

ORIGINAL ARTICLE

ANALYSIS OF CORNEAL ASPHERICITY (Q VALUE) AND ITS RELATED FACTORS: A STUDY IN KARACHI, PAKISTAN

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ABSTRACT

Background: Over the past few decades, global studies on corneal asphericity have been extensive, but there is a notable lack of research on factors influencing the corneal Q-value in Pakistan. The aim of this study was to analyze corneal Q-value and its relationship with associated factors.

Materials & methods: It was a cross-sectional study. A total of 619 left eye patients from Hashmanis Group of Hospitals, Karachi, were included, selected through convenience sampling method. Through slit-lamp bi-microscopy examination and topographic data using Pentacam scans was obtained. Participants were categorized into age groups of 18–29 years, 30–44 years, and 45–59 years. Statistical analysis included Spearman's rank correlation, independent sample test, and ANOVA utilizing SPSS V.25. A significance level of $p \leq 0.05$ was considered to indicate statistical significance.

Results: Among the 619 patients, 219 (35.4%) were males and 400 (64.6%) were females. The mean age of patients was 35.4 ± 7.6 years. The mean Q-value of the anterior (front) surface of the cornea was -0.400 ± 0.117 mm and the mean Q-value of the posterior (back) surface was -0.384 ± 0.125 mm.

Conclusion: Most of the corneas exhibited a prolate shape, indicating a more elongated structure in the anterior-posterior axis. The analysis revealed that asphericity of the posterior cornea showed a significant positive association with gender. However, the study did not find a significant relationship between posterior corneal asphericity and age, implying that age may not be a determining factor in corneal morphology. To strengthen the validity of these initial observations, further investigations with larger sample sizes and diverse populations are required.

KEY WORDS: Ophthalmology; Cornea; Ocular refraction; Hospitals; Pakistan.

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INTRODUCTION

The cornea plays a crucial role as the principal origin of refraction within the human eye, responsible for over two-thirds of the combined refractive capability of the eye. The physiological corneal asphericity

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plays a crucial role in conjunction with various optical elements within the eye to create a harmonious balance of aberrations, aiming to reduce the impact of spherical aberration and to provide the best possible visual acuity.^{1,2} Furthermore, the intricate interplay between the corneal asphericity and other optical components contributes significantly to the overall quality of vision experienced by an individual.^{3,4}

The implications of the relative corneal asphericity extend to various aspects of optometry and ophthalmology, such as contact lens construction, intra-ocular lens power calculations, and refractive surgery. When undergoing laser refractive surgery, it is important to consider that the procedure has the potential to disrupt the natural prolate shape of the

cornea, leading to the development of both lower and higher order aberrations, such as spherical aberration and coma. These induced aberrations can have a significant impact on the patient's visual function, manifesting as changes in contrast sensitivity and low luminance visual acuity. Therefore, a thorough understanding of corneal asphericity and its effects on ocular aberrations is essential for clinicians to optimize outcomes in patients undergoing refractive procedures.^{3,5}

In the past twenty years, numerous investigations have been carried out regarding corneal asphericity on a global scale. However, in Pakistan, it has been revealed from literature that there is a noticeable absence of studies focused on factors associated with the Q value within the Pakistani population.^{1,3,5-8} Therefore, our objective was to fill this gap by investigating and assessing the corneal asphericity within the local population and examining various factors, such as age and gender, in order to gain a comprehensive understanding of the determinants influencing this particular ocular characteristic.

MATERIALS & METHODS

The research design was an analytical cross-sectional evaluation. The study lasted one year, from February 1, 2023, to January 31, 2024. The study was conducted at Hashmanis Group of Hospitals in Karachi, Sindh, Pakistan.

The sample size in the current study was 619 selected through convenience sampling method, which is significantly larger than the minimum sample size calculated as follows. A district hospital's catchment area in Pakistan is estimated to be 1-3 million people.⁹ The prevalence of refractive errors in Pakistan is approximately 20% (20% in females and 23.9% in males).¹⁰ A study conducted in Asia (could not find a study in Pakistan) found that approximately 57.8% of respondents would not select the refractive surgery option.¹¹

$$\text{Population size} = 1,000,000 - 3,000,000 \times 0.2 \times 0.42 = 84000 - 252000$$

So, the final population is estimated to be between 84000 and 252000. Using the Raosoft sampling tool, the sample size was computed using the following formula.¹²

$$n = N x / ((N-1)E^2 + x)$$

At 95% confidence and a 5% margin of error, the minimal sample size for this population is 383. Our study's sample size was significantly higher than this value, indicating an adequate sample size with a lower margin of error.

The inclusion and exclusion criteria are as follows: It included 619 individuals above the age of 18 who were undergoing regular outpatient or preoperative assessments for refractive surgery at Hashmanis Group of Hospitals. Individuals excluded from the

study comprised those with a prior history of eye surgery or any systemic comorbidities, current users of contact lenses, individuals with co-existing eye conditions such as corneal surface irregularities, pterygium, strabismus, dry eye disease, keratoconus, those with inaccurate Pentacam data, as well as pregnant or lactating women.

The demographic information of the participants was meticulously documented, and each individual underwent a series of clinical assessments. These included a manifest refraction evaluation conducted using an auto-refractometer and subjectively adjusted to ascertain the spherical and cylindrical components of refraction. Additionally, the best-corrected distance visual acuity (BCDVA) was assessed utilizing a Snellen chart in decimal values, which were subsequently converted into logarithms of the minimum angle of resolution (logMAR) units for more in-depth analyses. Furthermore, detailed examinations of the anterior and posterior segments of the eye were performed using slit-lamp biomicroscopy. The mean Q values of both the anterior and posterior corneal surfaces were acquired in this study. In order to facilitate a comprehensive analysis, the individuals included in the study were categorized into three distinct age brackets: 18–29 years, 30–44 years, and 45–59 years. The statistical analysis was carried out utilizing SPSS v.25. To ensure the accuracy of the analysis, the normality of the data distribution was evaluated through the application of the Kolmogorov–Smirnov test. The calculation of mean and standard deviation (SD) was meticulously conducted for each age group to provide a clearer overview of the data. Furthermore, the distribution of gender within the sample was analyzed by calculating both the frequency and the percentages. Various statistical methods, such as Spearman's rank correlation, t-test, and ANOVA were judiciously employed to explore the relationships and differences within the data. Throughout the analysis, a significance level of p-value ≤ 0.05 was deemed as the threshold for indicating statistical relevance. This rigorous criterion ensured that only statistically significant findings were considered in the interpretation of the results.

The research followed the principles outlined in the Declaration of Helsinki and received approval at the institutional level, with consent being acquired from all subjects.

RESULTS

A total of 619 cases above 18 years of age were included in this study. Among 619 patients, 219 (35.4%) were males and 400 (64.6%) were females. The mean age of patients was 35.4 ± 7.6 years. According to age distribution, 324 (52.3%) were in the 18-29 years age group, while 245 (39.6%) and 50 (8.1%) were in the 30-44 years and 45-59 years age groups, respectively. Mean Q-value of anterior

(front) surface was found to be -0.400 ± 0.117 mm, and mean Q-value of posterior (back) surface was -0.384 ± 0.125 mm.

Stratification of Q-values of the anterior and posterior surfaces with respect to gender and age groups was done and found that there was an insignificant difference in either gender and all age groups for the mean Q-value of the anterior (front) surface, while there was a significant difference in both genders in the mean Q-value of the posterior (back) surface. The Q-value of the posterior (back) surface did not change with age.

It is worth noting that we found a moderately statistically significant correlation between Q-values of anterior (front) and posterior (back) surfaces ($r = 0.432$, $p\text{-value} < 0.001$). Corneal wide to wide diameter had a very weak correlation with the mean Q-value of the anterior (front) surface, while it had a weak significant correlation with the mean Q-value of the posterior (back) surface. (Figure 3-5)

Table-1: Frequency distribution of demographic variables

Gender	Frequency	Percent
Male	219	35.4
Female	400	64.6
Total	619	100.0
Age groups		
18-29 years	324	52.3
30-44 years	245	39.6
45-59 years	50	8.1
Total	619	100.0

Table-2: Mean of Q-values of anterior and posterior surfaces and their stratification with respect to gender and age groups

Mean Q-value Anterior (Front): -0.400 ± 0.117 mm		
Gender		
Female: -0.407 ± 0.121 mm	p-value (t-test): 0.063	
Male: -0.388 ± 0.110 mm		
Age groups		
18-29 years: -0.405 ± 0.113 mm	p-value (ANOVA): 0.053	Correlation Coefficient: 0.061
30-44 years: -0.395 ± 0.120 mm		
45-59 years: -0.391 ± 0.135 mm	p-value (Correlation): 0.128	
Mean Q-value Posterior (Back): -0.384 ± 0.125 mm		
Gender		
Female: -0.398 ± 0.125 mm	p-value (t-test): < 0.001	
Male: -0.357 ± 0.120 mm		
Age groups		
18-29 years: -0.394 ± 0.122	p-value (ANOVA): 0.043	Correlation Co-efficient: 0.007
30-44 years: -0.369 ± 0.124		
45-59 years: -0.406 ± 0.151	p-value (Correlation): 0.854	

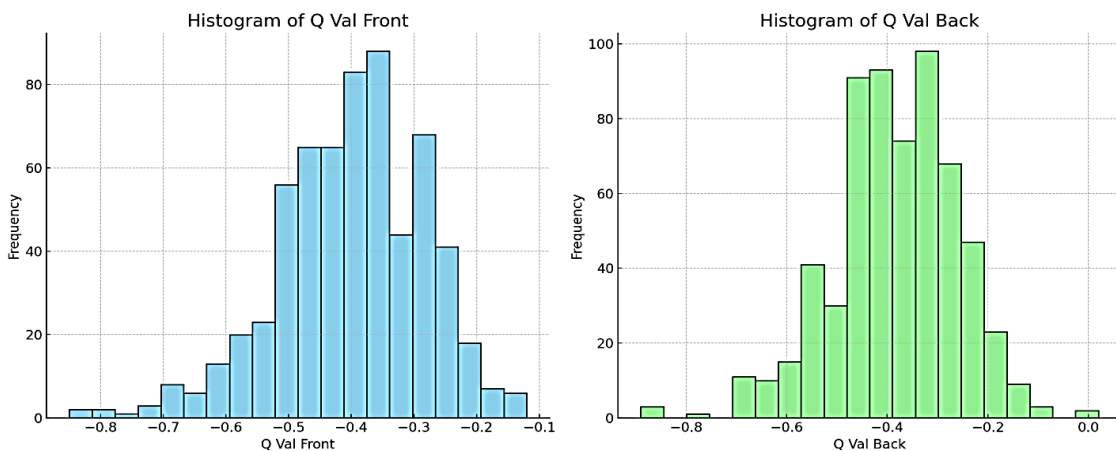


Figure-1: Histograms of Q-values of anterior (front) and posterior (back) surfaces

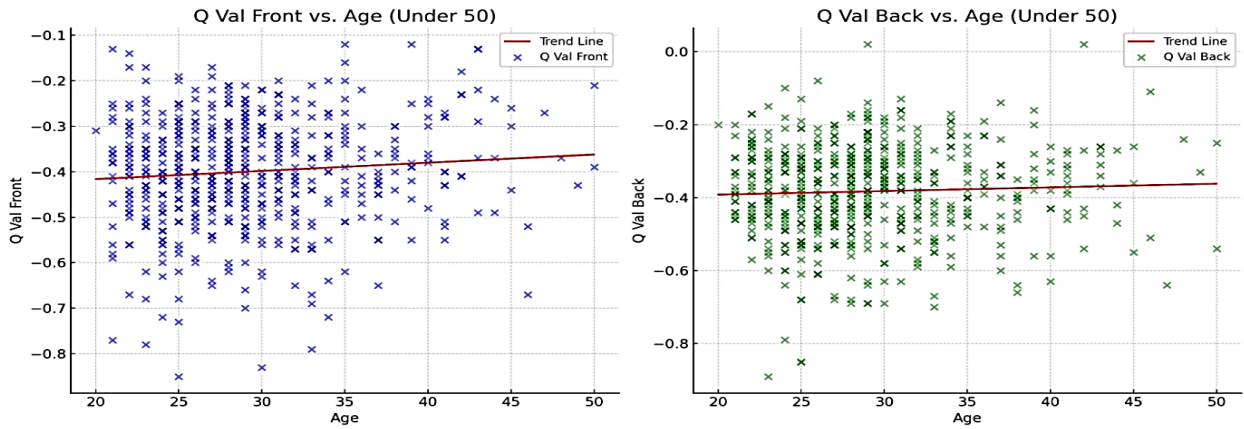


Figure-2: Comparison of Q-values of anterior (front) and posterior (back) surfaces with different age groups (Correlation: 0.061; p-value: 0.128 and Correlation: 0.007; p-value: 0.854)

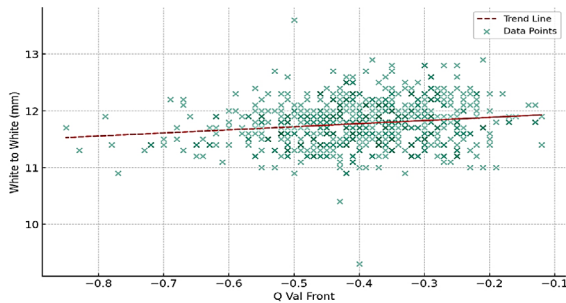


Figure-3: Correlation between Q-values of anterior (front) surface with white to white (Correlation: 0.157, p-value < 0.001)

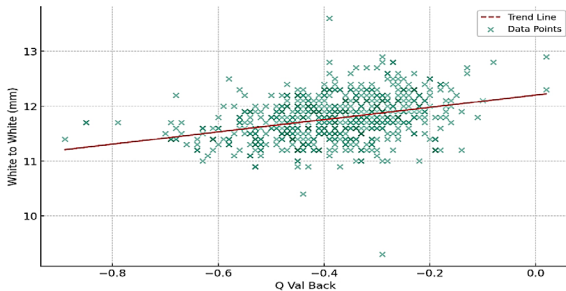


Figure-4: Correlation between Q-values of posterior (back) surface with white to white (Correlation: 0.341, p-value < 0.001)

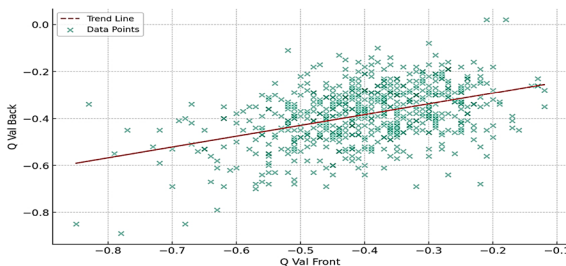


Figure-5: Correlation between Q-values of anterior (front) and posterior (back) surfaces (Correlation: 0.432, p-value < 0.001)

DISCUSSION

The study documented mean Q values of both the anterior and posterior corneal surfaces in the local population, showcasing a comprehensive analysis of corneal characteristics. Notably, a significant difference in posterior Q values was observed between genders, indicating potential gender-specific variations in corneal topography. Interestingly, despite these gender-related alterations, anterior or posterior Q values remained consistent across different age groups and showed no correlation, underscoring the stability of corneal asphericity throughout the aging process.

We conducted a study on a total of 619 left eyes within the age range of 18 to 59 years in order to investigate and assess the corneal Q value along with its associated factors such as age and gender. The average measurement of the anterior Q value was found to be -0.400 ± 0.117 mm. This outcome correlates with the findings reported in research conducted by Fuller and Alperin on African American participants⁵, as well as in the study by Dubbelman et al., which examined the right eyes of 114 individuals from the Netherlands, aged 18 to 65 years, utilizing the Topcon SL-45 system Scheimpflug camera.¹³ The consistency in results across different studies underscores the importance of understanding the link between age and sex on corneal characteristics.

Data regarding the asphericity of the anterior and posterior cornea exhibited a non-normal distribution. Fuller and Alperin also found that the Q value data for both African American and White subjects did not follow a normal distribution.⁵ Xiong and team investigated the right eyes of 1683 Chinese participants aged between 30 and 107 years, employing the Bausch & Lomb Orbscan Iiz.⁶ They also noted that the Q values for the anterior and posterior cornea were not normally distributed but instead displayed a leftward skew.⁶ Comparable outcomes were witnessed in various other research studies too.^{5,14,15,16} In

contrast, a Chinese study by Zhang and colleagues which included the right eyes of 1052 subjects, ranging in age from 6 to 83 years utilized a computerized videokeratoscope and found a Gaussian distribution within the Chinese populace, with a predominantly negative anterior Q value in 99.9% of the individuals.³

Our study involved the assessment of Q values pertaining to both the anterior and posterior surfaces of the cornea. No change in anterior Q value was noted whereas variations in the posterior asphericity between genders within our sample was evident. Females tend to have more negative posterior Q values as compared to males. Conversely, Xiong et al., Scholz et al., Dubbelman et al., and Chan et al. reported a more pronounced prolate anterior corneal surface among female subjects. One possible explanation for these differences was the anatomical differences present amongst the population sets.^{1,6,10,17}

The relationship between Q value and age is controversial in previous literature. Xiong and colleagues also noted a trend where the anterior corneal Q value showed a more negative shift, while the posterior Q value exhibited a less negative trend as age increased.⁸ In contrast, Zhang, Scholz, and Dubbleman, in their respective studies, did not find any substantial relationship between Q value and age.^{1,3,18} Our research findings indicated that there were no significant differences in corneal Q values between various age categories. Similar outcomes were noted by Fuller and Alperin as well as Cheung et al., who conducted a research study on the ocular characteristics of 63 Hong Kong-Chinese participants, with ages ranging from 18 to 39 years, utilizing the Topographic Modeling System.^{5,19}

In our study, we noted a statistically significant moderate correlation between the anterior Q value and the posterior Q value, suggesting a potential relationship between these two parameters. Conversely, Cheung et al. and Carney et al. both reported no significant correlation between anterior asphericity and radius of cornea.^{19,20}

CONCLUSION

The majority of corneas exhibited a prolate shape, indicating elongation along the vertical axis. Analysis revealed that the asphericity of the posterior cornea showed a significant positive association with gender, suggesting differences based on biological sex. Conversely, no notable connection was observed between posterior corneal asphericity and age, highlighting the independence of this parameter from the aging process. Although this multi-centered study had an adequate number of participants, generalization to the wider population may be limited. Future research should be undertaken to corroborate and expand upon the initial results put forward in this study.

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CONFLICT OF INTEREST

Authors declare no conflict of interest.

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None declared.

AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	RZ, NH
Acquisition, Analysis or Interpretation of Data:	RZ, NH, MUJ, NZ, JS, RA, SH
Manuscript Writing & Approval:	RZ, NH, MUJ, NZ, JS, RA, MMA

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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