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Original Article

Analysis of Corneal Astigmatism with NIDEK Axial Length Scan in Caucasian Cataract Surgery Candidates

R Duman, R Duman, E Çetinkaya, MC Sabaner, S İnan, M Doğan, İ Doğan[1]

Departments of Ophthalmology and [1]Clinical Biostatistics, School of Medicine, Afyon Kocatepe University, Afyonkarahisar, Turkey

Abstract

Aims and Objectives: The aim of the study was to analyze and quantify the pattern of corneal astigmatism in Caucasian cataract surgery patients using a new optical biometer (axial length [AL] Scan, NIDEK Co., Gamagori, Japan). **Patients and Methods:** The datasets of cataract surgery patients acquired between March 1, 2014, and April 15, 2016, were collected and analyzed. The corneal power (flat keratometry, steep keratometry, and mean keratometry), negative cylinder power, and axis of astigmatism were recorded. Keratometry values were optically measured by optical low coherence interferometry (AL-Scan, NIDEK Co., Ltd.,) before cataract extraction. **Results:** The study comprised 1233 eyes of 838 consecutive cataract candidates with a mean age of 66.8 ± 10.7 years (range 40–97 years). The mean keratometry value and corneal astigmatism were 43.69 ± 1.61 D and 0.84 ± 0.70 D, respectively. Corneal astigmatism of 1.00 D or greater was found in 344 eyes (27.9%), and 548 eyes (44.4%) had against-the-rule astigmatism. A trend toward decreasing J0 and J45 with age was found by linear regression models. The per-year increase in age was associated with a J0 and J45 decrease of 0.002 D and 0.001D, respectively. **Conclusion:** This study provides the distribution of astigmatism axis and power for cataract patients in age subsets from Turkey.

Keywords: *Astigmatism, Cornea, NIDEK axial length-scan, optical biometer*

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Introduction

Obtaining accurate measurements of anterior segment parameters is essential for intraocular lens (IOL) power calculation in cataract surgery to achieve the best refractive outcomes. Modern optical biometry devices measure anterior segment parameters such as keratometry (K), axial length (AL), anterior chamber depth (ACD), and horizontal white-to-white (WTW). The AL-Scan (NIDEK Co., Ltd.) is a modern optical biometry device that uses the principle of optical low coherence interferometry (OLCI). Optical biometry devices that use the principle of low coherence interferometry were found to be more reproducible and repeatable than ultrasound biometry devices.[1-6]

The prevalence of regular corneal astigmatism in the different cataract population has been reported by teams from the United States,[1] Europe,[2-3] and Asia.[4-6] However, to our knowledge, there is no large series of corneal astigmatism measurements with OLCI in the literature in a Caucasian cataract population. The purpose of this study was to evaluate and quantify the pattern of corneal astigmatism as measured using the AL-scan optical biometric device in healthy cataract patients.

Patients and Methods

In this retrospective study, patient datasets were acquired between March 1, 2014 and April 15, 2016, at the Department of Ophthalmology, Afyon Kocatepe University. The Bursa Yüksek Ihtisas Hospital's Ethics Committee approved the study. The criteria for inclusion were cataract

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Address for correspondence: Dr. R Duman, Department of Ophthalmology, School of Medicine, Afyon Kocatepe University, Afyonkarahisar, Turkey.
E-mail: drrahmi42@yahoo.com

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and age 40 years or older. The exclusion criteria were ocular surface disorders, corneal disease, previous corneal surgery, contact lens wear, history of ocular trauma, and inflammation. The patients were divided into five groups on the basis of age as follows: 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years and older.

Corneal astigmatism of the patients was divided into three groups on the basis of the axis of correcting minus cylinder. Corneal astigmatism was designated as with-the-rule (WTR) when the axis of correcting minus cylinder was within 180° ± 30°, against-the-rule (ATR) when the correcting minus cylinder axis was within 90° ± 30°s, and oblique if it was neither WTR nor ATR [Figure 1].[1]

Measurement device and technique

Measurements were taken with the NIDEK AL-Scan (NIDEK Co., Gamagori, Japan). The AL-Scan relies on a OLCI technique and uses low coherence superposition of light waves emitted from an 830 nm super luminescent diode to measure the AL of the eye within the range 14–40 mm. Corneal power was measured by analyzing the images of double-mire rings projected onto the cornea at the 2.4 mm zone and 3.3 mm zone (360°C).[7,8] In this study, the flattest K, steepest K, and mean K measurements of 2.4 mm zone recorded. Measurements were performed according to their respective manufacturer's guidelines. The patients were instructed to fixate on an internal fixation target within the device. Only high-quality measurements were included in the subsequent analysis.

The measurements were routinely performed by two trained doctors between 10 am and 5 pm. Three measurements were performed in each eye, and the values were averaged. Five major parameters (flat K, steep K, mean keratometry, negative cylinder power, and axis of astigmatism) were recorded.

Statistical analysis

Statistical analyses were performed using SPSS software (version 16; SPSS Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant. Distributions of normality of the ocular biometric parameters were checked with Kolmogorov–Smirnov test ($P > 0.05$).

Differences between groups were compared using an unpaired *t*-test or analysis of variance for normally distributed variables and a Mann–Whitney U-test or Kruskal–Wallis test for nonnormally distributed variables. Bivariate correlations were evaluated using Pearson or Spearman rank correlation coefficient for nonnormally distributed variables.

The power vector method, J0 and J45 values, and linear regression models were used to assess the association between age and astigmatism. The power vector method was used to assess the quantitative relationship between astigmatism and age. This method was described by Thibos *et al*.[9] and the following formulas were applied: J0 = (−C = 2) cos2α, J45 = (−C/2) sin2α, where C is the negative cylinder power, α is the cylinder axis, and J is the Jackson astigmatic vectors. The J0 value is the cylinder power set at the 90°C and 180°C meridians. A positive J0 value indicates WTR astigmatism and a negative J0 value, ATR astigmatism. The J45 value refers to a cross-cylinder set at 45°C and 135°C, representing oblique astigmatism.[10]

Results

The study evaluated 1233 eyes of 838 consecutive cataract patient datasets. Three hundred and ninety-five patients' bilateral eyes are concluded in this study. The mean age of the 490 men (58.5%) and 348 women (41.5%) was 66.8 ± 10.7 (range 40–97). Table 1 summarizes the measured parameters: corneal power (flat K, steep K, and mean K), negative cylinder power, and axis of astigmatism. The distributions of corneal power (K1, K2, and mean K) were normal ($P > 0.05$).

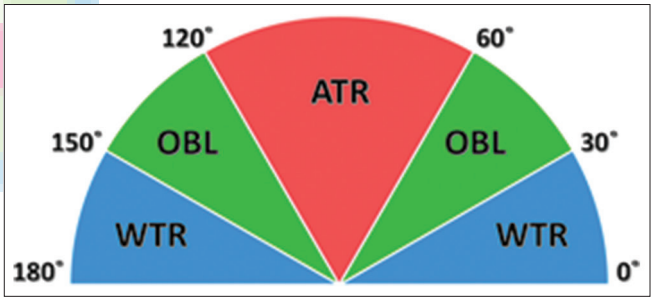

Figure 1: Diagram of the definitions for with-the-rule, against-the-rule, and oblique astigmatism. (ATR = Against-the-rule; WTR = With-the-rule; OBL = Oblique)

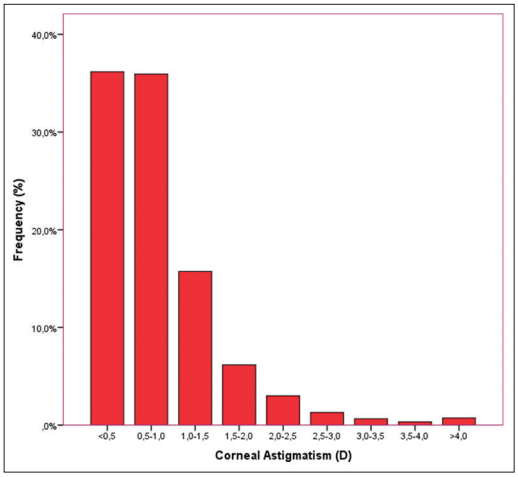

Figure 2: Corneal astigmatism distribution in 0.50 D steps in the entire sample (1233 eyes)

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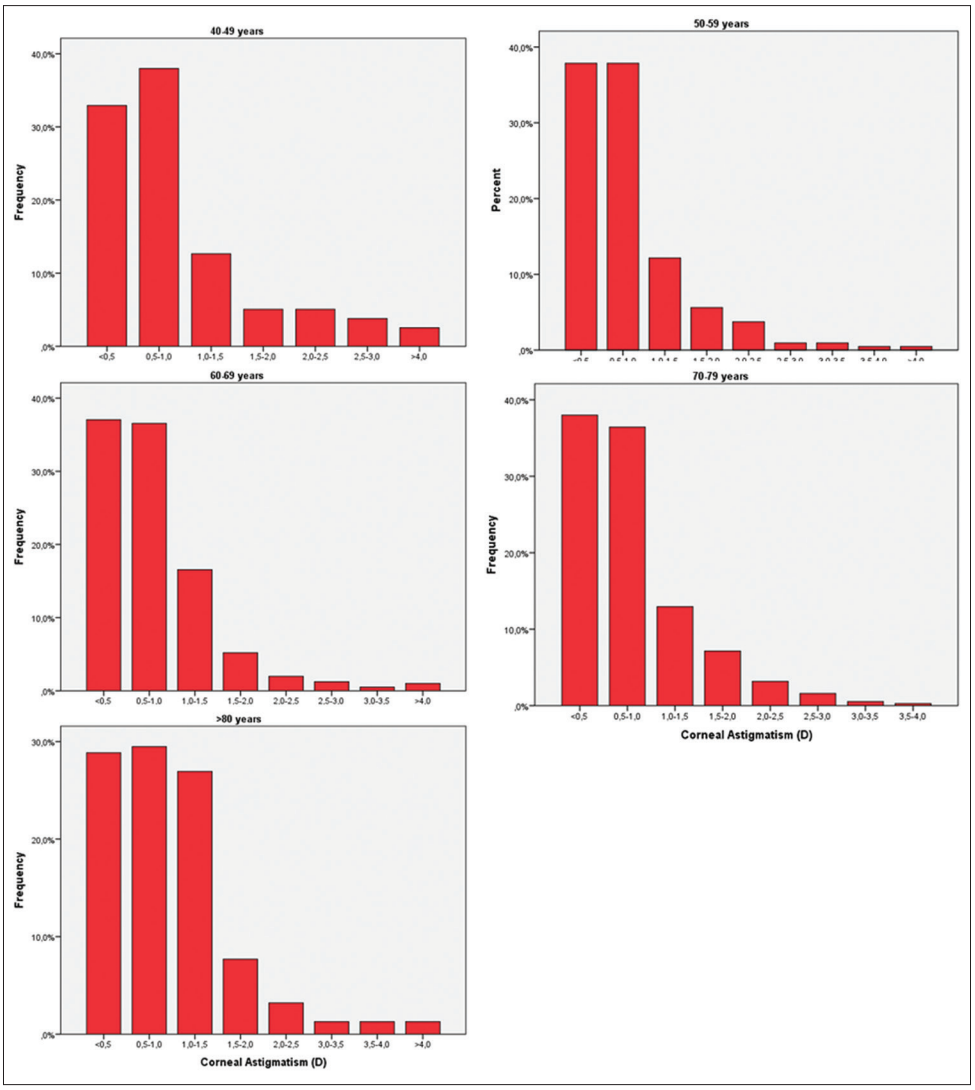

Figure 3: Frequency distribution of corneal astigmatism in 0.50 D steps for the 5 age groups

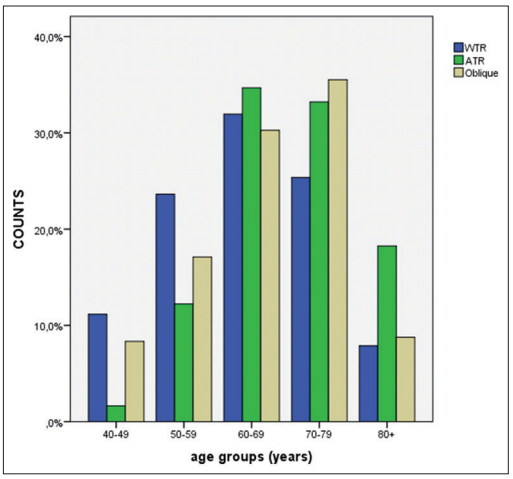

Figure 4: Frequency distribution of the astigmatism axis in five age groups

Figure 2 summarizes the percentage of eyes by level of corneal astigmatism. Results revealed that 72.1% of eyes had corneal astigmatism equal to or lower than 1.00 D,

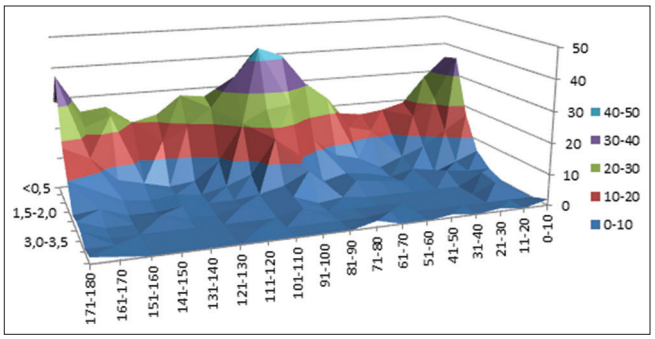

Figure 5: Frequency of corneal astigmatism in all eyes

24.9% of eyes have corneal astigmatism between 1 and 2.5 D, and 24.9% of eyes had astigmatism of 2.50 D or higher.

Figure 3 summarizes the percentage of the distribution of corneal astigmatism in 0.50 D in each group. The number of eyes in the five age groups was as follows: 40–49 years - 79 eyes, 50–59 years - 214 eyes, 60–69 years - 405 eyes, 70–79 years - 379 eyes, and 80 years - older 156 eyes.

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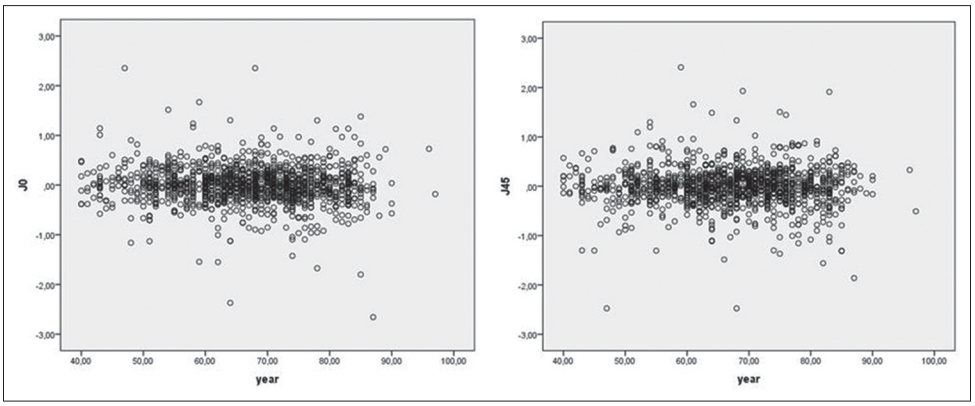

Figure 6: The J0 against age in all eyes (ß = 0.002, *P* = 0.029) and J45 against age in all eyes (β = 0.001, *P* = 0.303)

Table 1: Distribution of ocular biometric parameters

Characteristic	Value
K (D)	
Mean±SD	43.69±1.61
Min-Max	35.79, 48.49
K1 (D)	
Mean±SD	43.30±1.64
Min-Max	35.41, 48.21
K2 (D)	
Mean±SD	44.15±1.68
Min-Max	36.21, 54.61
Corneal astigmatism (D)	
Mean±SD	0.84±0.70
Min-Max	0.00, 6.49
Astigmatism angle	
Mean±SD	92.84±52.08
Min-Max	0.00, 180.00
J0	
Mean±SD	−0.0005±0.38
Min-Max	−2.66, 2.35
J45	
Mean±SD	−0.0065±0.39
Min-Max	−2.47, 2.41

K=Mean keratometry; K1=Flat keratometry; K2=Steep; CLY=Cylinder power; Angle=Axis of astigmatism

Figure 4 summarizes the frequency of the astigmatism axis in the five age groups. Regarding the distribution of the astigmatism axis, 457 eyes (37.1%) had WTR astigmatism, 548 eyes (44.4%) had ATR astigmatism, and 228 eyes (18.5%) had oblique astigmatism.

Figure 5 summarizes the amount of astigmatism for each meridian (rounded to 5°C). Figure 6 is the scatterplots of J0 and J45, respectively, against age in eyes. Linear regression analyses showed that the J0 and J45 value significantly decreased with age. JO and J45 decrease with age; a per-year decrease in age was associated with a decrease of 0.002 D of J0 (95% confidence interval [CI],−0.004-0.00; *P* = 0.029) and a decrease of 0.001 D of J45 (95% CI,−0.003-0.01; *P* = 0.303).

Table 2: Summary of clinical studies of prevelance of astigmatism in cataract patients

	Eyes/ patients	Mean Keratometry	Corneal astigmatism
Khan[2]			
	1230/746	43.43±1.486 D Flat 44.46±1.562 D Steep	1.03±0.728
Ferrer-Blasco[3]			
	4540/2415	43.48±1.61 D Flat 44.08±1.59 D Steep	0.90±0.93
Guan			
	1430/827	43.57±1.56 D Flat 44.64±1.65 D Steep	1.07±0.73
Cui			
	6750/4561	44.13±1.63 D 43.57±1.69 D Flat 44.69±1.69 D Steep	0.90 ±
Chen			
	2849/4831	43.76±1.53 D Flat 44.76±1.56 D Steep	1.01±0.69
Ünlü			
	219/219	43.53±1.56 D 43.43±1.81 D Flat 44.43±1.87 D Steep	1.00±0.96
Present			
	1233/838	43.69±1.61 D 43.30±1.64 D Flat 44.15±1.68 D Steep	0.84±0.70

Discussion

The management of astigmatism is an important topic for cataract surgeons. This problem has led to an increasing number of toric IOL options. For accurate toric IOL implantation, the prevalence of regular corneal astigmatism in the different cataract population is important to manufacturers. Since 2009, biometry measurements have been frequently performed with the IOL Master (Carl Zeiss Meditec) based on partial-coherence interferometry (PCI) and other devices based on OLCI such as the Lenstar (Haag-Streit AG),

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the AL-Scan (NIDEK Co. Ltd.), the Galilei G6 (Ziemer), and the Aladdin (Topcon EU, Visia Imaging). Previous studies have shown that the PCI and OLCI provide similar measurements.[11-14]

The AL-Scan is a new optical biometry that combines optical interference and the Scheimpflug principle to perform ocular measurements including central corneal thickness, ACD, AL, K values, flat K, steep K, and WTW distance. There are many reports in the literature of the epidemiology of corneal astigmatism and biometry data in different ethnicities; however, no Caucasian study has yet been done. Here, we assessed the prevalence and distribution of different axis and types of corneal astigmatism in our population. Table 2 summarizes a comparison of our study and several other studies from different countries.

Our mean astigmatism value is 0.84 D and is lower than the value reported by Khan and Muhtaseb,[2] Ferrer-Blasco *et al*.,[3] Mohammadi *et al*.,[4] Prasherand Sandhu,[5] Yuan's *et al*.,[6] and Ünlü *et al*.[15] Although the mean keratometry values are different from each other in different ethnic studies, our mean flat and steepest keratometry values are lower than the values from Khan and Muhtaseb,[2] Mohammadi *et al*.,[4] Prasher and Sandhu,[5] Yuan's *et al*.,[6] Ünlü *et al*.,[15] and Chen *et al*.[16]

In our population, the astigmatism axis was predominantly ATR (44.4%), and the frequency of ATR astigmatism increased with age. These results agree with those in previous studies.[1-4,17,18] Read *et al*.[19] determined that with increasing age, there is a shift in the axis of astigmatism from a predominance of WTR astigmatism (in adults younger than 40 years) to a predominance of ATR astigmatism (in adults older than 40 years). This shift may be related to the changes in the corneal tissue structure, reduction in pressure of the eyelids, extraocular muscle tension, visual feedback, and the effects of intraocular pressure on the curvature of the cornea.[19]

We found that 27.9% of cataract patients had corneal astigmatism of 1.00 D or more, which is lower than the results reported by Ferrer-Blasco *et al*.[3] (35%) and Khan and Muhtaseb[2] (40.41%), as well as Hoffmann and Hütz,[1] (36%). In Turkey, 12.2% of all eyes are potential candidates for toric IOL (1.5 D and more than astigmatism).

Ferrer-Blasco *et al*.[3] and Liu *et al*.[10] found that corneal J0 value decreased significantly for every 10 years with a mean decrease of approximately 0.15 D ($P = 0.001$) and 0.017. In our study, a significant reduction in both J0 and J45 values (J0 and J45 decrease of 0.002 D and 0.001D) was detected less than seen in these other studies.

This study had only one limitation. Multicenter studies with different localizations from our country may be more valuable in this aspect.

Conclusion

We report astigmatism data in a large sample of the patients before cataract surgery. Our reports into the prevalence of the axis and power of corneal astigmatism are an important normative reference for Caucasian ophthalmologists and help with planning in the toric lens manufacturing industry.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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