Ocular biometric characteristics of Han ethnicity in Tianjin and Uyghur ethnicity in Xinjiang undergoing cataract surgery

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Abstract

● **AIM:** To analyze and compare the differences among ocular biometric parameters in Han and Uyghur populations undergoing cataract surgery.

● **METHODS:** In this hospital-based prospective study, 410 patients undergoing cataract surgery (226 Han patients in Tianjin and 184 Uyghur patients in Xinjiang) were enrolled. The differences in axial length (AL), anterior chamber depth (ACD), keratometry [steep K (Ks) and flat K (Kf)], and corneal astigmatism (CA) measured using IOL Master 700 were compared between Han and Uyghur patients.

● **RESULTS:** The average age of Han patients was higher than that of Uyghur patients (70.22±8.54 *vs* 63.04±9.56y, *P*<0.001). After adjusting for age factors, Han patients had longer AL (23.51±1.05 *vs* 22.86±0.92 mm, *P*<0.001), deeper ACD (3.06±0.44 *vs* 2.97±0.37 mm, *P*=0.001), greater Kf (43.95±1.40 *vs* 43.42±1.69 D, *P*=0.001), steeper Ks (45.00±1.47 *vs* 44.26±1.71 D, *P*=0.001), and higher CA (1.04±0.68 *vs* 0.79±0.65, *P*=0.025) than Uyghur patients. Intra-ethnic male patients had longer AL, deeper ACD, and lower keratometry than female patients; however, CA between the sexes was almost similar. In the correlation analysis, we observed a positive correlation between AL and ACD in patients of both ethnicities (r_{Han}=0.48, r_{Uyghur}=0.44, *P*<0.001), while AL was negatively correlated with Kf (r_{Han}=-0.42, r_{Uyghur}=-0.64, *P*<0.001) and Ks (r_{Han}=-0.38, r_{Uyghur}=-0.66, *P*<0.001). Additionally, Kf was positively correlated with Ks (r_{Han}=0.89, r_{Uyghur}=0.93, *P*<0.001).

● **CONCLUSION:** There are differences in ocular biometric parameters between individuals of Han ethnicity in Tianjin and those of Uyghur ethnicity in Xinjiang undergoing cataract surgery. These ethnic variances can enhance our understanding of ocular diseases related to these parameters and provide guidance for surgical procedures.

● **KEYWORDS:** ocular biometric parameters; IOL Master 700; ethnic difference

INTRODUCTION

Ocular biometric parameters play an important role in the pathogenesis, diagnosis, and treatment of clinical diseases. Axial length (AL) is used in the diagnosis of axial myopia to assess the risk of posterior capsule rupture and retinal detachment after cataract surgery[1-2]. The assessment of anterior chamber depth (ACD) in the initial diagnosis of angle-closure glaucoma is closely related to glaucoma and refractive drift after cataract surgery[3]. Corneal curvature is used in the diagnosis of refractive myopia and astigmatism and is also the basis for the early identification of corneal diseases such as keratoconus and flat cornea[4-5]. In cataract surgery, the AL, ACD, and corneal curvature determine the type and power of the intraocular lens (IOL), surgical method, location of the intraoperative lens, and potential postoperative complications

such as loss of corneal endothelium due to a shallow ACD[6]. Several studies have shown that these ocular biometric parameters are affected by factors such as environment, ethnicity, genetics, sex, and age[7-9], and it is possible to identify people at high risk for eye diseases by assessing the association of these ocular biometric parameters and their contributing factors to epidemiology. Therefore, identifying these differences in ocular biometric parameters is useful for assessing the status of associated ocular diseases and guiding surgical and postoperative care.

Relevant studies have been conducted in countries such as the United States, Spain, South Korea, and Bosnia and Herzegovina[9-13]; however, most of them are limited to a single ethnic group in a single region. Owing to the differences in measuring instruments and patient inclusion criteria, it is difficult to compare ocular biometric parameters between ethnic groups. In China, there were few research on the distribution trend of ocular biometric parameters between different regional ethnicities. Tianjin, which is located in northern China, has a predominant Han ethnic population, whereas the Xinjiang Uyghur Autonomous Region, located in northwest China, is predominantly inhabited by the Uyghur ethnic minority. Because of their unique geography and ethnic demographics, they are ideal areas for comparative investigation of ethnic differences.

Using the IOL Master 700, known for its high precision, good repeatability, and better AL detection rate in cataract patients[14-15], we aimed to analyze and compare ocular biometric parameters between the Han ethnicity in Tianjin and the Uyghur ethnicity in Xinjiang undergoing cataract surgery. The differences in these ocular biometric parameters will help to evaluate the pathological condition of patients from different regions, ethnicities, and sexes. This can establish a relationship between eye-related parameters and disease incidence and have a positive impact on the personalized clinical diagnosis and treatment of patients.

SUBJECTS AND METHODS

Ethical Approval The prospective study was approved by the Ethics Committee of Tianjin Medical University Eye Hospital. All procedures were performed in accordance with the Declaration of Helsinki [2021KY(L)-33]. Informed consent was obtained from all patients undergoing the clinical examinations.

Patients Our study recruited Han patients who underwent cataract surgery at the Eye Hospital of Tianjin Medical University and Uyghur patients who underwent cataract surgery at the Ophthalmology Department of the People's Hospital of Hotan District in Xinjiang. The inclusion criteria were phacoscotasmus under a slit lamp and a corrected visual acuity of <0.7 in the affected eye. The exclusion criteria were

as follows: 1) history of corneal transplantation, eye refraction, and eye surgery; 2) diseases that affect the measurement of ocular biological parameters, such as corneal leukoplakia, keratoconus, corneal pterygium, and retinopathy; 3) the use of drugs that affect the depth of the anterior chamber and pupil diameters, such as pilocarpine and atropine; 4) recent wearing of orthokeratology and contact lenses; 5) coexisting eye diseases, such as retinopathy, glaucoma, and macular degeneration; 6) other systemic diseases, including diabetes, hypertension, and autoimmune diseases. Ocular biometric parameters for all subjects were measured using the IOL Master 700 (Carl Zeiss Meditec AG, Jena, Germany). These parameters included AL (the visual axial direction to the retinal pigment epithelium layer in the macular area), ACD (the distance from the anterior surface of the cornea to the anterior surface of the lens), flat K (Kf), steep K (Ks), and corneal astigmatism (CA; the absolute difference between Kf and Ks on the meridian).

Statistical Analysis The Kolmogorov-Smirnov test (K-S test) was used to determine the normality of the data ($P \geq 0.05$ is a normal distribution), and the sex comparison of the patients was tested using the Chi-square (χ^2) test. After adjusting for age as a covariate, the overall differences in AL, ACD, Ks, Kf and CA between Han and Uyghur patients were compared. Additionally, the differences in AL, ACD, Ks, Kf and CA between different age groups of Han and Uyghur patients were also compared. Intersex AL, ACD, Ks, and Kf were measured using an independent sample t-test, and CA was measured using the Mann-Whitney U test. The correlations between ocular biometric parameters were evaluated using Spearman correlation analysis; r was the correlation coefficient, and $P<0.05$ indicated statistical significance. SPSS Software (Version 26, IBM Corporation) was used for statistical analysis.

RESULTS

Population Demographics In this study, data were obtained for 410 patients (410 eyes) undergoing cataract surgery, including 226 Han patients (226 eyes) in Tianjin [99 males (99 eyes) and 127 females (127 eyes)], with a mean age of 70.22±8.54y. There were 184 Uyghur patients (184 eyes) in Xinjiang [91 males (91 eyes) and 93 females (93 eyes)], with a mean age of 63.04±9.56y. The mean age of Han patients was higher than that of Uyghur patients, and the difference was statistically significant ($P<0.001$). There was no significant difference between the sexes of the two ethnic groups ($P=0.081$). Figure 1 shows that Han patients had the highest incidence rate in the 70-79y age group, whereas Uyghur patients showed the highest incidence rate in the 60-69y age group.

Distribution of Ocular Biometric Parameters Between Han and Uyghur Patients Overall, the average AL
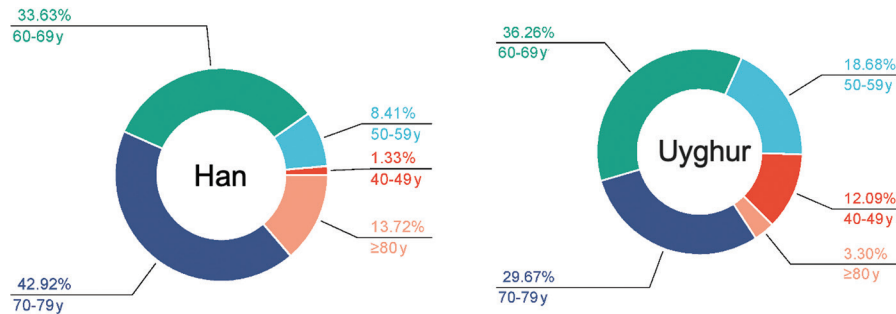
Figure 1 The proportion of Han and Uyghur patients in each age group.

Table 1 Comparison of ocular biometric parameters in Han and Uyghur patients

Age	AL (mm)	ACD (mm)	Kf (D)	Ks (D)	CA (D)
40-49y					
Han	24.69±3.34	3.10±0.68	42.34±1.12	43.64±0.50	1.31±0.65
Uyghur	23.08±1.24	2.95±0.46	43.27±1.27	44.26±1.44	0.99±0.75
P	0.002	0.340	0.674	0.06	0.437
50-59y					
Han	23.86±1.28	3.27±0.33	43.71±1.47	44.42±1.49	0.72±0.58
Uyghur	23.08±1.02	3.12±0.29	43.37±1.72	44.20±1.82	0.79±0.64
P	0.029	0.373	0.643	0.270	0.065
60-69y					
Han	23.50±0.94	3.20±0.42	44.13±1.35	45.02±1.41	0.90±0.54
Uyghur	22.75±0.95	2.93±0.45	43.43±1.85	44.23±1.88	0.81±0.65
P	0.001	0.023	0.007	0.130	0.001
70-79y					
Han	23.54±0.97	3.01±0.36	44.05±1.29	45.13±1.33	1.07±0.70
Uyghur	22.89±0.71	2.98±0.33	43.40±1.44	44.18±1.34	0.79±0.49
P	0.001	0.547	0.030	0.001	0.016
≥80y					
Han	23.40±0.79	2.92±0.42	43.54±1.66	44.88±1.80	1.33±0.81
Uyghur	23.33±0.68	2.84±0.43	42.99±1.13	43.95±1.03	0.96±0.36
P	0.907	0.909	0.332	0.168	0.006
Total					
Han	23.51±1.05	3.06±0.44	43.95±1.40	45.00±1.47	1.04±0.68
Uyghur	22.86±0.92	2.97±0.37	43.42±1.69	44.26±1.71	0.79±0.65
P	0.000	0.001	0.001	0.001	0.025

AL: Axial length; ACD: Anterior chamber depth; Ks: Steep K; Kf: Flat K; CA: Corneal astigmatism.

(23.51±1.05 mm) in Han patients was longer than that of Uyghur patients (22.86±0.92 mm, $P<0.001$). The ACD in Han patients (3.06±0.44 mm) was deeper than that of Uyghur patients (2.97±0.37 mm, $P=0.001$). The Kf (43.95±1.40 D), Ks (45.00±1.47 D), and CA (1.04±0.68 D) values in Han patients were higher than those of Uyghur patients (43.42±1.69 D, $P=0.001$; 44.26±1.71 D, $P=0.001$; and 0.79±0.65 D, $P=0.025$ respectively). Next, patients from both ethnicities were stratified into age groups. The results showed that the age-specific patterns of AL and ACD were similar for both ethnic groups, consistent with the overall findings. Specifically, the AL of Han patients was longer than that of Uyghur patients in all age groups, and the ACD of Han patients was consistently deeper than that of Uyghur patients. However, with the exception of the age range of 40-49y, the Kf (42.34±1.12 D) and Ks (43.64±0.50 D) values for Han patients were lower than those for Uyghur patients (43.27±1.27 D for Kf and 44.26±1.44 D for Ks) in the respective age groups. Conversely, for most other age groups, Han patients had higher Kf and Ks values than Uyghur patients. Regarding CA, except for Han patients in the age range of 50-59, whose CA values were similar (0.72±0.58 D for Han and 0.79±0.64 D for Uyghur), the CA of Han patients in other age groups was greater than that of Uyghur patients (Table 1).

Distribution of Ocular Biometric Parameters Between Han and Uyghur Patients by Sex The average AL of Han

Table 2 Distribution of ocular biometric parameters between sexes within the same ethnic group

Ethnicity	AL (mm)	ACD (mm)	Kf (D)	Ks (D)	CA (D)
Han					
Male	23.81±0.95	3.14±0.14	43.50±1.33	44.57±1.39	1.07±0.69
Female	23.28±1.07	3.00±0.45	45.30±1.35	45.31±1.45	1.01±0.68
t	3.87	2.50	-4.42	-3.85	0.67
P	0.001	0.014	0.001	0.001	0.501
Uyghur					
Male	23.11±0.87	3.03±0.39	43.00±1.74	43.86±1.72	0.82±0.59
Female	22.58±0.91	2.92±0.34	43.89±1.51	44.71±1.58	0.76±0.71
t	3.79	2.16	-3.40	-3.25	0.61
P	0.000	0.032	0.001	0.001	0.542

AL: Axial length; ACD: Anterior chamber depth; Ks: Steep K; Kf: Flat K; CA: Corneal astigmatism.

Table 3 Distribution of ocular biometric parameters of patients among different ethnic groups by sex

Sex	AL (mm)	ACD (mm)	Kf (D)	Ks (D)	CA (D)
Male					
Han	23.81±0.95	3.14±0.14	43.50±1.33	44.57±1.39	1.07±0.69
Uyghur	23.11±0.87	3.03±0.39	43.00±1.74	43.86±1.72	0.82±0.59
t	5.21	3.12	2.18	3.13	2.61
P	0.000	0.002	0.031	0.002	0.010
Female					
Han	23.28±1.07	3.00±0.45	45.30±1.35	45.31±1.45	1.01±0.68
Uyghur	22.58±0.91	2.92±0.34	43.89±1.51	44.71±1.58	0.76±0.71
t	4.79	0.62	2.02	2.77	2.51
P	0.000	0.045	0.045	0.006	0.013

AL: Axial length; ACD: Anterior chamber depth; Ks: Steep K; Kf: Flat K; CA: Corneal astigmatism.

male patients (23.81±0.95 mm) was longer than Han female patients (23.28±1.07 mm). The ACD of Han male patients was deeper than that of Han female patients (3.14±0.14 mm *vs* 3.00±0.45 mm, respectively). The Kf (43.50±1.33 D) and Ks (44.57±1.39 D) of the Han male patients were lower than those of Han female patients (Kf, 45.30±1.35 D; Ks, 45.31±1.45 D). The CA of Han male patients (1.07±0.69 D) was similar to that of Han female patients (1.01±0.68 D), and the difference was statistically insignificant. The mean AL (23.11±0.87 mm) in Uyghur men was longer than that in Uyghur women (22.58±0.91 mm). The ACD of Uyghur male patients (3.03±0.39 mm) was deeper than that of Uyghur female patients (2.92±0.34 mm). The Kf (43.00±1.74 D) and Ks (43.86±1.72 D) of Uyghur male patients were lower than those of the Uyghur female patients (Kf, 43.89±1.51 D; Ks, 44.71±1.58 D). The CA of Uyghur male patients (0.82±0.59 D) was similar to that of Uyghur female patients (0.76±0.71 D), and there was no statistical difference (Table 2). Han male patients had longer AL, deeper ACD, and greater Kf, Ks, and CA than Uyghur male patients. Han female patients had longer AL, deeper ACD, and greater Kf, Ks, and CA than Uyghur female patients (Table 3).

Overall Distribution and Correlation of Ocular Biometric

Parameters Between Han and Uyghur Patients The distribution characteristics of ocular biometric parameters between the two ethnicities of cataract patients were comparable: AL, ACD, and keratometry values (Ks, Kf) exhibited a normal distribution, while CA exhibited a skewed distribution. In Han patients, AL was positively correlated with ACD (r=0.48) but negatively correlated with Kf (r=-0.42) and Ks (r=-0.38). Kf was positively correlated with Ks (r=0.89) but negatively correlated with CA (r=-0.14), whereas Ks was positively correlated with CA (r=0.28). In Uyghur patients, AL was positively correlated with ACD (r=0.44) but negatively correlated with Kf (r=-0.64) and Ks (r=-0.66). Kf was positively correlated with Ks (r=0.93), while Ks was positively correlated with CA (r=0.19; Figure 2).

DISCUSSION

In this study, we recruited Han patients from Tianjin and Uyghur patients from Uygur Autonomous Region who underwent cataract surgery. We compared and analyzed the differences in ocular biometric parameters of these patients between different ethnicities and sexes using the IOL Master 700. Previous studies have shown that there are differences in the distribution of AL, ACD, and keratometry values in terms of ethnicities and sex, which is consistent with most studies on
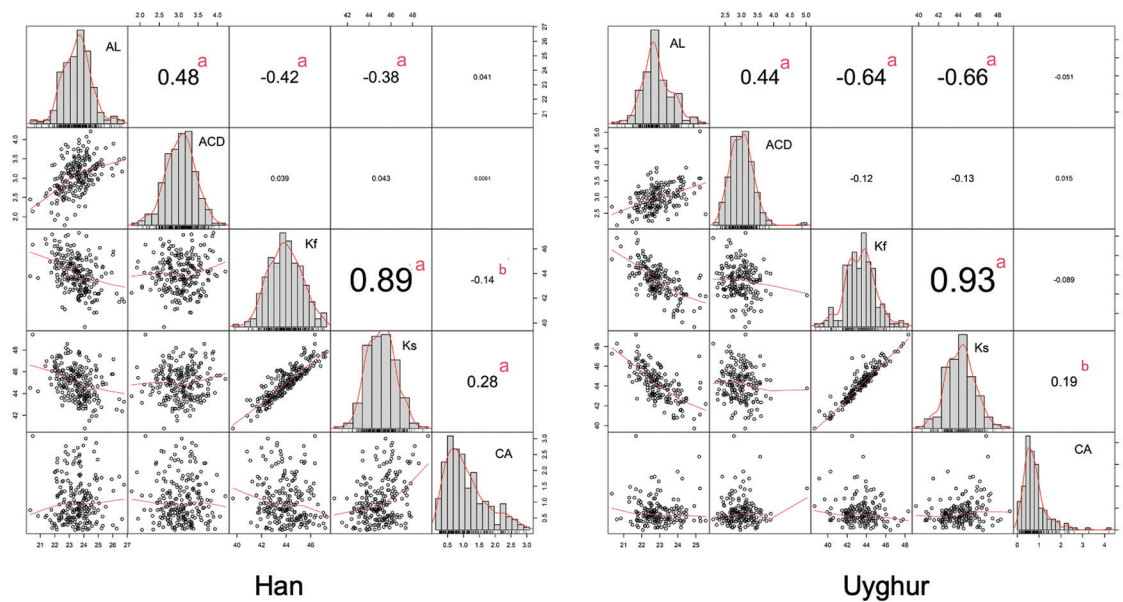
Figure 2 Overall distribution and correlation of ocular biometric parameters between Han and Uyghur patients The bottom left corner of the image shows a scatter plot of two parameters, the middle corner shows the data distribution of the corresponding parameters, and the top right corner shows the correlation size and significance. [a]$P<0.001$, [b]$P<0.05$. AL: Axial length; ACD: Anterior chamber depth; Kf: Flat K; Ks: Steep K; CA: Corneal astigmatism.

differences in ocular biometric parameters between different ethnicities and sexes[7-9]; however, for the comparison of specific ocular biometric parameters, the conclusions of some ethnic studies are different.

A multiracial study in San Francisco showed a difference in lens position [defined as the ACD+1/2 lens thickness (LT)] and relative lens position (defined as the lens position/AL) in Caucasians compared to Asians, Hispanics, and African Americans, which may be related to the relative risk of acute angle-closure glaucoma and the effect of intraocular pressure control after cataract surgery in different populations[9]. Research in Auckland showed differences between AL, ACD, IOL power, and CA among Māori, Asian, Pacific, and Caucasians, and this difference contributes to the improvement of IOL power calculations[10]. A study in Texas showed differences in ACD among patients from Hispanic and non-Hispanic white races with cataracts, and this ethnic difference may be a risk factor for developing corneal endothelial damage after cataract surgery[16]. The research involving patients with cataracts from Bosnia and Herzegovina and India's Northeast region showed differences in AL, ACD, and keratometry between sexes[13,17].

Our study showed that the average age of Han patients with cataracts is higher than that of Uyghur patients with cataracts, consistent with the epidemiological survey results of Xie et al[18] and Lou[19] on Xinjiang Uyghur and Han patients. Some studies have shown that ultraviolet exposure is closely related to cataract incidence[20]. The duration and intensity of ultraviolet radiation received by people in Xinjiang are higher than those in Han areas. Therefore, ultraviolet radiation may be the main factor leading to age differences in the two regions.

Uyghur patients have a shorter AL and shallower ACD than Han patients, and Uyghur patients exhibit anatomical characteristics such as small eyeballs, shallow anterior chambers, and deep sunken eyeballs[21]. AL is a decisive factor in refractive error. Han Chinese patients have a longer AL (23.51±1.05 mm) than white Europeans (23.43±1.51 mm) and other ethnic minorities in China, including Uyghurs (22.86±0.92 mm). This corresponds to a myopia rate of 51.49% among Han individuals, which is significantly higher than the Uyghur myopia rate of 13.53% and 12% to 28% higher than that of Europeans[22-25]. In addition, the heritability of myopia rates varies among different ethnicities, with Shi et al's[26] study indicating a heritability of 36.86% among the Han population and 30.27% among the Uyghur population. Han individuals exhibit higher heritability than Uyghurs.

The difference in AL between patients from these two ethnic groups may be attributed to various factors, including environmental exposure, genetic factors, cultural influences, and lifestyle habits. Genetic evidence shows that AL is related to 2p24, 5q, and 14q loci, and its heritability ranges from 40% to 94%[27-28]. According to Xu et al's[29] admixture genomic analysis, the Uyghur population has 60% European white ancestry and 40% Asian ancestry. In terms of culture and living habits, Uyghurs prefer a nomadic lifestyle, whereas Han people prefer working and indoor study[21], and studies have shown that light intensity and time slow down the increase of AL[30]. The AL in male patients was longer than that of female

patients in all ethnic groups, which is consistent with the Blue Mountain eye disease study[31]. Some studies have attributed the difference in AL between sexes to the difference in height between sexes[32]. However, sex differences in AL remained significant in a multivariate analysis adjusted for height in a study on the Malaysian population, suggesting that sex may be an independent determinant of AL[33].

Han patients had deeper ACD than Uyghur patients, and male patients in all ethnic groups had deeper ACD than female patients. The results were consistent with the sex differences between the correlation of ACD and AL in patients with cataracts in South Korea and Israel[12,34]. It is suggested that female patients with a shallow ACD may be more likely to develop acute primary angle-closure glaucoma than male patients based on cataract impacts. This is consistent with the finding of an epidemiological study that the incidence rate among females is higher than that in males[35]. Similarly, Uyghur patients are more likely to develop acute primary angle-closure glaucoma than Han patients. Uyghur females with acute primary angle-closure glaucoma combined with cataracts may benefit more from lens removal. Correlation analysis revealed a positive correlation between AL and ACD, which may be related to the anatomical development of the eyeball. The longer the AL, the deeper the ACD. In addition, genetic evidence suggests that ACD is associated with the 1p32 gene locus, with a heritability rate of 51%-54%[28,36]. ACD is strongly associated with postoperative cataract complications and refractive status, and ACD less than 2.5 mm is at increased risk of complications during cataract surgery[37]. We found that approximately 1% of Han and Uyghur patients had an ACD<2.5 mm, with a greater variability in Han patients (shallowest: 1.78 mm for Han ACD and 2.13 mm for Uyghur ACD).

Patients with a shallow preoperative ACD tend to have myopia drift in their refractive state, whereas patients with deeper anterior chambers before surgery tend to have hyperopia drift in their refractive state[4]. AL and ACD are related to the IOL concentration after cataract surgery. The deeper the ACD, the greater the vertical concentration of the IOL (upward movement), which increases the patient's higher-order aberrations and worsens the patient's postoperative visual quality[38]. Therefore, to avoid refractive drift and IOL concentration in patients after cataract surgery, consideration of subtle differences in ACD among patients of different sexes and ethnicities has certain benefits for ensuring postoperative refractive quality.

The keratometry parameters of Han patients were greater than those of Uyghur patients, and the mean CA of Han patients was greater than 1 D. Han patients had more severe astigmatism than Uyghur patients. After correlation analysis, we found that Ks was positively correlated with CA in both Han and Uyghur patients, whereas Kf was negatively correlated with CA in Han patients. However, there was no correlation between Kf and CA in Uyghur patients. The different relationships between Kf, Ks, and CA may be the reason for the differences in astigmatism between the two ethnicities. In addition, there is genetic evidence indicating that keratometry is related to the 2p25, 3p26, and 7q22 gene loci, with a heritability rate of 60%-92%[28,36]. Furthermore, Kf, Ks, and AL were negatively correlated in both groups of patients, while Kf and Ks, which are closely related to eye anatomy and physiology, were positively correlated. Shorter eyes tend to have hyperopia, and the cornea becomes steeper, whereas longer eyes tend to exhibit more myopia, and the cornea becomes flatter. As AL increases, the curvature of the cornea decreases, which is related to the mechanism of maintaining emmetropia in the eyes[39]. Correcting low to moderate astigmatism during cataract surgery can improve the postoperative visual satisfaction of patients[34,40].

The limitation of this study lies in the fact that selection bias could not be ruled out in the collection of cataract population data from hospitals. Moreover, other ocular biometric parameters, such as corneal thickness, corneal endothelial cell density, LT, and vitreous cavity depth, were not obtained from all patients. Further systematic data collection and statistical analysis in this area are needed in the future.

In conclusion, ocular biometric parameters of patients with cataracts could respond to a certain extent to the ocular parameter distribution of the normal population. The results of this study indicate that there are differences in ocular biometric parameters, including AL, ACD, Kf, Ks, and CA, among different regions, ethnicities, and sexes. We further explored the reasons for these differences and established connections with parameter-related eye diseases. In all age groups, Han patients exhibit longer AL compared to Uyghur patients, which corresponds to a higher incidence of high myopia in the Han population. Among Uyghur patients, females may have a higher susceptibility to acute primary angle closure glaucoma due to their short eye axis and shallow anterior chamber characteristics. In clinical diagnosis and treatment, it is imperative to consider the relationship between ocular biometric parameters and diseases in patients from diverse regions and ethnic backgrounds.

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