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Correlation of angle kappa with biometry and higher-order aberrations of cataract patients at Prof. Ngoerah Hospital Ophthalmology Clinic

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ABSTRACT

BACKGROUND
Advancements in ophthalmic surgery now hinge on intricate interplays among ocular parameters. Angle kappa, measuring deviation between visual and pupillary axes, is crucial, especially in refractive procedures with multifocal intraocular lens implants. The research aimed to correlate angle kappa with biometry and higher-order aberrations (HOA) to enhance surgical outcomes among adult cataract patients at Prof. Ngoerah Hospital Ophthalmology Clinic, Denpasar, Bali.

METHODS
This cross-sectional study included 29 male and female cataract patients aged 18-80 years, without prior treatment. All patients had a basic examination that included testing of visual acuity using Snellen chart, autorefractometer, measurement of ocular pressure using non-contact tonometry, and slit-lamp examination for cataract grading. Patients who met the inclusion criteria were then examined for biometry (axial length, spherical equivalent, white-to-white distance, anterior chamber depth) using Nidek AL Scan and for angle kappa and HOA using OPD scan III.

RESULTS
Data from 50 eyes of 29 subjects (15 females and 14 males) were analyzed. The mean age of the subjects was 60.6 ± 12.5 years. Age and spherical equivalent had positive correlation with angle kappa (r =0.104, r=0.213), but the correlation was not statistically significant. In this study, interestingly angle kappa was not significantly correlated with HOA, AXL, WTW, and ACD (r = -0.050, r = -0.192, r = -0.104, r = -0.195, p >0.05).

CONCLUSION
In conclusion, angle kappa may increase with age and spherical equivalent. Further study with larger sample size is required.

Keywords: Angle kappa, biometry, higher-order aberrations, cataract

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METHODS

Research design

A cross-sectional study was performed at the Prof. dr. I.G.N.G. Ngoerah General Hospital Ophthalmology Clinic from July to October 2022.

Research subjects

The target population encompassed all cataract patients attending the Prof. Ngoerah General Hospital Ophthalmology Clinic. The study sample included patients who met the inclusion criteria, which involved being aged between 18 and 80 years and having no history of previous cataract surgery (with allowance for those with a history of corneal refractive surgery, such as LASIK). Exclusion criteria comprised conditions such as corneal ectasia, moderate to severe dry eye disease, intraocular inflammation, infection, cataract grade IV and above, glaucoma, and retinal abnormalities. The sample size, determined through the mean estimation formula, was set at 40, with a 95% confidence interval and a type I error of 5%. The sampling technique employed was consecutive sampling, wherein subjects meeting the selection criteria were included until the required number was attained.

Instrumentation

OPD-Scan III aberrometer

An OPD-Scan III aberrometer (Nidek, Japan) provided the total and intraocular high-order aberration (HOA) and angle kappa data, which were recorded as mean ±SD. The OPD-Scan III aberrometer is designed to calculate the angular deviation between the visual and pupillary axes, gathering specific data in photopic settings to discern variations in the visual axis in daylight (angle kappa photopic). Furthermore, its functionality extends to mesopic conditions, ensuring a thorough examination of visual and pupillary axis alignment in diminished lighting environments (angle kappa mesopic).

ALScan optical biometer

Biometry data were obtained using the ALScan optical biometer (Nidek, Japan) in the form of axial length (AXL), horizontal white-to-white (WTW), anterior chamber depth (ACD), and spherical equivalent (SE).

Examination

Patients who came to the Prof. dr. I.G.N.G. Ngoerah General Hospital Ophthalmology Clinic were subjected to basic examinations such as visual acuity with the Snellen chart or the logMar chart (Space Saving Chart SSC-370, Nidek) and autorefractometer, intraocular pressure examination with non-contact tonometry (Shin Nippon NCT 200, Japan), slit-lamp biomicroscopy examination to assess the anterior and posterior segments using a +78 D lens, and grading of cataract opacities using the Buratto criteria.[13]

Statistical analysis

Descriptive data were presented in the form of frequency distribution, cross tabulation, percentage, and mean. The normality test of the data is conducted using Shapiro-Wilk. Since the data is normally distributed, the Pearson correlation coefficient (r) test is then performed to assess the correlation between variables. A value of $p < 0.05$ was considered statistically significant. For the statistical analysis the SPSS 24.0 software was used.

Ethical clearance

This study was conducted after obtaining a certificate of ethical clearance from the research ethics commission of the Faculty of Medicine, Udayana University under number 1982/UN14.2.2.VII.14/LT/2022.

RESULTS

The number of subjects in this study was 29 people (15 men and 14 women) with a total of 50 eyes (26 right eyes, 24 left eyes) whose data were statistically analyzed. The age range of subjects in this study was 24-80 years, with mean patient age of 60.6 ± 12.5 years. Notably, the majority of cataract cases were classified as grade III, accounting for 88.46% for right eyes and 79.16% for left eyes. The mean magnitude of photopic and mesopic angle kappa for the right eyes was 0.31 ± 0.18 mm and 0.36 ± 0.18 mm, respectively, while for the left eyes, it measured 0.35 ± 0.16 mm and 0.39 ± 0.15 mm (Tables 1 & 2).

In this study, it was found that out of the total eyes examined, 6 eyes had AXL measurements greater than 27.5 mm. The mean angle kappa values for photopic and mesopic conditions in these eyes were 0.313 ± 0.168 and 0.425 ± 0.137, respectively. On the other hand, in eyes with AXL measurements less than 27.5 mm, the mean angle kappa was 0.331 ± 0.169 for photopic conditions and 0.370 ± 0.167 for mesopic conditions.

In this study, the obtained data was normally distributed, therefore the Pearson correlation test was conducted. There was no statistically significant correlation between angle kappa and age in this study (r= 0.014, r= 0.098). There was a negative relationship of photopic and mesopic angle kappa values with AXL, WTW, and ACD that was not statistically significant (p-value >0.05). We found a positive relationship of spherical equivalent with photopic and mesopic angle kappa values (r=0.213; r=0.079, respectively), but the relationship was not statistically significant. There was also a non-significant negative relationship of photopic and mesopic angle kappa values with HOA (Table 3).

DISCUSSION

In this study, a total of 29 subjects (15 males and 14 females) with 50 eyes met the inclusion and exclusion criteria, reflecting a diverse sample. The age range of the participants was broad, spanning from 24 to 80 years, with Grade III cataracts being the most prevalent at 82%. By addressing conflicting findings from previous studies, this research contributes to a more nuanced understanding of how age, spherical equivalent, and other factors may or may not influence angle kappa. The application of Pearson correlation tests revealed no significant correlation between angle kappa and age in this research. The mean angle kappa was 0.38 ± 0.17 in photopic conditions and 0.33 ± 0.17 in mesopic conditions. Interestingly, a non-significant negative correlation was observed between photopic and mesopic angle kappa values and key ocular parameters such as AXL, WTW, and ACD.

Angle kappa is the deviation between the axis of vision and the pupillary axis. This parameter holds significant importance as it influences IOL decentration, particularly in multifocal lens implantation, and may subsequently impact postoperative visual outcomes.[12] A study by Hashemi et al.[1] reported a non-significant relationship between increasing age and angle kappa. In our study, we also found no evident link between angle kappa and age. Although there was a positive correlation of age and spherical equivalent with angle kappa (r = 0.104, r = 0.213), it is important to note that this correlation did not achieve statistical significance. This is in contrast the study by Choi & Kim, [11] who reported a positive relationship between angle kappa and age, with angle kappa increasing with age. The largest angle kappa values were found in males aged 50 years and in females older than 70 years. This highlights the nuanced nature of this relationship and underscores the need for further exploration into the factors influencing angle kappa across different age groups.

Spherical equivalent has a linear correlation with angle kappa.[14] The study of Choi & Kim [11] in Korea also reported that angle kappa increased with SE. The research conducted by Ibrahim et al.[15] concentrated on exploring the correlation between angle kappa and spherical equivalent through the utilization of Orbscan 3. Their study highlighted a positive correlation between angle κ and spherical equivalent. Our study also found a positive correlation between spherical equivalent and both photopic and mesopic angle kappa (r=0.213; r=0.079). However, these correlations were not statistically significant, warranting further investigation.

In this study, interestingly angle kappa was not significantly correlated with HOA, AXL, WTW, and ACD. A previous study by Wang et al. [16] had established the normative values for angle kappa in a Caucasian population, revealing

Table 1. Ocular biometric parameters of the right eye (n=26)

Parameter	n (%)
Cataract grading (n%)	
Grade I	0 (0)
Grade II	3 (11.54)
Grade III	23 (88.46)
Spherical equivalent (diopters)	17.20 ± 5.45
Axial length (mm)	24.44 ± 2.31
White to white distance (mm)	11.76 ± 0.45
Anterior chamber depth (mm)	3.06 ± 0.53
High order aberrations	1.03 ± 1.19
Angle kappa photopic (mm)	0.31 ± 0.18
Angle kappa mesopic (mm)	0.36 ± 0.18

Note: data presented as mean ± SD, except for cataract grading n (%)

a significant positive correlation of mesopic and photopic angle kappa with SE. However, no specific correlation was found between angle kappa and HOA.(16) Another analysis involving 15,127 eyes of cataract patients at Fudan University, Shanghai, obtained a mean angle kappa value of 0.30 ± 0.18 mm. Factors such as WTW and ACD were identified as influencing variations in angle kappa. The study noted nonlinear changes in this angle with increasing AXL, impacting the position of angle kappa relative to the visual axis.(17) Kaharnova et al.(18) reported that an increase in AXL value is associated with a smaller critical angle kappa value, while a shallow ACD is associated with a larger angle kappa value. The angle kappa is considered a critical angle kappa if the incident light passes through the first ring of the multifocal IOL. This critical angle kappa is also related to centration and other biometric parameters such as ACD. This is supported by studies showing that a shallow ACD accompanied by a high angle kappa is a risk factor that can cause photic phenomena after multifocal IOL implantation.

Table 2. Ocular biometric parameters of the left eye (n=24)

Parameter	n (%)
Cataract grading (n%)	
Grade I	0 (0)
Grade II	5 (21.74)
Grade III	19 (79.16)
Spherical equivalent (diopters)	16.75 ± 5.84
Axial length (mm)	24.43 ± 2.31
White to white distance (mm)	11.81 ± 0.46
Anterior chamber depth (mm)	3.17 ± 0.55
High order aberrations	0.88 ± 1.14
Angle kappa photopic (mm)	0.35 ± 0.16
Angle kappa mesopic (mm)	0.39 ± 0.15

Note: data presented as mean ± SD, except for cataract grading n (%)

In some studies, a smaller angle kappa was found in patients with AXL <27.5 mm but the value became larger at AXL >27.5 mm. Large WTW values correlate with changes in pupillary diameter and can affect angle kappa measurements.(17,19) In the present study, we found that the mean mesopic angle kappa in the group of patients with an AXL of >27.5 mm was larger compared to the mesopic angle kappa in the group of patients with an AXL of <27.5 mm. However, from correlation testing, a statistically non-significant negative association was observed of the photopic and mesopic angle kappa values with AXL. Similarly, there was no statistically significant association of angle kappa with the values of WTW and ACD in our subjects.

Velasco-Barona et al.(20) reported a positive non-significant correlation between angle kappa and total HOA. A large angle kappa value was associated with a higher incidence of halo and glare in patients who had multifocal lens implantation, but no effect on postoperative visual acuity was found. Intriguingly, the study revealed a non-significant negative relationship between photopic and mesopic angle kappa values and higher-order aberrations. This finding challenges existing assumptions about the impact of angle kappa on visual quality after multifocal lens implantation, urging a re-evaluation of the factors contributing to postoperative visual outcomes.

The limitation of this study is that the sample size may not have been large enough to detect subtle correlations between angle kappa and other variables. Additionally, the study acknowledges conflicting findings in previous research regarding the relationship of age and spherical equivalent with angle kappa, which may introduce some uncertainty in the interpretation of the results. The study lacks consideration of potential

Table 3. Correlation between angle kappa and age and ocular biometrics

Parameters	Photopic angle kappa		Mesopic angle kappa	
	r *	p value	r *	p value
Age	0.014	0.236	0.098	0.499
AXL	-0.192	0.181	-0.055	0.707
SE	0.213	0.138	0.079	0.584
ACD	-0.195	0.175	-0.212	0.140
WTW	-0.104	0.473	-0.094	0.514
HOA	-0.050	0.365	-0.218	0.128

*r = Pearson correlation coefficient

confounding variables that could affect the correlation between angle kappa and other parameters, potentially compromising the validity of its conclusions. The research design, using a cross-sectional approach and consecutive sampling, may introduce selection bias, and the categorized cataract severity lacks a detailed breakdown that could impact angle kappa measurements. Unaccounted factors such as ethnic diversity, refractive history, and corneal biomechanics could contribute to variations in ocular parameters. Pupil dynamics in mesopic conditions and unexplored corneal aberrations might further confound angle kappa associations. Addressing these variables in future research would enhance result reliability and deepen the understanding of angle kappa influences.

Future research should expand this study by addressing key areas. Presumably the results of the present study are due to the limited sample size, therefore larger and more diverse participant pools are essential for detecting subtle correlations between angle kappa and other variables. A detailed breakdown of cataract severity, exploration of ethnic diversity, refractive history, and corneal biomechanics could offer valuable insights into ocular parameter variations. A longitudinal study design would capture dynamic changes over time, while investigating pupil dynamics in mesopic conditions and exploring corneal aberrations could deepen understanding of angle kappa associations. These refinements aim to enhance result reliability, informing surgical decisions, and optimizing visual outcomes in cataract multifocal implantation procedures.

CONCLUSION

This study demonstrated that angle kappa might increase with age and spherical equivalent in cataract subjects. Additionally, the study provides valuable insights into the lack of significant correlations of angle kappa with HOA, AXL, WTW, and ACD.

CONFLICT OF INTERESTS

Competing interests: No relevant disclosures.

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AUTHOR CONTRIBUTIONS

S conceived the idea for the study and its design, and performed statistical analysis and manuscript evaluation. IGARS elaborated on the study idea and design, and drafted the manuscript. SE was in charge of statistics and data analysis, page setting, and editing of the manuscript. All authors have read and approved the final manuscript.

DATA AVAILABLE STATEMENT

The data used to support the findings of this study is available from the corresponding author upon request.

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