

The Relationship between Anterior Chamber Depth, Axial Length and Intraocular Lens Power among Candidates for Cataract Surgery

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Type of article: Original

Abstract

Introduction: Basic anatomical parameters in ophthalmology are variable in different countries according to ethnic groups, genetics and some environmental factors. The aim of this study was to determine the relationship between axial length (AL), anterior chamber depth (ACD) and intraocular lens power (IOL) in a referral center from eastern Iran among patients who had cataract surgery, in comparison to studies from other regions of the world.

Methods: In a cross-sectional retrospective study from 2011 to 2013, the records of 698 cataract patients referring to Khatam Al Anbia general hospital in Mashhad, Iran were evaluated. We divided patients, based on their AL and ACD, into three separate groups and compared their results. The SPSS software was used for data analysis. The Chi-Square test and the Independent-samples t-test were used to compare qualitative and quantitative data between two groups, respectively. The Kendall and the Pearson product-moment correlation tests were used to assess the relationship between AL and ACD. The linear Regression model was used to obtain a mathematical model to estimate ACD, using AL, age and sex.

Results: Among individuals who had normal AL (between 22-24.5mm), there was a positive correlation between AL and ACD ($p < 0.001$, $r = 0.17$), however, among individuals with short ($AL < 22\text{mm}$) or long sightedness ($AL > 24.5\text{mm}$), no significant correlation was detected. We also found that older people have shorter AL ($p = 0.001$ and $r = -0.287$). Men have an average longer AL ($23.7 \pm 2.4\text{mm}$ vs. $22.9 \pm 2.1\text{mm}$; $p < 0.001$) and deeper ACD compared to women ($2.93 \pm 0.45\text{mm}$ vs. $2.82 \pm 0.42\text{mm}$, $p = 0.002$).

Conclusion: Our findings were mostly similar to previous literature from other regions of the world and although some anatomical variations may exist regarding ophthalmic anatomy, factors like race and geographical area have little effect on the relationship between ACD, AL and IOL power calculation, furthermore our results support the use of third and fourth generation formulas for IOL power calculation.

Keywords: Anterior chamber depth; Axial length; Intraocular lens power; Cataract; Iran

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Received: May 13, 2016, Accepted: July 09, 2016, Published: October 2016

iThenticate screening: July 04, 2016, English editing: September 28, 2016, Quality control: October 08, 2016

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1. Introduction

Cataracts are among the most common causes of decreased vision and even blindness (1) and approximately 17.2% of the population over 40 years old in the US will develop a cataract in at least one of their eyes (2). One of the most important indexes to evaluate post cataract surgery emmetropia is intraocular lens (IOL) power (3, 4). Numerous methods and formulas have been suggested for the measurements of IOL power, which are mostly based on axial length (AL), refractive power of the cornea and an estimation of the postoperative distance between the corneal epithelium and the lens. In these measurements, the preoperative anterior chamber depth (ACD) is considered as a constant part in the formula, because it was believed that by an increase in AL, the ACD increases accordingly (5). In the study by Holladay et al. (6) a new measurement formula was suggested, in which the preoperative ACD was implemented in the measurement of the IOL and a new formula was introduced as the Holladay 2 formula. The formula is shown to be precise in measuring IOL power when dealing with patients who have an AL of < 20 (7). Today new IOL calculation formulas recognize preoperative ACD in addition to AL, as an important factor (8-10). It has been proven that basic anatomical parameters (such as AL and ACD) in ophthalmology are variable in different countries according to ethnic groups, genetics and some environmental factors. In result, this may affect some parameters such as IOL power calculations, yet no study has specifically evaluated this matter (11, 12). Understanding region specific differences regarding IOL power calculations is vital for post cataract surgery evaluations. Considering race related differences, we hypothesized that this difference may affect the relationship between AL, ACD and IOL power, so here we investigate the relationship between AL, ACD and IOL power in a referral center from eastern Iran, among patients who had cataract surgery and we compared it to studies from other regions of the world.

2. Material and Methods

2.1. Study design and Patient selection

In a cross-sectional study from 2011 to 2013, the records of 698 cataract patients referring to Khatam Al Anbia general hospital in Mashhad, Iran were extracted. The study protocol was approved by the ethics committee of Mashhad University of Medical Sciences. All patients who visited the medical care center to have cataract operations of one eye in the two year time period, were included in the study. Any patient whose biometry was performed outside of the hospital, cases of traumatic cataract, phacomorphic glaucoma and finally any records that had missing data were excluded from the study.

2.2. Data collection

A questionnaire which included data on age, sex, AL and ACD was filled for each patient, based on their records. The ACD and AL were extracted from the biometry reports. AL and ACD measurements were carried out using an Optikon sonography machine by a trained medical worker. The biometry testing was carried out using the contact method. In this method a drop of tetracaine is applied in both eyes, in a supine position. While looking at the red light on the probe of the sonography machine, the probe is put in contact with the patient's cornea without applying any pressure. In this method, the probe is set vertical on the corneal surface, in order to obtain the highest echo spike. This was repeated five times for each patient and the average AL was calculated by the machine. ACD was calculated automatically by the machine.

2.3. Classification and measurements

We considered $AL < 22\text{mm}$ as short sighted, $22\text{mm} < AL < 24.5\text{mm}$ as normal AL and $AL > 24.5\text{mm}$ as long sighted. For ACD we considered $ACD < 2.45\text{mm}$ as low depth, $2.45\text{mm} < ACD < 3.31\text{mm}$ as normal ACD and $ACD > 3.31$ as high ACD.

2.4. Statistical analysis

Data were analyzed by the SPSS version 18 (SPSS Inc., Chicago, IL, USA). Patients were classified into age groups of less than 30, 31-50, 51-60, 61-70, and over 70 years old for better comparison and evaluation. Descriptive data are presented as frequency and percentage, where appropriate. Qualitative data were compared among groups using the Chi-Square test. The Independent-samples t-test was used, to compare quantitative data between two groups. The Kendall and the Pearson product-moment correlation tests were used, to assess the relationship between AL and ACD. The linear Regression model was used, to obtain a mathematical model to estimate ACD using AL, age and sex. All the data are displayed as mean \pm standard deviation. A p-value of less than 0.05 was considered as statistically significant.

3. Results

Overall 698 cases (eyes) were studied and among whom, 361 cases were men (51.7 %). The overall mean age of the patients was 61.5 ± 15.6 years. The mean (SD) age of the men and women was 61.1 ± 16.3 and 61.9 ± 14.8 years old, respectively. The two sexes did not display a statistically meaningful difference in their age ($p = 0.53$) (Table 1). Four hundred and sixty-seven patients had normal AL (66.9 %), 87 patients were long sighted (12.5%) and 144 patients were short sighted (20.6%). Four hundred and seventy seven patients had normal ACD (68.3%), 117 patients had high ACD (16.8%) and 104 patients had low ACD (14.9%) (Table 2). The mean (SD) AL was 23.3 ± 2.35 mm. Men had significantly longer AL in comparison to women (23.7 ± 2.4 mm vs. 22.9 ± 2.1 mm; $p < 0.001$). The mean (SD) ACD was 2.8 ± 0.48 mm. The overall ACD was statistically higher in men in comparison to women (2.93 ± 0.45 mm vs. 2.82 ± 0.42 mm, $p = 0.002$). Data analysis showed that there is an overall meaningful difference in the distribution of patients, based on the classification of AL and ACD ($p < 0.001$). The Kendal Correlation and the Pearson correlation tests showed that there is a direct (linear) and positive relationship between AL and ACD ($r = 0.308$; $p = 0.001$). This was only seen in cases with normal AL ($r = 0.175$; $p = 0.001$), and was not significant in short and long sighted patients. Overall, there was a significant and inverse relationship between AL and age ($r = -0.287$; $p = 0.001$). We found a positive and direct correlation between age and AL in short sighted patients ($r = 0.537$; $p = 0.001$) and an inverse correlation in long sighted patients ($r = -0.615$; $p = 0.001$), no significant correlation was seen between age and AL in the group of patients with normal AL ($p = 0.14$). Overall ACD and age displayed an inverse correlation ($r = -0.173$; $p = 0.001$). This correlation was seen in patients with normal ACD ($r = -0.134$; $p = 0.001$). There was no significant correlation between ACD and age in patients with high and low ACD ($p = 0.83$ and $p = 0.87$, respectively). The linear regression model was used, to assess the relationship between ACD, age, sex and AL and the following result was obtained: $ACD = 1.822 + 0.051 (AL) - 0.003 (age) + 0.0644 (sex)$. In this model, 1 for males and 0 for females should be substituted instead of sex.

Table 1. Patients' baseline characteristics

Variables		Statistics	p-value
Sex; n (%)	Male	361 (51.7)	
	Female	337 (48.2)	
Age (year)	Male	61.1 ± 16.3	
	Female	61.9 ± 14.8	0.53
Age groups (years); n (%)	Less than 30	40 (5.7)	
	31-51	117 (16.8)	
	51-60	120 (17.2)	
	61-70	209 (29.9)	
	Above 70	212 (30.4)	

Table 2. Distribution/number of patients according to the classification of axial length and anterior chamber depth

Variables		Statistics			p-value
		Male	Female	Total	
Axial length	<22	44 (12.2)	100 (29.7)	144 (20.6)	<0.001
	22.24.5	264 (73.1)	(60.2) 203	467 (66.9)	
	>24.5	53 (14.6)	(10.1) 34	87 (12.5)	
	Overall	361 (100)	(100) 337	698 (100)	
Anterior chamber depth	<2.55	46 (12.7)	(17.2) 58	104 (14.9)	<0.066
	2.45-3.31	254 (67.9)	(68.8) 232	477 (68.3)	
	>3.31	70 (19.4)	(13.2) 47	117 (16.8)	
	Overall	261 (100)	(100) 337	698 (100)	

4. Discussion

In this study, we evaluated the relationship between AL and ACD with IOL in a sample of Iranian patients undergoing cataract surgery and we found that similar to recent studies in other populations (10, 13, 14) and contrary to previous belief, the majority of our patients with short and long sightedness had normal ACD values (63.9% and 59.8%, respectively), indicating the use of third and fourth generation IOL power calculation formulas in the Iranian population. In a study published in 2010, Hoffmann and Hutz (15) analyzed AL, ACD and the corneal radius of 15,448 patients during a six year period in Germany. They found that the mean (SD) AL and ACD were 23.43 ± 1.51 mm and 3.11 ± 0.43 mm, respectively. Hoffer (16) evaluated 7,500 patients with cataracts, and found

that the mean AL and ACD among these patients were $23.65 \pm 1.35\text{mm}$ and $3.24 \pm 0.44\text{mm}$ which was comparable to our study (AL: $23.3 \pm 2.35\text{mm}$ and ACD: $2.8 \pm 0.44\text{mm}$). In the study by Holladay (13) among 1000 patients, 82% had normal AL and only 0.9% of patients had short sightedness. The number of short sighted patients, documented in the latter study, was less than that documented in our study (20.6%). The average AL was significantly higher in men compared to women and this was seen only in the group with normal AL. This finding was in coherence with the study by Jivrajka et al. (14), where they studied 750 patients and documented that among patients referring for refractive surgery, male patients had longer AL ($23.76 \pm 1.00\text{ mm}$ versus $23.27 \pm 1.01\text{ mm}$) and a younger age for disease presentation. The relation between AL and ACD was the main goal of this study. Holladay et al. (13) found that among long sighted patients, 90% have normal ACD, 10% have high ACD and none of them have short ACD (59.8%, 37.9% and 2.3% in our study, respectively). In the group of patients with normal AL, they found that 90% of patients had normal ACD, none of them had low ACD and 10% had high ACD (71.3%, 13.5% and 15.2% in our study, respectively). In patients with short sightedness they found that 20% have low ACD, 80% have normal ACD and none of them have high ACD (27.1%, 63.9% and 9% in our study, respectively). In a study by Hosny et al. (17), they evaluated 211 patients in Spain and found that ACD has a positive and meaningful relation with AL and the diameter of the Cornea. This was in coherence with the findings of Jivrajka et al. (14) who documented positive correlation between AL and ACD ($r = 0.423$; $P < 0.001$). We also documented a linear and positive correlation between AL and ACD, although K J Hoffer in 1993 (18), postulated a curve like relationship between AL and ACD. In our study the linear relationship was only seen in patients with normal AL and not in short and long sighted patients. We documented a positive correlation between AL and age, in the group with an AL of less than 22mm (short sightedness), but this was an inverse correlation in the group who had an AL of more than 24.5mm (long sightedness). Overall an inverse relationship was observed between age and AL, this finding was also seen in the studies by Hosny et al. (17) and Jivrajka et al. (14). We found an inverse correlation between ACD and age, which was seen only in the group with normal ACD. Hsu et al. (19) studied 1,480 preoperative cataract patients from 2006 to 2010 and evaluated the correlation between ACD and age, sex and body height. They found that ACD has an inverse correlation with age, while sex was not an independent associating factor for ACD. In order to obtain a mathematical model and to assess the relationship between ACD, AL, age and sex, we used the regression model, and found that ACD is dependent on AL, age and sex. Our study was not without limitation. First was its retrospective nature which did not allow an assessment of other factors which may have affected AL and ACD, including lens thickness and corneal diameter. Although our study mostly aimed to evaluate region specific differences regarding IOL power calculation, AL and ACD, our results were similar to what was published in previous literature. Since our study had a retrospective nature, we were not able to alter the AL calculation method which was used in our study (contact method), which is among the least accurate methods of AL measurement.

5. Conclusions

Our study findings were mostly similar to studies from other regions of the world and although some anatomical variations may exist in ophthalmic anatomy, factors such as race and geographical area have little effect on the relationship between ACD, AL and IOL power calculation. Similar to previous literature, our results support the use of third and fourth generation formulas for IOL power calculation in the Iranian population. Prospective multi-centered studies and systematic reviews should be designed to evaluate the changes in IOL power calculation and its relationship to AL and ACD in different regions of the world.

Acknowledgments:

This study was affiliated with Mashhad University of Medical Sciences and is the thesis of Dr. Naghmeh Tehranian.

Conflict of Interest:

There is no conflict of interest to be declared.

Authors' contributions:

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

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