D and 2.5 D or less in 3.8% and that of more than 2.5 D and 3 D or less in 1.8%. Ante Ercegović etal[13] study found corneal astigmatism 0.50 DCyl or less in 38.3%, between 0.51 and 1.0 DCyl in 30.1%, between 1.01 and 2.0 DCyl in 25%, between 2.01 and 3.0 DCyl in 3.3% and corneal astigmatism higher than 3.0 DCyl in 3.3% eyes. 66.9% of the eyes had astigmatism equal to or >1.00 diopter, but only 6.12% had astigmatism >3.00 diopters in M Isyaku etal study.[14] Yuan, X etal reported corneal astigmatism to be 0.5 diopters (D) or less in 20.76% of eyes, 1.0D or more in 47.27%of eyes, 2.0D or more in 13.16% of eyes, and 3.0D or more in 3.75%of eyes.[15] Rashid etal showed that the percentage of pre-existing corneal astigmatism was 1D or less was in 69.6%, more than 1D and less than 1.5D in 27.6% and more then 1.5D and less then 2D in 2.8%.[1] Blasco T et al observed that 13.2% eyes had no corneal astigmatism, in 64.4% corneal astigmatism was between 0.25 and 1.25D and in 22.2% it was 1.5D or higher.[11] Our study shows similarity to studies done by Blasco etal and MA Rashid etal in observing corneal astigmatism to be upto 1.5 D in 64.4% and 69.6% respectively .[1,11]

The pattern of corneal astigmatism in our study was, with-the-rule (WTR) astigmatism in 44.4% (n=100) eyes, against-the-rule (ATR) astigmatism in 40.04% (n=91) eyes, oblique astigmatism in 12.9% (n=29) eyes and 2.2% (n=5) of the corneas were spherical**.** MA Rashid etal observed ATR astigmatism 79%, WTR astigmatism 17% and Oblique 4%.[1] Ante Ercegović etal[13] observed 1% eyes to have spherical corneas (No Astigmatism), 22% had WTR astigmatism, 45% had ATR astigmatism, and 32% had Oblique Astigmatism. X Yuan, etal have also observed WTR astigmatism in 30.36% of eyes, while ATR in 52.41% of eyes.[15]. Our study showed nearly equal number of eyes with WTR and ATR as our study group included patients from 16-90 years. Our study also had similar observations

like other studies that the mean corneal astigmatism increased with extremes of age.

Hoffmann PC etal reported astigmatism to be with the rule (WTW) in 46.8% of eyes, against the rule in 34.4%, and oblique in 18.9% in a largest population based study from Germany on biometric data[19] which is similar to our finding of WTR astigmatism which was 44.4% and oblique astigmatism was 12.9% . The other studies reported more of ATR as the prevalence of ATR astigmatism increases significantly with the age. It is well known that corneal astigmatism changes with age from WTR to ATR[20,21,22]. The cornea might change its flattest meridian toward the 90 degree axis with age[20]. In addition, changes in the crystalline lens as a consequence of aging, sclerosis and loss of transparency could also contribute to this shift from WTR to ATR.[11,19] Our study and M Isyaku etal study found that younger adults and the elderly generally exhibited higher values of astigmatism signifying that these group of patients probably require more attention in the preoperative assessment for corneal astigmatism before cataract surgery.[14]

18% of patients had astigmatism > 1.5 D and 65% had astigmatism between 0.25- 1.5D in our study, whereas Ante Ercegović etal have reported astigmatism equal to or higher than 1.0 DCyl in 31.6% and up to 40.4% in the study by Khan and Muhtaseb[13,23]. Hence, this level of residual astigmatism if not considered pre-operatively before cataract surgery will significantly influence the final postoperative refractive outcome, leaving the patient symptomatic with the need of additional correction. According to a recent study by Hayashi et al.[24], distance visual acuity decreases by more than 1 line when 0.50 DCyl is added to the best distance refraction. The same amount of astigmatism changes high-contrast visual acuity by approximately 1 logMAR line.[25] Therefore, reduction of astigmatism greater than 0.50 DCyl will noticeably improve visual acuity. Corneal astigmatism can be managed at the time of cataract surgery by positioning corneal incision on the steep axis of the cornea, using single or paired relaxing corneal or limbal incisions, and toric IOL implantation. Thus, preoperative assessment of corneal astigmatism is important for better visual satisfaction of the patient in this modern era of advanced technology even in developing country like Nepal.

Some limitations of this study include smaller sample size and non-measurement of posterior corneal astigmatism. Anterior corneal astigmatism though more significant, underestimates total corneal astigmatism by about 0.25–0.50 diopter.[6] Although manual keratometry is both accurate and reliable as a method of measuring corneal astigmatism, computerized corneal topography has over time become the gold standard[26] which was not used in this study .

Conclusion

Significant numbers of patients have preoperative corneal astigmatism of 1D or more which can affect the quality of vision after cataract surgery. This astigmatism is significantly seen in extremes of ages. As cataract blindness is still increasing, advances in technology have made patients more aware of their visual demands and the need for correction of corneal astigmatism. Hence, this study necessitates the importance of preoperative assessment of corneal astigmatism and methods to correct it for best visual results and patient satisfaction after cataract surgery.

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Conflict of interest: None

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