

Axial ocular dimensions and corneal astigmatism: The Kuala Pilah Cluster Cataract Study

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Abstract

Introduction: The Kuala Pilah Cluster Project involves Kuala Pilah Hospital as the lead hospital and the Jempol Hospital and Tampin Hospital as the district hospitals, serving as a single entity to provide ophthalmology services to the local population.

Purpose: To evaluate the distribution of ocular biometric parameters and corneal astigmatism in patients presenting for cataract surgery within the Kuala Pilah Cluster Hospital System.

Study design and methods: A cross-sectional study conducted on 273 consecutive patients presented for cataract surgery between January and June 2017. Ocular biometry measurements, including axial length (AXL), lens thickness (LT), and anterior chamber depth (ACD) of each right eye were measured using immersion A-scan ultrasound. Keratometric (K) readings were obtained via auto keratometer.

Results: The mean values for AXL, ACD, and LT were 23.40 ± 0.90 mm, 3.17 ± 0.49 mm, and 4.45 ± 0.96 mm, respectively. The average K-reading was 44.40 ± 1.59 D, with a mean corneal astigmatism of 0.82 ± 0.62 D. In this population, the females have significantly shorter AXL and ACD, but steeper K compared to the males ($P < 0.001$). The local Malays have higher AXL and ACD values compared to the Chinese and Indians. A total of 35.5% patients exhibited a corneal astigmatism greater than 1 D. The magnitude of preoperative astigmatism positively correlated with age ($P < 0.001$).

Conclusions: Ocular dimensions vary with gender and race in cataract patients from the Kuala Pilah cluster population. The probability of a patient requiring astigmatic

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correction increases with age. The average profile of ocular biometric data and corneal astigmatism may help local ophthalmologists to predict intraocular lens selections prior to cataract outreach projects.

Keywords: astigmatism, axial length, cataract, keratometry, ocular biometry

Dimensi aksial dan astigmatisma kornea: Kajian Katarak Kluster Kuala Pilah

Abstrak

Pengenalan: Projek Kluster Kuala Pilah melibatkan Hospital Kuala Pilah sebagai hospital utama, Hospital Jempol dan Hospital Tampin sebagai hospital daerah, yang berfungsi sebagai entiti tunggal untuk menyediakan perkhidmatan oftalmologi kepada penduduk setempat.

Tujuan: Untuk menilai liputan parameter biometrik okular dan astigmatisma kornea pada pesakit yang menjalani pembedahan katarak di Sistem Hospital Kluster Kuala Pilah.

Reka bentuk dan kaedah kajian: Kajian keratan rentas yang dilakukan pada 273 pesakit yang dijadualkan untuk pembedahan katarak antara Januari dan Jun 2017. Pengukuran biometri okular, termasuk panjang paksi (AXL), ketebalan lensa (LT), dan kedalaman ruang anterior (ACD) setiap mata kanan diukur dengan menggunakan ultrasound A-scan imersi. Bacaan Keratometrik (K) diperoleh melalui auto keratometer.

Keputusan: Nilai min bagi AXL, ACD, dan LT masing-masing adalah 23.40 ± 0.90 mm, 3.17 ± 0.49 mm, dan 4.45 ± 0.96 mm. Purata bacaan K adalah 44.40 ± 1.59 D, dengan min astigmatisma kornea ialah 0.82 ± 0.62 D. Dalam populasi ini, wanita didapati lebih pendek AXL dan ACD, tetapi K lebih curam berbanding dengan lelaki ($P < 0.001$). Melayu tempatan mempunyai nilai AXL dan ACD yang lebih tinggi berbanding kaum Cina dan India. Sebanyak 35.5% pesakit mempamerkan astigmatisma kornea yang lebih besar daripada 1 D. Besarnya astigmatisma pra-operasi positif berkorelasi dengan usia ($P < 0.001$).

Kesimpulan: Dimensi ocular berbeza dengan jantina dan kaum pesakit katarak dari populasi kluster Kuala Pilah. Kebarangkalian pesakit yang memerlukan pembetulan astigmatik meningkat dengan usia. Profil data biometrik okular dan astigmatisma kornea boleh membantu pakar mata tempatan untuk meramalkan liputan kuasa kanta intraokular diperlukan sebelum projek pengesanan katarak luar bandar dijalankan.

Kata kunci: astigmatisma, biometri okular, katarak, keratometri, panjang axial

Introduction

The Kuala Pilah Cluster Program is part of the Hospital Cluster Concept implemented by the Ministry of Health Malaysia. As one of the initiatives under the programme 'Transformasi Sistem Kesihatan' (Health Care Transformation System), this cluster system involves collaboration between government hospitals within the same state and geographical area.¹ Together, the hospitals work as a single entity by sharing resources and facilities to provide specialist services to the local population. The Kuala Pilah Cluster Program comprises our centre, Tuanku Ampuan Najihah Kuala Pilah Hospital, as the lead hospital, along with two other district hospitals, Tampin Hospital and Jempol Hospital.

In 2014, the National Eye Survey II identified untreated cataract as the commonest cause of visual impairment in Malaysia, accounting for 58.6% of the total blindness.² Accessible eye care with prompt cataract surgery is the key ophthalmology service provided by the Kuala Pilah Cluster Program as an initiative to combat cataract blindness in this region. Accurate measurements of ocular biometry and keratometry before cataract surgery are crucial for obtaining the precise power of intraocular lens in order to achieve good postoperative outcomes. Ocular biometric parameters are known to have racial variations.^{3,4} The Singapore Epidemiology of Eye Diseases (SEED) study reported ethnic variation in the ocular dimensions measured by IOLMaster (Carl Zeiss Meditec AG, Jena, Germany) among the three major ethnic groups – Chinese, Malays and Indians – in the urban area.⁵ However, there are no population-based studies available in Malaysia to compare demographics and ocular biometric trends in cataract patients from our multiethnic society and largely suburban dwellers with different socioeconomic background from our neighbouring country.

In this study, we aim to obtain an overview of the biometric characteristics across different gender and ethnic groups within the local population, and to determine the prevalence of corneal astigmatism before cataract surgery in the Kuala Pilah Cluster Hospital System.

Materials and methods

This is a prospective cross-sectional study conducted in the Kuala Pilah Cluster Hospital System. This study was approved by the institutional review board and adhered to the tenets of the Declaration of Helsinki. Consecutive patients who underwent cataract surgery between January and June 2017 were recruited. Exclusion criteria included history of refractive surgery, intraocular surgery, corneal

disease and trauma. Ocular biometry measurements including axial length (AXL), lens thickness (LT), and anterior chamber depth (ACD) of each right eye were obtained using immersion A-scan ultrasound (Quantel Compact Touch A/P/B, Quantel Medical, Cournon d'Auvergne Cedex, France). Meanwhile, keratometry (K) readings were obtained via auto-kerato-refractometer (Autoref/keratometer ARK-1/ARK-1a/ARK-1s, Nidek, Japan). Keratometry (dioptres) was measured in flat and steep meridians. The K value was calculated as the mean of these two meridians; Keratometric astigmatism calculated as the difference between these two meridians.

All statistical tests were performed using the IBM SPSS for Windows statistical software package (version 24.0; SPSS Inc., Chicago, Illinois, USA). Chi square was used for categorical variables, while the independent-sample t-test was used for continuous variables that are normally distributed and the Mann-Whitney U test was used when the distribution was not normal. An ANOVA (analysis of variance) test was used to analyse different means among the variable group. Meanwhile, Pearson correlation was used to measure the strength of a linear association between two variables. P values less than 0.05 were considered statistically significant.

Results

This study evaluated 273 eyes of 273 patients with a mean age of 67.99 ± 8.74 years. The majority of the patients were male (55.7%) and ethnic background showed predominantly Malays (57.1%), followed by Chinese (28.6%), Indians (13.6%), and others (0.7%).

The mean AL was 23.40 ± 0.90 mm. The mean values for ACD and LT were 3.17 ± 0.49 mm and 4.45 ± 0.96 mm, respectively. The average K-reading was 44.40 ± 1.59 D, with a mean corneal astigmatism of 0.82 ± 0.62 D. Figure 1 shows the distribution of corneal astigmatism in the study population. A total of 35.5% patients exhibited a corneal astigmatism greater than 1 D.

In this population, females have significantly shorter AL and ACD than males (23.17 ± 0.92 mm and 3.03 ± 0.45 mm respectively, $p < 0.001$). However, females have steeper K compared to males (44.83 ± 1.48 D, $p < 0.001$) (Table 1). In terms of ethnicity, Malays have significantly longer AL (23.48 ± 0.87 mm, $p = 0.027$) and ACD (3.26 ± 0.48 mm, $p < 0.0001$), whereas Indians have greater LT (4.66 ± 0.84 , $p = 0.003$) (Table 2).

Pearson correlation analysis showed that lens thickness increases with age ($p = 0.046$), while ACD decreases with age ($p < 0.0001$). Moreover, the magnitude of preoperative astigmatism also positively correlates with age ($p < 0.001$). There was no significant association between axial length and age (Fig. 2).

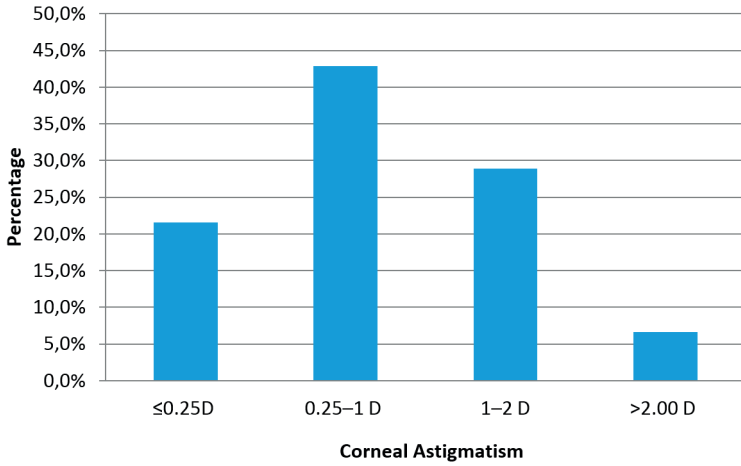


Fig. 1. Distribution of corneal astigmatism in the study population.

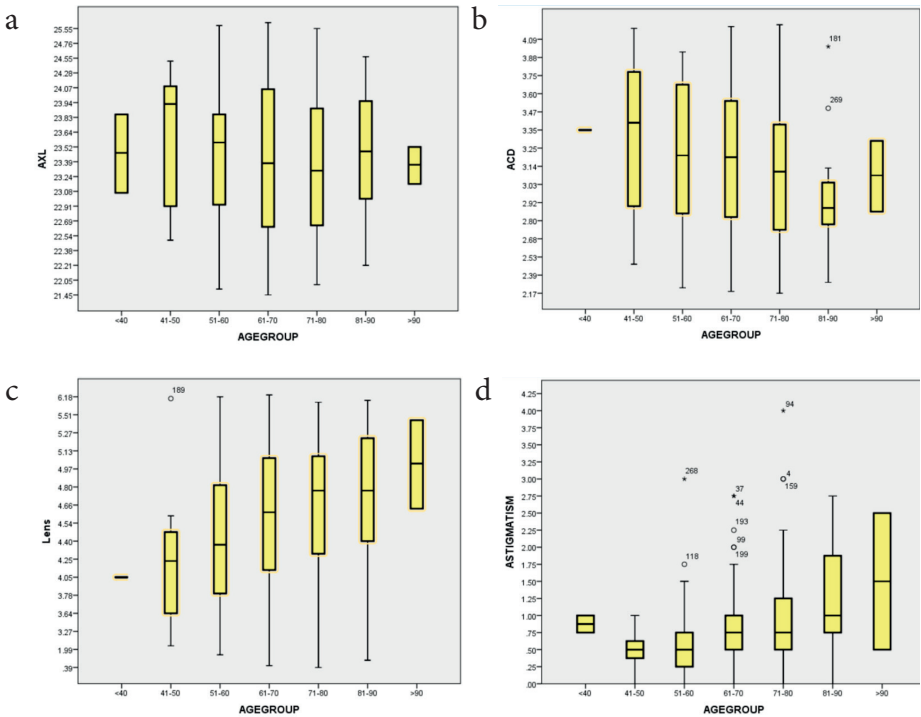


Fig. 2. Box-plot showing correlation between age group and AL (a), ACD (b), LT (c), and corneal astigmatism (d).

Table 1. Ocular biometry distribution by gender

| Variables | Total (n = 273) | Male (n = 152) | Female (n = 121) | P value |
|----------------|--------------------|---------------------|---------------------|----------|
| AXL, mm | 23.40 ± 0.90 | 23.58 ± 0.83 | 23.17 ± 0.92 | < 0.0001 |
| ACD, mm | 3.17 ± 0.49 | 3.28 ± 0.49 | 3.03 ± 0.45 | < 0.0001 |
| LT, mm | 4.45 ± 0.96 | 4.42 ± 0.99 | 4.47 ± 0.95 | 0.661 |
| Average K, D | 44.41 ± 1.59 | 44.07 ± 1.59 | 44.83 ± 1.48 | < 0.0001 |
| Astigmatism, D | 0.82 ± 0.62 | 0.86 ± 0.67 | 0.77 ± 0.56 | 0.203 |

ACD: anterior chamber depth; AXL: axial length; LT: lens thickness; D: dioptre
 AXL, ACD, LT: independent t-test; average K, astigmatism: Mann-Whitney U test
 p-values < 0.05 considered significant

Table 2. Ocular biometry distribution by ethnicity

| Variables | Total (n = 273) | Malay (n = 156) | Chinese (n = 78) | Indian (n = 37) | p |
|----------------|--------------------|---------------------|---------------------|--------------------|----------|
| AXL, mm | 23.40 ± 0.90 | 23.48 ± 0.87 | 23.41 ± 0.93 | 23.00 ± 0.84 | 0.027 |
| ACD, mm | 3.17 ± 0.49 | 3.26 ± 0.48 | 3.03 ± 0.44 | 3.01 ± 0.48 | < 0.0001 |
| LT, mm | 4.44 ± 0.97 | 4.38 ± 0.96 | 4.52 ± 0.94 | 4.66 ± 0.84 | 0.003 |
| Average K, D | 44.41 ± 1.59 | 44.30 ± 1.50 | 44.50 ± 1.53 | 44.71 ± 2.05 | 0.454 |
| Astigmatism, D | 0.82 ± 0.62 | 0.78 ± 0.59 | 0.92 ± 0.60 | 0.77 ± 0.76 | 0.405 |

ACD: anterior chamber depth; AXL: axial length; LT: lens thickness; D: dioptre
 ANOVA test used to calculate difference between groups
 p-values < 0.05 considered significant

Discussion

Our study reports cross-sectional data on demographic and ocular biometric characteristics for a multiethnic population in the Kuala Pilah Cluster Hospital Program presenting for cataract surgery. Patients presenting for cataract surgery in Kuala Pilah were predominantly elderly, male, of Malay ethnicity, and with corneal astigmatism less than one D. Although there are similar studies conducted in other South East Asian countries, to our knowledge, our study is the first to provide normative data for ocular dimensions in Malaysian population.

The ocular dimensions of the eye have been known to be influenced by ethnicity and racial factors. Table 3 summarises the ethnic group differences between our population and other major population-based studies. The mean AL of our population is 23.40 mm, shorter than Singaporeans (23.88 mm),⁵ longer than Burmese (23.14 mm),⁶ Chinese (23.11 mm),⁷ Mongolian⁸ (23.13 mm), and Auckland Caucasians (23.14mm),⁹ but similar to the Latinos (23.38 mm).¹⁰ It is worthwhile to dissect our findings by ethnic groups, where we found the Malays have significantly longer AXL and deeper ACD compared to the local Chinese and Indians.

Table 3. Comparison of demographic features between the present study and other published studies

| | Present study | SINDI ¹² | TPS ¹³ | SIMES ¹¹ |
|----------------------|---------------------|------------------------|-------------------------|-----------------------|
| Location | Kuala Pilah cluster | Adult Indian Singapore | Adult Chinese-Singapore | Adult Malay Singapore |
| Eyes/patients | 273/273 | 2785/2785 | 1004/1004 | 2788/2788 |
| Age (y) Mean | 67.99 ± 8.74 | 57.8 ± 10.1 | NA | 57.3 |
| Range | 28, 94 | 40, 83 | 40, 81 | 40, 80 |
| Male/Female | 152/121 | 1406/1379 | 457/547 | 1333/1455 |
| AXL (mm) | | | | |
| All | 23.40 ± 0.90 | 23.45 ± 1.10 | 23.23 ± 1.17 | 23.55 |
| Male | 23.58 ± 0.83 | 23.68 ± 1.06 | 23.54 ± 1.10 | 23.75 |
| Female | 23.17 ± 0.92 | 23.23 ± 1.10 | 22.98 ± 1.16 | 23.38 |
| ACD (mm) | | | | |
| All | 3.17 ± 0.49 | 3.15 ± 0.36 | 2.90 ± 0.44 | 3.08 |
| Male | 3.28 ± 0.49 | 3.19 ± 0.36 | 2.99 ± 0.45 | 3.13 |
| Female | 3.03 ± 0.45 | 3.10 ± 0.35 | 2.81 ± 0.47 | 3.03 |
| Keratometry | K-reading (D) | K-reading (D) | Corneal radius (mm) | Corneal radius (mm) |
| Male | 44.07 ± 1.59 | 43.88 | 7.73 ± 0.29 | 7.71 |
| Female | 44.83 ± 1.48 | 44.63 | 7.59 ± 0.24 | 7.59 |

ACD: anterior chamber depth; AL: axial length; D: dioptre

Similar findings were shown in population-based studies in Singapore, namely, the Singapore Malay Eye Study (SIMES),¹¹ Singapore Indian Eye Study (SiNDI),¹² and Tanjong Pagar Survey (Singapore Chinese).¹³ It is interesting to note that Chinese adults among our local population have longer AXL and deeper ACD compared to the Singapore Chinese¹³ and Liwan Chinese.⁷ Meanwhile, Indians among our local population have shorter AXL than the Singaporeans, but much longer than the Indians from Central India (22.6 mm). These findings are in line with emerging evidence that biometric parameters are influenced by anthropometric measurements and socioeconomic backgrounds, rather than by genetic ancestry.¹⁴⁻¹⁷ Urbanisation is believed to contribute to the elongation of AXL by increasing the demand of near-sighted work and less exposure to sunlight.^{18,19}

In this population, females were shown to have significantly shorter AXL and ACD. Other ocular biometry studies have produced similar results.^{7,8,10,15} This shows that ocular dimensions correlate well with human anthropometrics, where females have smaller body stature compared to males. The shorter AXL and ACD in females contribute towards a shallower ACD, predicting a higher risk for angle-closure glaucoma. LT was shown to increase with age; conversely, ACD had a negative correlation with age. Naturally, with the occurrence of cataract, the LT increases, thus reducing the ACD. Cataract surgery is proven to significantly deepen the anterior chamber.²⁰ We postulate that early cataract surgery in older women from our local population may reduce the incidence of angle-closure glaucoma.

The results of this study also show the positive correlation between preoperative corneal astigmatism ($P < 0.001$) with age. The prevalence of corneal astigmatism and its association with age have been well documented in the literature.²¹⁻²⁴ Hayashi *et al.* has shown that irregular corneal astigmatism tends to increase from middle to older age groups regardless of cataract surgery.²³ It is hypothesised that changes in upper lid tension and corneal degeneration contribute to this changes.²⁵ We have found that 35.5% of the cataract patients have a corneal astigmatism greater than 1 D. This figure is almost identical to that of Hoffmann *et al.* from Germany, who reported 36%²⁶ and Ferrer-Blasco from Spain (34.8%).²⁷ Other major studies have shown a slightly higher percentage, with De Bernardo *et al.* from Italy reporting 41.4%²⁸ and Wakefield *et al.* from England reporting 44.2%.²² Patients with more than 1 D of astigmatism should be considered for surgical correction during surgery for better postoperative visual outcomes and spectacle independence.

The limitation of our study is that this is a hospital-based study, and therefore more susceptible to selection bias. Population-based data with cluster samples will provide a more accurate illustration of normative data in Malaysia. We also recommend for our National Eye Registry for Cataract Surgery to include ocular biometry data to pave ways for future studies on ocular anatomical differences.

In conclusion, in the Kuala Pilah Cluster population, females have significantly shorter AL, ACD, and steeper K compared to males. Moreover, Malays among the local population have higher AXL and ACD values compared to Chinese and Indians

in the same population. This study also shows that the probability of a patient requiring astigmatic correction increases with age. The information regarding the average profile of ocular biometric data and corneal astigmatism may help local ophthalmologists to select intraocular lens more precisely prior to cataract outreach projects within this population.

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