ORIGINAL ARTICLE

Accuracy of Immersion Biometry for Cataract Surgery in Refraction Division Cipto Mangunkusumo Hospital 2013-2014

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ABSTRACT

Introduction and Objective : With the improvement in surgical techniques, accurate preoperative intraocular lens (IOL) power calculations in cataract surgery are fundamental to achieving the desired refractive outcomes. To determine IOL power, biometry data are necessary in estimating of the postoperative effective lens position. Currently there are 3 techniques in biometry examination; optical, applanation, and immersion. In Cipto Mangunkusumo Hospital immersion technique was most often used. The aim of this study is to determine the accuracy of IOL calculations in eyes undergoing phacoemulsification cataract surgery with IOL implantation using immersion A-scan ultrasound biometry and evaluating the most influencing factors in biometry.
Methods : Review retrospectively medical records of patients having phacoemulsification with in-the-bag IOL implantation measured in ultrasound immersion biometry, determining AL, average K, ACD, lens thickness IOL power calculations with the SRK/T formulas, and postoperative predictability of the device. Demographic characteristic, refractive outcomes, and correlation between variable were evaluated.
Results : Five hundred and six patients were evaluated. The accuracy of immersion ultrasound biometry in this study was 82% in range of <0.25D. The estimation refractive outcome had positive correlation with sphrerical equivalent post operatively. ACD was shown to be the most significant variable in predicting the accuracy of biometry.
Conclusion : The realibility of physician for doing and interpreting immersion ultrasound biometry has reached the ideal result in this study. A comprehensive learning with continuing education and training is essential for biometry's operator, to ensure the accuracy of post-operative result in cataract surgery.

Keywords : *Biometry, immersion ultrasound, cataract, phacoemulsification, refractive outcomes accuracy*

Cataract is one of the leading causes of eyesight loss in the world, resulting to over 20 million cases of blindness in 2010 alone.[1] Due to increase of life expectancy, combined with the rise of cataract risk factors – among others; smoking, diabetes mellitus, and high BMI – the number of cases is predicted to double by 2020.[2] In the USA, change of lens health is reported on 42% of population aged 52 – 64 years old, 60% at age of 65 -

74 years old, and 91% at the age of 75 – 85 years old.[3]

Treatment of cataract involves implanting an artificial intraocular lens (IOL) in replacement of the thickened lens. Outcome of this treatment can be maximized through selecting an appropriate size of the implanted lens. In turn, selection of implanted lens is dependent of an accurate eye anatomy measurement and the use of formula to predict lens power fitting to the patient.[4]

Biometry measurement in Indonesia is performed through three methods. The first two methods are done by ultrasound A with two technique alternatives; applanation and immersion. The last method is called partial coherence interferometry (PCI), which otherwise is known as optical biometry. Currently, Cipto Mangunkusumo hospital (RSCM) implements immersion technique for biometry measurement. This technique is chosen due to superior accuracy compared to applanation, notably in pediatric patients.[5] Despite being inferior to PCI in terms of accuracy and refractive correction, immersion technique delivers a good result which is above the current standard of practice.[6]

Siregar SR[7] has performed a descriptive study on immersion technique in 2010. Result of this study showed, that the accuracy of biometric ultrasonography with immersion technique within the ± 0,5 D range is that of 56.25%. To build on previous result, report to the result of the immersion technique in cataract operation performed in Ophthalmology department of Faculty of Medicine, University of Indonesia (FMUI), in conjunction with RSCM is needed. Also in the effort to expand the previous result, the study will be conducted within a longer time period, namely from January 2013 throughout January 2014.

METHODS

Study design. This is a descriptive retrospective cross-sectional study. It was performed in Ophthalmology department of FMUI – RSCM in Jakarta as well as in the Ophthalmology operating theatres.

Study subjects. Study population was obtained from secondary data collected from medical records of patients undergoing biometrical ultrasonography with immersion technique in refractory division of Ophthalmology medical department of RSCM. Data was attained from cataract operation carried out between January 2013 and January 2014. We included all patients undergoing cataract operation with phacoemulsification technique, along with implanted ocular lens of any kind (acrylic hydrophilic foldable US IOL, ER40E, SA60AT, SN60AT, FH105, FH106, SN60WF, Neo Eye) with 'in the bag' position. We excluded patients with incomplete data in their medical records and/or post-operative visual acuity data, patients with abnormalities of the posterior segment, and patients who experienced complication both intra- and post-operative.

Statistical methods. All statistical analysis was performed using 'Statistical Package for the Social Science' software, version 11.

RESULT

Out of the 605 participants recruited, 67 were excluded due to incomplete medical record, 17 due to missing medical records, and 15 due to absence during follow-up session. The remaining 506 participants were all eligible to be included in the study. Subject and biometric characteristics are depicted in Table 1.

Mean power of implanted lens on study subject was 19.91 with refraction target of between -2.80 and 1.15. Post-operation sphere had a range of between -3.50 and 0.75 with post-operative cylindrical average of -0.72. ,, post-operative spherical equivalent (SE) in this study had an average of -0.65 with range between -4.25 and 2.63. Data on refractory results and lens power used is shown in Table 2.

Correlation test between refraction targets with post-operative SE was performed with Spearman's test resulting in a significant p (p=0.000), with correlation value of 0.204, which shows weak positive correlation.

Table 1. Demographic and Biometric Characteristics of Patients

Variable	Mean (SD) or N (%)	Range
Gender		
Male	259 (51,2%)	
Female	247 (48,8%)	
Eye		
Right	248 (49%)	
Left	258 (51%)	
Age (years)	622.22 (11.54)	6-83
Keratometry		
K1	43.89 ± 1.56	39.55 – 48.85
K2	43.88 ± 1.57	39.50 – 48.85
Average K	43.83 ± 1.94	16 – 48.35
BMD	3.28 ± 0.47	2.28 – 4.49
Lens thickness	4.36 ± 0.69	1.67 – 6.32
Eyeball length	23.85 ± 1.59	15.86 – 32.42

Table 2. Post-operative Refraction Results Based on IOL Power

Refractory variables	Mean ±SD	Range
IOL Power	19.91 ± 4.12	-5.00 – 29.00
Refraction target	-0.51 ± 0.32	-2.80 – 1.15
Post-op Cylindrical	-0.72 ± 0.85	-8.00 – 2.00
Post-op SE	-0.60 ± 0.91	-4.25 – 2.63
Post-op sphere	-0.52 ± 0.71	-3.50 – 3.00

Table 3. Post-operative Differences Between Refraction Target and Spherical Equivalent (SE)

Refractory variables	Mean ±SD	Range
Refraction target	-0.51 ± 0.32	-2.80 – 1.15
Post-op SE	-0.60 ± 0.91	-4.25 – 2.63

This study also showed that 415 (82%) of subjects had a biometrical accuracy of less than 0.25 D, while 66 participants (13%) had an accuracy of between 0.25 and 0.50 D, 14 (2.80%) had an accuracy of between 0.50 and 1.00 D, and 11 (2.20%) had an accuracy of between 1.00 and 2.00 D. Table 4 below provides biometrical accuracy data obtained from this study.

Average of mean refraction error and mean absolute refraction error was -0.10 D and 0.66 D (Table 5). There was an 81% biometrical accuracy obtained in this study (Table 6). As many as 9.50% was placed in <22.50 mm AXL (axial length) group with average mean absolute refraction error of 0.68 D. This study depicted that 48.42% of patients' eyes were within the 43.00 – 45.00 group and had a mean absolute refraction error of 0.65 D (Table 8). It was also shown that 81.62% of patients' eyes were at 3.00 – 5.00 lens thickness group, with average mean absolute refraction error of 0.65 D (Table 9). Meanwhile, 35.57% of patients eye were within 3.50 – 4.50 BMD group and had an average mean absolute refraction error of 0.58 D (Table 10).

Bivariate correlation analysis was run to identify correlation between refractive predictability with each variables influencing biometrical measurement. The result demonstrated that there was a

significant correlation between refractive predictability with BMD (p<0.05) (Table 11).

Table 4. Biometrical Accuracy based on Refraction Results

Biometrical Accuracy	Frequency	Percentage	Cumulative
< 0,25 D	415	82%	82%
0.25 - 0.50 D	66	13%	95.10%
0.50 - 1.00 D	14	2.80%	97.80%
1.00 - 2.00 D	11	2.20%	100%

Table 5. Refractive Predictability Error

Refractive Variables	Mean ±SD	Range
Mean Refractive Error	-0.10 ± 0.88	-3.92 – 2.98
Mean Absolute Refractive error	0.66 ± 0.59	0 – 3.92

Table 6. Refractive Predictability Error

Deviation	n = 506 eyes	Cumulative percentage (%)
≤ 0.25 D	124	24.50
≤ 0.50 D	143	52.80
≤1.00 D	143	81
> 1D	96	100

Table 7. AXL Proportion to Refractive Predictability

AXL (mm)	n (%)	Mean Absolute Refraction Error (D)
< 22.50	48 (9.5)	0.68 ± 0.68
22.50 – 24.00	291 (57.50)	0.65 ± 0.59
> 24.00	167 (33)	0.66 ± 0.58

Table 8. Keratometry Proportion to Refractive Predictability

Keratometry Average (mm)	N (%)	Mean Absolut Refraction Error (D)
< 43.00	151 (29.84)	0.67 ± 0.58
43.00 – 45.00	245 (48.42)	0.65 ± 0.61
> 45.00	110 (21.74)	0.63 ± 0.57

Table 9. Lens Thickness Proportion to Refractive Predictability

Lens Thickness (mm)	N(%)	Mean Absolut Refraction Error (D)
< 3.00	18 (3.56)	0.78 ± 0.60
3.00 – 5.00	413 (81.62)	0.65 ± 0.58
> 5.00	75 (14.82)	0.65 ± 0.64

Table 10. BMD Proportion to Refractive Predictability

ACD (mm)	N(%)	Mean Absolut Refraction Error(D)
< 3.50	326 (64.43)	0.69 ± 0.62
3.50 – 4.50	180 (35.57)	0.58 ± 0.52
> 4.50	0 (0)	-

Table 11. Correlation Between Refractive Predictability and Biometrical Variables

		Average of K	AXL	Lens Thickness	BMD
Predictability	p	0.969	0.639	0.465	0.001
Refraction	r	-0.002	-0.021	-0.033	-0.142

DISCUSSION

This descriptive study used biometrical ultrasonography with immersion technique. By using this technique, the ultrasonography probe will be 5 – 10 mm from the cornea, therefore not applying pressure to the cornea. Absence of pressure to the cornea in the immersion technique meant more accurate biometrical measurements in comparison with applanation technique.

This study showed that the average age of patients undergoing cataract operation in Ophthalmology department of FMUI – RSCM between January 2013 and January 2014 is 62.22±11.54 years old, with the youngest being 6 years old and the oldest 83 years old. Male participants outnumber female participants in term of gender proportion with 51.2% and 48.8% of the total participants respectively. This is in accordance with Wadud Z *et al*[8] who found in their study that cataract incidence is more common among men compared to women. However, Wimalasundera S *et al*[9] found a

different result in which women outnumber men in terms of cataract incidence. Such difference may be explained by the higher number of visiting male patients compared to their female counterparts.

Biometric characteristic as demonstrated in Table 1 showed that value of vertical keratometry is higher than that of horizontal keratometry, therefore the sample of the studies can be categorized as 'with the rule' astigmatism.

A study conducted by Shammas HJ *et al* stated that 98% of cornea curvature lies between 40.00 to 48.00 D, while 68% are between 42.00 to 45.00 D. This study also suggest for re-examination whenever a difference of 0.3 mm of eyeball length or 1 D cornea curvature is found. Additionally, error minimalization can be done through proper calibration of the keratometer.[10,11]

Furthermore, Shammas *et al* found an average of lens thickness of 4.36 ± 0.69 mm with interval of 1.67 – 6.32 mm. This could be due to absence of limb support given to the lens to the zonular structure hence increasing the likelihood of thickening. Moreover, there is also the theory that lens will thicken parallel to the increase of age.

According to the guideline by The Royal College of Ophthalmologists (RCOphth) in 2004,[12] one of the indicators of an excellent biometry quality is a post-operative Spherical Equivalent (SE) of 0.5 – 1 D. As many as 97% of the patients (n=500) obtained a post-operative SE of 1 D after A constant adjustment. However, other studies have shown that without A constant adjustment, only 87% (n=50) to 93% (n=100) participants achieve a post-operative SE of 1 D. This study showed a post-operative SE of an average of -0.60 ± 0.91 D with an average of refraction target of -0.51 ± 0.32 D.

Studies conducted by Astbury *et al*[10] and Shammas *et al*[13] advised to conduct re-examination when AXL difference between two eyes is more than 0.3 mm. Several studies reported that AXL measurement with applanation technique results in 0.24 – 0.32 mm shorter AXL in comparison to measurement with immersion technique.[14,15]

Results from Spearman's correlation test on eyeball length and gender showed a significant p value of $p<0.001$ and $r = -0.192$. This demonstrated a very weak negative correlation between eyeball length and gender. The average length of male participants' eyeballs (23.95 mm) is longer than that of female participants (23.73 mm). This is in congruence with results of several other researches that suggest that men have longer AXL compared to women.[16,17,18,19,20]

In this study, post-operative SE was shown to experience overcorrection rather than undercorrection. Most patients also need refractive correction with minus sphere glasses. A biometrical accuracy of 82% was obtained in under 0.25 D. This meant that the power of implanted ocular lens during opeartion has an accuracy of 82% within ±0.25 dioptry, while between 0.25 – 0.5 dioptry, the obtained biometry accuracy is at 95.10%. Based on these results, it is suggestive that the performance of biometric evaluation operator in Ophthalmology department of FMUI – RSCM between the period of January 2013 to January 2014 could be regarded as excellent.

A normal AXL (ranging from 22.5 – 24 mm) was observed in 57.5% of the patient. This group of patients have the least mean absolute refraction error at ±0.65D, followed by the >24 mm AXL group, with a ±0.66D value. This is in accordance with the study conducted by Lestari in 2013.[21] According to the study, biometry measurement in highly myopic eyes has a high accuracy, with mean absolute refraction error of 0.5 D, similar to the value that our study showed.

Average absolute refractive predictability error that was obtained was at 0.66 D with biometrical accuration of 81%. Naicker *et al*[22] in their study presented an absolute refractive predictability error of 71%. This difference may be explained by the difference in sample and research population, as well as inclusion and exclusion criteria, and the study methods.

Table 8 in the result section depicted proportion of eyeball length towards the absolute refractive predictivity. We demonstrated that as many as 57.5% is included in the 22.5 – 24 mm length group (with refractive predictability of 0.65 D). This result showed that an eyeball length of 22.50 – 24 mm has the least mean absolute refraction error compared to the other groups, namely <22.50 mm, and >24 mm. Keratometry variable showed a mean absolute refraction error at 0.63 D is on 21.74% of the >45 mm group. Meanwhile, when considering the lens thickness variable, 3 – 5 mm thickness group has least mean absolute refraction error. The least mean absolute refraction error within the ACD variable is 3.50 – 4.50 mm group. These differences may be due to uneven distribution of the patients.

Relationship between various biometrical variables have been analyzed using bivariate correlation test. The result of the analysis showed a significant correlation between refractive predictability and ACD ($p<0.05$). This showed that ACD is an important factor which is often undervalued in attaining an optimised refraction target after a cataract surgery.

Selecting formula in biometrical measurement is one of the factors affecting the accuracy of the measurement of implanted ocular lens. Each formula work best in a certain AXL. The SRK/T formula is thought to be best on eyes with normal AXL (22.50 – 24 mm) and longer AXL (>24 mm).[23,24] Therefore, applying this formula correctly is expected to increase the accuracy of measurement of implanted lens power in this descriptive study.

This study has several limitations, among others, missing medical records, uneven sample distribution, varying degree of cataracts among participants, incomplete post-operative biometry and visual acuity data, variability in operator skill while performing biometrical measurement and best visual acuity, as well as selection of implanted ocular lens and variability of techniques between surgery operator.

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