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Biometric parameters, corneal astigmatism and ocular comorbidity in cataract surgery patients

Aistė Varoniukaitė[1], Laurita Vaičaitė[1], Loreta Kuzmienė[2]

[1]Faculty of Medicine, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania
[2]Department of Ophthalmology, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania

ABSTRACT

Introduction: Evaluation of corneal astigmatism, biometric parameters and ocular comorbidities are of great importance before cataract surgery in order to plan and select intraocular lense and achieve the best postoperative visual function.

Aim: To evaluate biometric parameters, analyze the distribution and prevalence of magnitude, orientation and age-related changes of corneal astigmatism as well as ocular comorbidity prevalence in cataract surgery patients.

Methods: The retrospective study included case histories of 422 patients (502 eyes) examined before cataract surgery. Data of demographics, biometric parameters, corneal astigmatism, visual acuity and ocular comorbidities were analyzed. P value <0.05 was considered statistically significant.

Results: The mean age was 71.68 ± 9.77 y. The AL was 23.40 ± 1.36 mm and ACD was 3.01 ± 0.45 mm. Higher AL and lower keratometry values were observed in male patients. The overall astigmatism was 0.80 ± 0.75 D. A significant correlation was determined between ACD and age, AL and, ACD and corneal astigmatism. The magnitude of astigmatism was > 1.0 D in 23.3% of cases. < 1.0 D corneal astigmatism magnitude was significantly more common in older patients. The most frequent orientation of corneal astigmatism was against-the-rule astigmatism (56.9%). The rate of WTR astigmatism significantly decreased with the older age, while ATR and OB rate increased. Mean preoperative BCDVA was 0.31 ± 0.25 D. Ocular comorbidities were present in 48.6% of cases, with glaucoma being the most frequent one (31.3%).

Conclusions: almost a half of cataract surgery patients present ocular comorbidities and one-fifth have corneal astigmatism > 1.0 D. The results are important to consider before surgery and analyze the demand of toric IOLs.

Keywords: corneal astigmatism, cataract surgery, biometric parameters, ocular comorbidity

INTRODUCTION

The prevalence of cataract is constantly growing as the life expectancy increases. As the result, cataract surgery with ultrasound phacoemulsification and intraocular lens (IOL) implantation has become the most common elective surgery worldwide [1]. Evaluation of biometric parameters and corneal astigmatism plays a pivotal role in cataract surgery and identifying ocular comorbidities are of great importance in predicting the postoperative visual function. Ocular biometric parameters such as axial length (AL), corneal power (K1 and K2), and anterior chamber depth (ACD) are known to vary with gender, age, and ethnicity [2]. Optical biometers are used for evaluating axial lenght, keratometry, corneal topography and even wavefront analyses. These data are used for planning cataract surgery and selecting IOL [3]. It has been reported that between 15% and 50% of cataract patients have from 1 diopter (D) to 2 D corneal astigmatism [4]. Both preoperative and residual postoperative corneal astigmatism impair visual function and vision-related quality of life, which may result in increased humanistic burden, such as continuous need for vision correction with spectacles [5]. Toric intraocular lens (IOL) implantation can correct pre-existing corneal astigmatism in patients undergoing cataract surgery [4] and demonstrate better results in visual acuity (VA) or residual astigmatism comparing with non-toric IOLs [6]. However, the demand of toric IOL is still not evaluated in Lithuania.

METHODS

The retrospective study included case histories of patients examined before scheduled cataract surgery in Lithuanian University of Health Sciences (LUHS), Department of Ophthalmology, reviewed and analyzed from January 1, 2017 till March 1, 2017.

Data from outpatient case histories was collected: demographics (gender, age), ocular comorbidities (OC), preoperative visual acuity (VA), best-corrected distance visual acuity (BCDVA, decimal), axial length (AL, mm), flat (K1, diopter) and steep (K2, diopter) keratometry, axis (AX, °), magnitude of corneal astigmatism (diopter) and anterior chamber depth (ACD, mm). After keratometric data evaluation orientation of corneal astigmatism was defined as with-the-rule (WTR), when steep corneal curvature was 90° ± 30°, against-the-rule (ATR) - 180° ± 30°and oblique astigmatism (OB) - 120° - 150° or 30° - 60°. Patients were divided into age groups: <60 years (y), [61-70] y, [71-80] y, > 81y. BCDVA was evaluated and divided into 3 groups: ≤ 0.1, (0.1-0.4] , > 0.4.

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Statistical analysis was performed with MS Excel 2010 and IBM SPSS 22.0. Basic characteristics presented in percentage (%). Descriptive statistical data results were described as mean ± standard deviation (SD). Kolmogorov-Smirnov test was used to test normality of data. Comparisons were made using Stjudent t-test, Chi square tests and Mann-Whitney test for nonparametric data. Spearman's correlation analysis was used to determine correlations. P value < 0.05 was considered statistically significant.

RESULTS

In the study, data of 502 eyes of 422 patients (324 (64.5%) women and 178 (35.5%) men with no difference between gender, p=0.174) were analyzed.

The mean age of the patients was 71.68 ± 9.77 y (range 36-90 y). The distribution of eyes in age groups as shown in Figure 1 was determined as follows: ≤ 40y - 5 eyes (1.0%), 41-50 y – 12 eyes (2.4%), 51-60 y – 55 eyes (10.9%), 61-70 y – 100 eyes (20.0%), 71-80 y – 226 eyes (45.0%), ≥ 81 y – 104 eyes (20.7%).

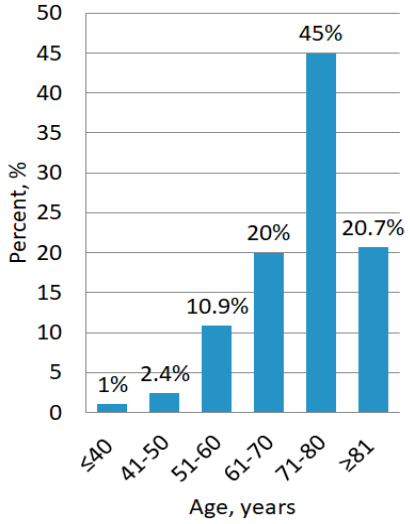


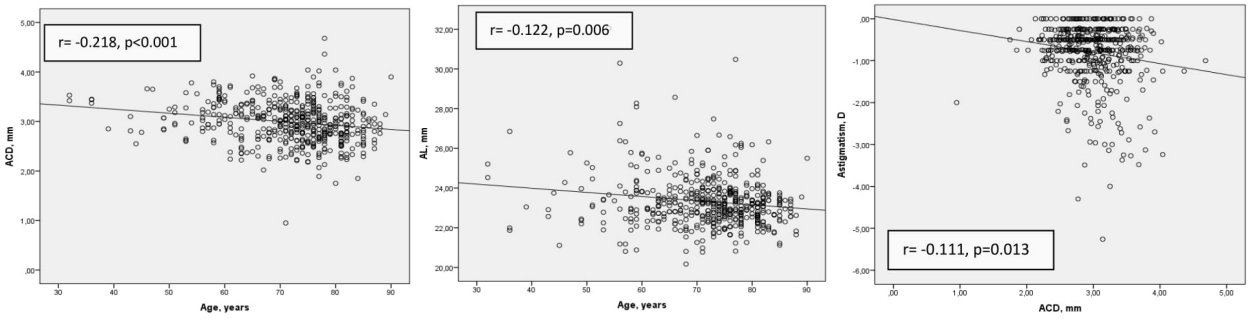
Figure 1. The distribution of patients according to age.

The differences in characteristics of biometric parameters between male and female patients are shown in Table 1. The mean AL was 23.40 ± 1.36 mm (range 20.17 - 28.27) with AL being significantly higher in men, than women (23.66 ± 1.34 and 23.15 ± 1.29 mm respectively, p<0.001) and the mean ACD was 3.01 ± 0.45 (range 0.95 - 4.04), without gender differences.
The mean K1 value was 43.53 ± 1.42 (range 38.35 - 47.25) and K2 - 44.41 ± 1.53 (range 39.04 - 48.18), gender-dependent. Mean corneal astigmatism was 0.80 ± 0.75 D (range 0.00 - 5.26 D), with no significant difference between male and female in the examined population (p=0.659).

	All patients(n=502)		Female (n=324)	Male (n=177)	p value
Parameter	Mean ± SD	Range	Mean ± SD	Mean ± SD	
AL (mm)	23.40 ± 1.36	20.17 - 28.27	23.15 ± 1.29	23.66 ± 1.34	**<0.001**
ACD (mm)	3.01 ± 0.45	0.95 - 4.04	2.97 ± 0.40	3.02 ± 0.46	0.182
K1 (D)	43.53 ± 1.42	38.35 - 47.25	43.67 ± 1.42	43.24 ± 1.46	**0.001**
K2 (D)	44.41 ± 1.53	39.04 - 48.18	44.46 ± 1.48	44.02 ± 1.51	**0.002**
AX (°)	70.55 ± 62.94	0.00 - 180.00	69.71 ± 63.29	76.11 ± 56.06	0.076
Astigmatism (D)	0.80 ± 0.75	0.00 - 5.26	0.80 ± 0.75	0.81 ± 0.75	0.659
VA (D)	0.21 ± 0.18	0.01 - 0.80	0.21 ± 0.17	0.20 ± 0.19	0.147
AL = axial length, ACD - anterior chamber depth, K1 - flat meridian, K2 - steep meridian, AX = axis. VA - visual acuity. P values <0.05 show significant difference between genders.					

Table 1. The differences in characteristics of biometric parameters between genders.

A significant negative correlation was determined between ACD and age (r= -0.218, p<0.001), AL and age (r= -0.122, p=0.006), ACD and corneal astigmatism (r= -0.111, p=0.013), as shown in Figure 2.1 - 2.3.



2.1 2.2 2.3

Figure 2.1 - 2.3. Correlations between parameters.

The distribution of astigmatism groups was not significant between gender groups (p=0.179) and comprised as follows (Figure 3): 0 D – 52 eyes (10.4%), (0-0.5] D – 191 eyes (38.0%), (0.51-1] D – 142 eyes (28.3%), (1-1.5] D – 64 eyes (12.7%), (1.5-2] D – 16 eyes (3.2%), (2-2.5] D – 15 eyes (3.0%), (2.5-3] D - 11 eyes (2.2%) and more than 3.0 D - 11 eyes (2.2%). 23.3% of all patients had corneal astigmatism >1.0 D.

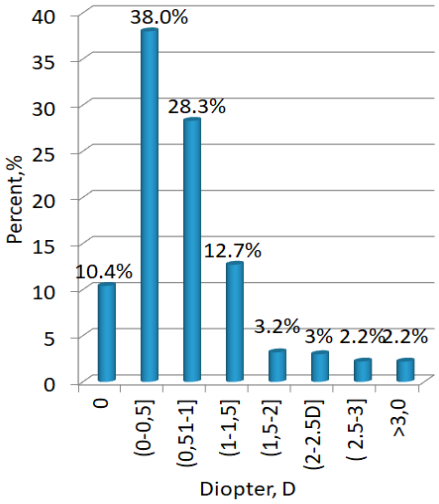


Figure 3. The distribution of astigmatism ranges.

The magnitude of corneal astigmatism 1.0 D or below was significantly (p=0.002) more common in older patients groups: 61-70 y; 71-80 y; ≥ 81 y (75.0, 81.4 and 78.8% respectively). 41.7% of operated patients 60 y or younger had > 1.0 D astigmatism, while in older groups - 25%, 18.6%, 21.2%, respectively (Figure 4).

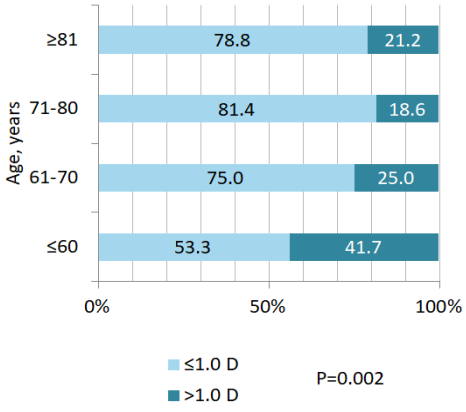


Figure 4. Astigmatism prevalence among age groups.

Regarding the distribution of the astigmatism axis, WTR astigmatism was found in 134 (26.9%) eyes, ATR – 284 (56.9%), OB – 81 (16.2%), n=499. With the older age, the rate of WTR astigmatism decreased, while the rate of ATR and OB astigmatism increased. In patient group 60 y or younger WTR astigmatism comprised 65.0%, 61-70 y - 91.0%, in 71-80 y group decreased to 63.0% and in 81 y or older group - 27.0%. In the oldest age group ATR astigmatism was 54.0% (Figure 5).

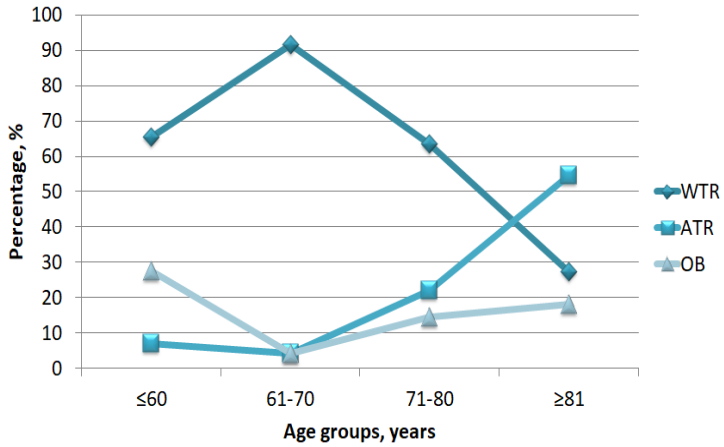


Figure 5. Distribution of with-the-rule (WTR), against-the-rule (ATR), and oblique (OB) astigmatism in different age groups.

51.4% of analyzed cases had no ocular comorbidities (OC). OC was diagnosed in 48.6% of patients, with frequencies as follows: 31.3% - glaucoma, 10.8% - age-related macular degeneration (AMD), 4.8% - diabetic retinopathy (DR), 11.8% - other diseases (Figure 7). Most eyes (39.0%) was diagnosed with only one OC, while 2 comorbidities accounted for 9.2% and 3 - 0.4%. Age groups had a significant difference in increasing rate of OC: the number of glaucoma cases increased in 71-80 y aged group, meanwhile AMD in 71-80 y and ≥ 81 y both groups.

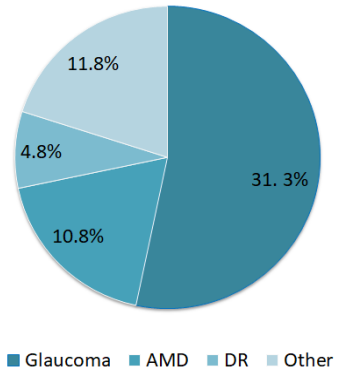


Figure 7. The frequency of ocular comorbidities. AMD - age-related macular degeneration, DR - diabetic retinopathy, other - other ocular comorbidities.

Mean preoperative VA was 0.21 ± 0.18 D. Mean preoperative BCDVA was 0.31 ± 0.25 D. BCDVA groups comprised as follows: ≤ 0.1 D - 32.5%, (0.1-0.4] D - 43.3%, >0.4 D - 24.2%, with no statistically significant difference in preoperative BCDVA between eyes with and without OC.

Table 2. Comparison of the publications

Parameter	Present study	Ferreira et al [2]	Bernardo et al [8]	Collier et al [9]	Nemeth et al [10]	Mohammadi et al [11]	Prasher and Sandhu [12]	Yu et al [13]	Curragh and Hassett [14]
Country	Lithuania	Portugal	Italy	United Kingdom	Hungary	Iran	India	China	Northern Ireland
Publish year	2018	2017	2014	2016	2013	2016	2017	2017	2017
Eyes/ patients, n	502/ 422	6506/ 6506	757/ 380	2247/ 2247	1092/ 675	2156/ 1317	2502/ 2312	3209/ 2821	2080/ 1788
Age, mean±SD	71.68±9.77	69±10	71.89±10.19	72.28±13.84	69.64±15.25	64.92±11.48	59.54±10.96	70.51±9.81	75.20±10.57
Male/ female, n	178/ 324	2785/ 3721	176/ 204	ND	399/ 276	609/ 708	1152/ 1160	1071/ 1750	805/ 1228
K1, mean±SD	43.53±1.42	ND	43.54±1.43	43.18±1.64	43.53±1.56	43.70±1.70	43.87±1.92	43.75±1.59	43.09±1.61
K2, mean±SD	44.41±1.53	ND	44.56±1.52	44.29±1.70	44.43±1.59	44.83±1.79	44.91±1.88	44.84±1.65	44.16±1.62
AL, mm	23.40±1.36	23.8 ±1.55	ND	23.99±1.85	23.32±1.49	23.33±1.37	ND	24.38±2.47	ND
ACD, mm	3.01±0.45	3.25±0.44	ND	3.08±0.52	3.17±2.03	ND	ND	3.15±0.48	ND
Corneal astigmatism, mean±SD	0.80±0.75	1.08±0.84	1.02±0.69	1.11±0.88	0.89±0.72	1.12±1.10	1.04±1.04	1.09±0.77	1.09±0.83
Corneal astigmatism ranges, n (%)									
≤0.5 D	243 (48.4)	ND	177 (23.4)	503 (22.4)	255 (23.38)	503 (23.3)	ND	680 (21.19)	521 (25)
>0.5 D	259 (51.6)	ND	580 (76.6)	1744 (77.6)	837 (76.62)	1653 (76.7)	ND	2529 (78.81)	1559 (75)
>1.0 D	117 (23.3)	1415 (43.5)*	313 (41.36)	993 (44.2)	358 (32.76)*	1038 (48.1)	716 (28.62)*	1407 (43.85)*	859 (41.3)
≤1.0 D	385 (76.7)	5091 (56.5)	444 (58.64)	1254 (55.8)	734 (67.24)	1118 (51.9)	1786 (71.38)	1802 (56.15)	1221 (58.7)
Types of corneal astigmatism, n (%)									
WTR	134 (26.9)	1077 (33.1)	333 (44)	ND	585 (53.3)	796 (36.9)	709 (28.34)	1186 (36.96)	ND
ATR	284 (56.9)	1513 (46.5)	294 (39)	ND	309 (28.3)	1010 (46.8)	1298 (51.88)	1535 (47.83)	ND
OB	81 (16.2)	663 (20.4)	130 (17)	ND	201 (18.4)	350 (16.2)	598 (23.9)	488 (15.21)	ND

ND - no data available, K1 - flat keratometry, K2 - steep keratometry, AL - axial lenght, ACD - anterior chamber depth.
* including 1.0 D

DISCUSSION

The aim of cataract surgery – is to achieve good postoperative results and restore visual function. Astigmatism and ocular comorbidities are the factors that have great impact on postoperative visual acuity. In cases of ocular comorbidities postoperative visual acuity depends not only on proper selection of IOL, but also on level the damage of other ocular structures. In case of corneal astigmatism better visual results can be achieved by correcting residual astigmatism with spectacles or using intraoperative correction with toric intraocular lenses. This method leads to higher spectacle independence.
Astigmatism correction in cataract surgery has been increasingly highlighted due to its influence to visual acuity. Regarding advanced surgical techniques and variety of IOL types better quality postoperative visual acuity is a demand for a successful result [7].
The study evaluated biometric parameters, prevalence of corneal astigmatism, VA and ocular comorbidities in cataract patients.
The mean age of patients was 71.68 ± 9.77 years, which is comparable to 71.89 ± 10.19 years as reported by De Bernardo et al [8], and 72.28 ± 13.84 years by Collier Wakefield et al [9], whereas other authors have found lower [2, 10, 11, 12, 13] and higher [14] mean ages (comparison of publications in Table 2).
The mean values of our biometric data parameters were similar to larger cohorts of patients in other publications' data [10], with similar results in mean of AL [10, 11, 12], ACD [9, 10, 13], keratometric parameters [8, 10, 11, 13]. We observed differences between genders in AL, K1, K2 and no significant difference in magnitude of corneal astigmatism. Present study results revealed that females had shorter AL and higher values of K1 and K2 parameters, comparing to males, other authors support the data as well [2, 10, 11, 12].
ur mean magnitude of corneal astigmatism (0.80 ± 0.75) was lower than those previously reported, from 0.89 ± 0.72 by Nemeth et al [10] to 1.12 ± 1.10 by Mohammadi et al [11]. The difference of the results may be due to relatively small sample size of 502 eyes, comparing with 1092 eyes from Nemeth et al [10], 2156 eyes from Mohammadi et al [11] or almost 13 times larger research population of 6506 eyes from Ferreira et al [2]. Mentioned studies [2, 8, 9, 11, 12, 13, 14] included patients scheduled for cataract surgery, as our study did, meanwhile Nemeth et al [10] research was population based.
Prasher and Sandhu [12] and Collier Wakefield et al [9] described positive correlation between magnitude of corneal astigmatism and age, but our data does not comply with this finding, as no correlation between those two parameters was found ($p>0.05$). However, current study showed correlations between ACD and age; AL and age; AL and keratometric parameters, which is compatible to that previously reported by Nemeth et al [10].
Our retrospective study demonstrated that a fifth of the examined population (23.3%) had higher than 1.0 D corneal astigmatism before cataract surgery. Other publications report even higher prevalence of > 1.0 D corneal astigmatism [2, 8, 9, 10, 11, 12, 13, 14], which varied from 28.62%, as reported by Prasher and Sandhu [12], and 48.1% by Mohammadi et al [11], in which cases correction of astigmatism during surgery has a great value of consideration and may implicate better postoperative visual acuity outcomes. Lower rate of >1.0 D corneal astigmatism in present research, comparing with other studies, may be due to its relation and shift with age groups. Our mean age was 71.68 ± 9.77 years, which slightly differs from other publications [2, 10, 11, 12] and as our results suggest, that corneal astigmatism 1.0 D or below increases as > 1.0 D decreases with age shifting gradually until 80 years. This information about data difference may provide cataract surgeons additional information about specific Lithuanian population. Regarding the orientation of corneal astigmatism, ATR astigmatism was the most frequent type with more than half of cases (56.9%). This result differs from [8, 10], where WTR astigmatism was the most frequent type (44 and 53.3%, respectively), however other publications results [11, 12, 13, 2] comply well with our data with ATR being the most common type as well

(46.5, 46.8, 51.88 and 47.83 %, respectively).Moreover, regarding the orientation of corneal astigmatism and relationship with age, our data is similar to other authors findings [8, 10, 11, 12, 13], that WTR astigmatism decreases with age, while ATR and OB gradually increases, ATR making up to 54.0% in the oldest age group, which makes an importance for cataract surgeons to overcorrect ATR astigmatism and undercorrect WTR astigmatism in older population [8]. The increasing rate of ATR astigmatism may be because of scleroses, fibrosis, loss of lens transparency [11] or due to changes in corneal curvature which might be related to the reduction in tension of the eyelids that typically occurs with age [15]. The evaluation of preoperative magnitude and types of corneal astigmatism is necessary not only to provide extra information for cataract surgeons before operation, but for planning the demand of toric IOLs as well.The mean preoperative BCDVA of 0.31 ± 0.25 D in the current study is similar to previous study [16] in which logMAR VA was 0.50 (decimal approximation 0.32).

Ocular comorbidity was present in less than half of the population, with glaucoma being the most common one and AMD the second. This partially corresponds with Day et al [16] where AMD was the most frequently recorded as glaucoma the second one.

Additional information of ocular comorbidities may provide wider overview of the patient before cataract surgery.

In conclusion, our results in this firstly reported study about corneal astigmatism prevalence among the cataract surgery patients in Lithuania are mostly compatible with other larger cohorts studies. The current research stated that over one-fifth of Lithuanian cataract patients present corneal astigmatism above 1.0 D which is important to consider before surgery for the best post-operative result as well as may help to establish the demand of toric IOL for this specific population.

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Conflict of Interest Statement: None of the authors has conflict of interest with this submission.

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