

# Association Between Optical Biometry, Demographics and Diabetes: A Retrospective Cross-Sectional Study Among Cataract Patients in Bangladesh

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## Abstract

**Introduction:** To assess gender, age, and diabetic status-associated differences in the ocular biometric parameters and demographics among patients presented for cataract surgery in a hospital setting.

**Methods:** This retrospective cross-sectional study analysed 1007 eyes undergoing cataract surgery at Chattogram Lions Charitable Eye Institute and Hospital, Bangladesh, between November 2023 and November 2024. Biometric parameters, axial length (AL) and keratometry (K) were measured using the IOL Master 700. Demographic and systemic variables (age, sex, diabetes status) were obtained from medical records. Associations were assessed using t-tests, ANOVA, Pearson correlations, and multivariate regression.

**Results:** The mean age of the cataract patients was  $60.9 \pm 10.6$  years; 53.1% were female. Mean AL was  $23.13 \pm 1.09$  mm, mean K1 was  $44.60 \pm 1.70$  D, and mean corneal astigmatism was  $0.89 \pm 0.52$  D. Males had significantly longer AL than females ( $23.40$  vs.  $22.99$  mm,  $p < 0.05$ ). Diabetes was associated with shorter AL, particularly in females. Keratometry values correlated negatively with AL ( $r = -0.36$ ,  $p < 0.001$ ). Astigmatism increased with age ( $p < 0.05$ ), with against-the-rule being more dominant in older and younger age groups. Females had significantly steeper corneas than males (mean difference  $0.74$  D,  $p < 0.05$ ).

**Conclusions:** Gender, diabetes, and corneal curvature were significant predictors of axial length, whereas age strongly influenced the type of astigmatism. These findings have direct clinical implications for IOL power calculation and emphasize the importance of incorporating demographic and disease-specific considerations into cataract surgery planning.

**Keywords:** Ocular Biometry, Axial Length, Keratometry, Astigmatism, Diabetes, Demographic Factors

## 1. Introduction

Cataract is the leading cause of preventable blindness and vision loss worldwide, with South Asia reporting the highest prevalence [1]. Globally, approximately 43.3 million people are blind, and 295 million suffer from moderate to severe visual impairment. As of 2020, cataracts were responsible for 39.6% of global blindness and 28.3% of moderate to severe visual impairment [2]. Phacoemulsification with intraocular lens (IOL) implantation is currently the standard and most effective technique of cataract management [3,4]. This method treats cataract through a surgical procedure, replacing the cataract with an intraocular lens (IOL) in the posterior chamber. Accurate measurement of IOL

using advanced biometry techniques is required to attain emmetropia and ultimately, achieve the desired refractive outcome [5,6]. Ocular biometry involves measuring the morphometric parameters of the eyes, including corneal curvature (keratometry), axial length, and anterior chamber depth [7]. The prediction of refractive error post-surgery also depends on the precise calculation of the biometric parameters. These measures are commonly correlated and may differ by age, gender, and race [8]. Cataract surgeons must be familiar with the normal range and interrelationships of biometric values, enabling them to identify outliers and potential measurement inaccuracies promptly [9].

Diabetes is a risk factor for cortical and posterior subcapsular cataracts due to its metabolic mechanisms [4]. In diabetes mellitus, the activation of the polyol pathway converts excess glucose into sorbitol, leading to osmotic stress and lens fiber degeneration. This process generates free radicals that damage lens proteins, while non-enzymatic glycation promotes protein aggregation and lens opacity [10]. Literature indicates that systemic diseases, such as diabetes, are associated with ocular biometry. A study in Turkey, however, did not show any statistically significant variation in axial length and corneal curvature between diabetic and non-diabetic patients [11]. Studies from the past decade suggest that optical biometry is associated with gender and age [12]. South African men have longer axial lengths than women, whose value gradually increases with age [13]. This finding is consistent with a retrospective study at Auckland Public Hospital involving 4,935 eyes [14]. On the other hand, keratometry values in rural Iranian populations vary by age and are generally higher in women and individuals with myopia [15]. A cross-sectional study among 10-11-year-old children found that South Asians have longer axial lengths compared to other ethnicities [16]. Although these findings are valuable, they are not directly comparable to the unique geography, culture, and ethnic composition of Bangladesh. A cross-sectional study conducted among 200 emmetropic eyes in Bangladesh revealed a negative correlation between axial length and corneal power; however, these findings may not be generalizable to the cataract population [17]. Since cataractous eyes constitute the primary population undergoing ocular biometry for surgical planning, there remains a lack of population-specific data on their biometric characteristics in Bangladesh.

Our study aims to investigate the impact of gender, age, and diabetic status on ocular biometric parameters and demographic characteristics in adults with cataracts. By understanding the relationship between axial length, corneal steepness, and astigmatism, we aim to identify patterns that are clinically relevant for eye care and surgical planning.

## 2. Methods

This retrospective cross-sectional study included 1007 eyes that underwent cataract surgery at Chattogram Lions Charitable Eye Institute and Hospital (Bangladesh) between November 2023 and November 2024. De-identified records were used in accordance with institutional policy, and no identifiable patient information was collected or disclosed. The study was approved by the Lions Eye Institute Ethical Review Board and conducted in compliance with the Declaration of Helsinki. Given the retrospective design and the use of de-identified data in the study, the Lions Eye Institute Ethical Review Board (Approval No. LEI/IRB/2025/11) waived the requirement for informed consent.

### 2.1. Participants

The eligible patients were aged 16 years or older with complete biometric measurements obtained using the IOL

Master 700. Exclusion criteria included corneal disease, dense cataract, opaque ocular media, or any anterior or posterior segment pathology that compromised image quality. Demographic and systemic data (age, sex, comorbidities) were extracted from medical records.

### 2.2. Data Collection

From hospital records, we retrieved the following information: age, sex, ethnicity, systemic disease history, axial length (AL), keratometry (K1, K2, mean K), corneal astigmatism (magnitude and axis), and intraocular lens power for emmetropia. Astigmatism was classified as with-the-rule ( $45^\circ$ – $135^\circ$ ) or against-the-rule ( $<45^\circ$  or  $>135^\circ$ ). Keratometry was expressed as K1 (flat) and K2 (steep), with the mean keratometry value being  $(K1 + K2)/2$ . Astigmatism magnitude was  $|K1 - K2|$ , and the axis was defined by K2. Partial coherence interferometry (refractive index 1.3375) and the SRK/T formula were used for IOL calculations.

### 2.3. Quality Control

The IOL Master 700 was calibrated daily according to manufacturer guidelines, with axial length and keratometry verified against a reference model.

### 2.4. Statistical Analysis

Data were entered into Excel and analyzed using SPSS (version 22.0, IBM, Chicago, IL, USA) and R Studio. Fifteen records (1.5%) with missing values were excluded after confirming that missingness was completely at random. Normality was tested using the Kolmogorov-Smirnov test. Continuous variables were summarized as mean  $\pm$  SD. Group comparisons used Student's t-test. Pearson's correlation was used to assess the association between age and AL. Associations of AL with ocular parameters were evaluated using univariate and multivariate regression. Differences across age groups were assessed using ANOVA for normally distributed data and the Kruskal-Wallis test for non-normally distributed data. Statistical significance was defined as  $p < 0.05$ .

## 3. Results

A total of 1007 patients (1007 eyes) were included. The mean age at surgery was  $60.9 \pm 10.6$  years (range, 16–95 years). Of these, 535 (53.1%) were female and 472 (46.9%) male. Surgery was performed on 602 eyes (59.7%) by phacoemulsification and 405 eyes (40.3%) by manual small-incision cataract surgery (SICS). A total of 515 right eyes (51.1%) and 492 left eyes (48.9%) were included in the study. Out of 1007 eyes, 992 had complete data for axial length and keratometry and were included in the correlation analysis. Among the cataractous eyes, only 13 were myopic ( $AL > 26.5$  mm).

### 3.1. Demographic and Clinical Characteristics

Table 1 summarizes the demographic, systemic, and biometric characteristics of the study population.

|                                             |                |     |
|---------------------------------------------|----------------|-----|
| Variable                                    |                | 386 |
| <b>Gender</b>                               |                | 387 |
| Male (%)                                    | 472 (46.9%)    | 388 |
| Female (%)                                  | 535 (53.1%)    | 389 |
| <b>Location</b>                             |                | 390 |
| Urban                                       | 382 (37.9%)    | 391 |
| Rural                                       | 601 (59.7%)    | 392 |
| Ethnic                                      | 22 (2.2%)      | 393 |
| <b>Ocular Biometry</b>                      |                | 394 |
| Axial Length (mm, mean± standard deviation) | 23.13 ± 1.09   | 395 |
| K1 (D, mean± standard deviation)            | 44.25 ± 1.57   | 396 |
| K2 (D, mean± standard deviation)            | 45 ± 1.62      | 397 |
| K (D, mean± standard deviation)             | 44.60 ± 1.70   | 398 |
| Age (Years, mean± standard deviation)       | 60.88 ± 10.637 | 399 |
| <b>Systemic diseases</b>                    |                | 400 |
| Diabetes (%)                                | 352 (35%)      | 401 |
|                                             |                | 402 |
|                                             |                | 403 |
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|                                             |                | 413 |

\*Data are presented as n (%) for categorical variables and mean ± standard deviation for continuous variables. K1 = Flat keratometry (diopters, D); K2 = Steep keratometry (D); K = Mean keratometry (D); AL = Axial length (mm).

**Table 1: Demographic and Clinical Characteristics of Study Participants (N = 1007)**

### 3.2. Association of Axial Length with Demographic and Clinical Variables

Univariate regression analysis using the Pearson correlation test showcased that axial length does not change with age. However, males had longer eyes than females (23.40 mm vs. 22.99 mm;  $p < 0.05$ ). Diabetes was associated with shorter AL; diabetic females had eyes on average 0.07 mm shorter than non-diabetic females. Male diabetics have a mean axial length of 23.15, while the average axial length of female diabetics is 22.92. K1 showed a strong negative correlation

with AL ( $r = -0.36$ ,  $p < 0.001$ ). In multivariate regression, K1 was the strongest predictor of AL, while gender and diabetes had a modest influence on the outcome. Patients with steeper corneas (higher keratometry values) had shorter AL, whereas flatter corneas were associated with longer AL.

### 3.3. Astigmatism Across Age Groups

Table 2 & 3 shows that in this sample, astigmatism in older adults is almost exclusively Against-The-Rule (ATR), with very few cases of With-The-Rule (WTR). As age increases,

ATR not only becomes more dominant but also tends to show slightly higher average astigmatism power. Figure 1:

| Age Group | Astigmatism Type and Frequency |      | Percentages of Astigmatism |      | Mean Astigmatism |       | Mean Astigmatism |
|-----------|--------------------------------|------|----------------------------|------|------------------|-------|------------------|
|           | WTR*                           | ATR* | WTR                        | ATR  | WTR              | ATR   |                  |
| 30-50     | 0                              | 171  | 0                          | 100  |                  | 0.789 | 0.789            |
| 50-60     | 3                              | 306  | 1                          | 99   | -0.267           | 0.658 | 0.650            |
| 60-70     | 6                              | 376  | 1.6                        | 98.4 | -1               | 0.755 | 0.727            |
| 70-80     | 1                              | 113  | .9                         | 99.1 | -0.5             | 1.03  | 1.02             |
| 80-100    | 0                              | 24   | 0                          | 100  |                  | 1     | 1                |

\*WTR = With-the-rule astigmatism; ATR = Against-the-rule astigmatism. Percentages denote the proportion of each astigmatism type within the specified age group.

**Table 2: Distribution of Astigmatism Type and Mean Values Across Age Groups**

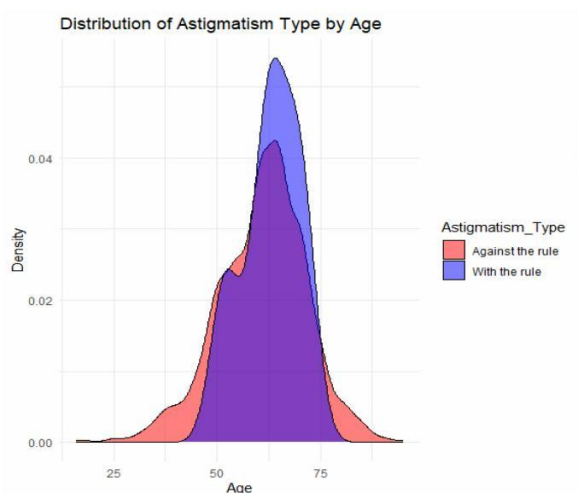


**Figure 1: Density Distribution of Astigmatism Types, with-the-Rule (WTR) and Against-the-Rule (ATR) Across Different Age Groups. The Blue Area Represents with-the-Rule Astigmatism, and the Red area Represents Against-the-Rule Astigmatism. A Predominance of ATR Astigmatism is Observed in Older Age Groups**

| Predictor                | Univariate $\beta$<br>(95% CI) | p-value | Multivariate $\beta$<br>(95% CI) | p-value |
|--------------------------|--------------------------------|---------|----------------------------------|---------|
| Age (years)              | -0.002 (-0.008 to 0.004)       | 0.42    | -0.001 (-0.007 to 0.005)         | 0.68    |
| Gender (male vs. female) | 0.41 (0.22 to 0.60)            | <0.001  | 0.38 (0.19 to 0.57)              | <0.001  |
| Diabetes (yes vs. no)    | -0.15 (-0.29 to -0.01)         | 0.03    | -0.12 (-0.26 to 0.02)            | 0.09    |
| K1 (D)                   | -0.36 (-0.42 to -0.30)         | <0.001  | -0.34 (-0.40 to -0.28)           | <0.001  |
| K2 (D)                   | -0.18 (-0.24 to -0.12)         | <0.001  | -0.10 (-0.16 to -0.04)           | 0.001   |

\* $\beta$  = regression coefficient; CI = confidence interval; K1 = flat keratometry; K2 = steep keratometry. Univariate analysis was performed using simple linear regression; multivariate analysis was adjusted for age, gender, and diabetes status.

**Table 3: Univariate and Multivariate Regression Analysis of Predictors of Axial Length (AL)**

### 3.4. Group Comparisons

No significant differences in axial length were found between urban, rural, and ethnic groups ( $F(2,987) = 1.40$ ,  $p = 0.25$ ,  $\eta^2 < 0.01$ ). Mean astigmatism did not differ significantly between males and females. The mean keratometry value in males is  $44.21 \pm 1.53D$ , while that in females is  $44.95 \pm 1.79D$ . However, keratometry values were significantly higher in females, who had, on average, steeper corneas than males by  $0.74D$  ( $p < 0.05$ ). A one-way ANOVA revealed that astigmatism varied significantly across different age groups. Astigmatism increased as the age group progressed from age group 50-60 to 60-70 and  $\geq 70$ . However, the astigmatism was significantly lower in the 51-60 and 61-70 age groups compared to the  $\leq 40$  group. Astigmatism was significantly higher in the age groups  $\geq 71$  years compared to those aged 51-60 and 61-70 years.

### 4. Discussion

While some research has explored ocular biometry in the Bangladeshi population, this is the first to analyze axial length, corneal curvature, and diabetes status among cataract patients in Bangladesh [17-19]. Our findings align with similar studies in other South Asian populations, highlighting the regional nuances of ocular parameters. The mean axial length observed in this study ( $23.13 \pm 1.09$  mm) is consistent with the findings from other global studies. The Ural Very Old Study in Bashkortostan, Russia, reported a mean axial length of  $23.1 \pm 1.1$  mm among individuals aged 85 and older [20]. However, the mean axial length in Pakistan ( $23.36 \pm 1$  mm) and Thailand ( $23.64 \pm 1.43$  mm) is slightly higher [21,22]. The average axial length of South African adults aged 10-66 years is comparatively lower ( $23.05$  mm

$\pm 0.98$  mm) [13]. The global average is reported at  $23.49 \pm 1.35$  mm [23]. Contrary to other studies in cataractous populations, the percentage of myopic eyes ( $AL > 26$  mm) was significantly lower (1.31%) in the current study [24]. These variations in axial length can be attributed to differences in study populations, measurement techniques, and sample sizes, stressing the importance of considering these factors in biometry studies.

Our study also found that men had longer axial lengths than women, which may be related to their generally greater height, as taller individuals tend to have longer axial lengths [25,26]. Tan et al. reported that every 10 cm increase in height results in a 0.30 mm increase in axial length [27]. A population-based cohort study found that axial length increases by 0.02 mm for every centimeter increase in height [20]. A Cameroonian clinical study also indicated that men had significantly longer axial lengths ( $24.01 \pm 0.88$  mm) compared to women ( $23.47 \pm 0.84$  mm), aligning with studies from India, Italy, and Australia [22,26,28-30]. A retrospective study in Korea found that older age was significantly associated with shorter axial length, also supported by De Bernardo [31,32]. Conversely, the current study found no significant association between age and axial length. Several confounding factors, such as refractive error, height, may compromise the internal validity of our findings. The relationship between age and ocular biometry can be pretty complex, requiring further validation through the adjustment of confounding factors in future studies. In the current study, diabetic eyes have shorter axial lengths. Interestingly, our findings align with a study by Amornpetchsathaporn et al, contrary to the general trend of

longer axial lengths observed in diabetic myopes [22]. The presence of subtle diabetic macular oedema (DME) might have affected globe length measurements. Given the high prevalence of diabetes in Bangladesh, future studies should stratify patients by the severity of diabetic retinopathy and DME to better understand this relationship.

The mean keratometric value in our study was  $44.60 \pm 1.70$  D, which is comparable to values reported in other studies of cataractous eyes [32]. The mean corneal curvature was found to be higher in China [24]. Our study confirmed previous findings that females have steeper corneas than males [22,29]. These biometric disparities may be the result of morphological variations such as height, weight, and hormonal differences between genders [29]. Understanding the difference in corneal curvature is crucial for toric IOL implantation, as it helps avoid overcorrection of ATR astigmatism and undercorrection of WTR astigmatism,

especially in male patients. These findings suggest the need for gender-specific approaches in IOL calculations, too.

The relationship between axial length and corneal astigmatism has been a topic of debate in the literature. A cross-sectional study among cataractous eyes found an inverse relation between ATR astigmatism and axial length in the UK [33]. Conversely, a study of 3,438 cataract patients in China reported that high axial length was associated with increased corneal astigmatism [34]. However, Han et al found no significant relationship between the axial length and astigmatism. The authors claim that their small sample size and focus on individuals with extreme axial lengths might limit the generalizability of these findings [35]. Our study, with a larger, more age-diverse population, did not observe any significant association, suggesting that other factors may contribute to the development of astigmatism in cataract patients.

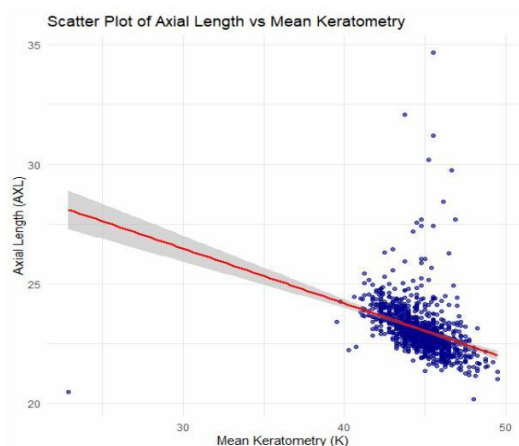


**Figure 2: Scatter Plot of Axial Length (AXL) Versus Mean Keratometry (K) with Fitted Regression Line (Red) and 95% Confidence Interval (Grey)**

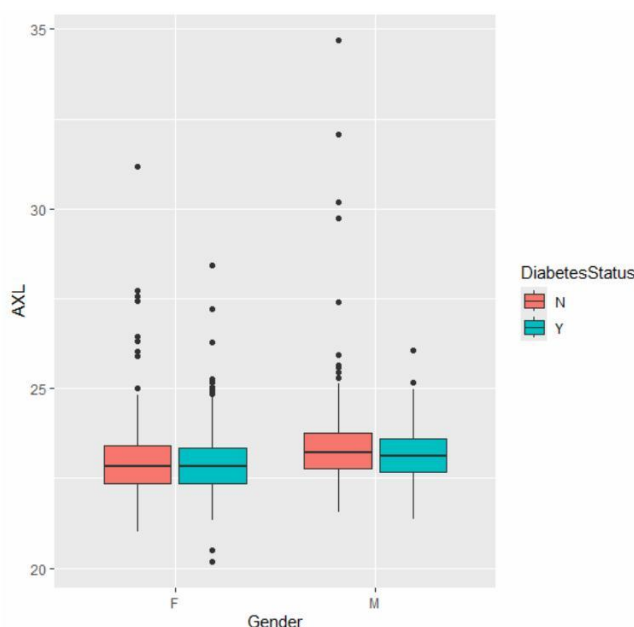


**Figure 3: Distribution of Axial Length (AXL) by Gender and Diabetes Status. Each Box Represents the Interquartile Range, with the Median Shown as a Horizontal Line. Outliers are Displayed as Individual Points. Red Boxes (n) Indicate Non-Diabetic Participants, and Blue Boxes (y) Indicate Participants with Diabetes. AXL= Axial Length**

The current study shows a non-linear association between astigmatism and age. In the current study, against-the-rule astigmatism is more dominant, and elderly males exhibited a higher prevalence of ATR astigmatism, aligning with the findings by De Bernardo age-related changes in corneal curvature, such as the shift toward against-the-rule (ATR) astigmatism, may be due to physiological mechanisms including decreased eyelid pressure, reduced tension in extraocular muscles, and degenerative changes in corneal tissue [25,36]. Finally, our study found a negative correlation between axial length and keratometry, consistent with findings from Kim. A similar correlation has been reported in other studies of older populations with shorter axial lengths [35]. This inverse relationship supports the concept of emmetropization, where corneal curvature adapts to axial length during childhood and stabilizes with age [8,29]. This highlights the significance of understanding refractive changes in older adults and considering both axial length and corneal curvature in cataract surgery planning.

Given the retrospective nature of this study, its limitations include the potential inclusion of eyes with ocular comorbidities, particularly in patients under 50 years of age. Due to the availability of limited data, other confounding variables such as height, BMI, and education level were excluded, which does not confirm the results as a causal relationship. The inclusion of other biometric parameters, such as Lens Thickness (LT) and Anterior Chamber Depth (ACD), could have enabled a deeper subgroup analysis. Future prospective population-based studies, including additional sociodemographic factors, are necessary to confirm these findings and further explore the interplay between ocular biometry and systemic conditions. The current study was conducted in a charitable hospital located in the largest division of Chattogram, which attracts patients from the central city, the hills, and the remote, rural areas. Thus, the likelihood that the findings are representative of the study population and their generalizability is high. The variations observed in the present study highlight the importance of considering demographics during ophthalmic assessments to diagnose and treat refractive errors and ocular comorbidities accurately.

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