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Original Article

OPTICAL VERSUS ULTRASONIC BIOMETRY IN INTRAOCULAR LENS CALCULATION IN HIGH MYOPIC CATARACTOUS PATIENTS: A COMPARATIVE STUDY

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Abstract

Purpose: *To compare between accuracy of optical and ultrasonic biometry in IOL calculation in high myopic cataractous patients to achieve the desired postoperative refraction.* ***Methods:*** *Prospective, Comparative, Randomized Interventional study included 50 eyes with axial length of 26.5 mm or more divided into 2 groups:* ***Group (1): (optical biometry group)*** *included 25 eyes and* ***Group (2): (ultrasonic biometry group)*** *included 25 eyes. Haigis formula was used for intraocular lens power calculation. Phacoemulsification with intrabagal IOL was performed. The 2 groups were compared preoperatively for axial length (AL), K readings and Ant chamber depth (ACD) and they were compared postoperatively for spherical equivalent (SE), prediction error (PE) and mean absolute error (MAE) one month postoperatively.* ***Results****: the study was conducted on 50 eyes who were divided into 2 groups****.*** *As regard preoperative measures, mean AL measured by* ***optical*** *biometry was 28.76±1.56 mm whereas that measured by* ***ultrasonic*** *biometry was 28.58±1.55 mm with a mean difference of 0.18±0.27 mm, which was* ***statistically significant*** *(P <0.05) whereas other parameters: k readings, ACD, were nearly comparable in both groups. (P > 0.05). As regard the postoperative results, the difference between 2 groups in postoperative spherical error, prediction error and mean absolute error was also not statistically significant (P > 0.05), however better postoperative refractive outcomes were noticed with* ***optical*** *biometry****. Conclusion:*** *optical biometry provides more accurate measurements of biometric parameters, especially axial length than applanation ultrasonic biometric in high myopic patients, also Haigis formula is preferred with high myopia, providing acceptable postoperative refractive outcomes with both methods.*

Keywords: *High myopia, IOL calculation, Optical biometry, Ultrasonic biometry, Phacoemulsification*

1. Introduction

Cataract surgery is considered one of the most important ophthalmic surgical procedures ever, having great priority to improve its refractive outcomes to meet the increasingly patients' refractive expectations. This was met by many trials to improve surgical techniques and methods of IOL calculation. The achievement of satisfactory refractive outcomes is markedly dependent on precise preoperative intraocular lens [IOL] power calculation .Axial length (AL), keratometry, and lens formulas are among many factors affecting the refractive state after cataract surgery and IOL imp-

lantation. Of all, the preoperative axial length (AL) measurement is the most critical for IOL power calculation [1]. It can be measured by either ultrasonic or optical biometry. Previously, ultrasound biometry was the standard for IOL calculation using usually a 10-MHz acoustic wave transducer, however, over the last decade, optical biometry was introduced as a new, non-contact method based on partial coherence interferometry (PCI), increasingly replaced ultrasound biometry due to its efficiency over wide range of axial lengths and different conditions. In spite of the continuous progress in IOL calculation methods, there are many conditions associated with high incidence of postoperative refractive surprise. *High myopia* represents one of the most important conditions associated with unexpected refractive outcomes *Myopia* is a worldwide health issue; defined as spherical equivalent of ≤ −0.5 D whereas high myopia is defined with spherical equivalent of ≤ -6.0 D [2]. *High myopia* is one of the conditions in which IOL calculation is challengeable with increased tendency to unexpected hyperopic outcomes and increase the error rate of formula prediction with long AL [3]. In this study we compared between optical and ultrasonic biometry to determine which method is more accurate for prediction of posto-perative refraction in high myopic cataractous patients with axial length more than 26.5 mm

2. Patients and Methods

2.1. *Study design*

Prospective, Comparative Randomized Interventional study

2.1.1. Subjects

This study included 50 eyes of 50 patients scheduled for phacoemulsification and IOL implantation in the department of ophthalmology, Sohag university hospital in the period from August 2021 to October 2022. Written consent was obtained from the patients after explaining the purpose of the study. The study gained approval of Medical Research Ethics Committee (MREC), Sohag University under IBR registration number: Soh-Med-21-06-01 and data collection was conformed to all local laws and was compliant with the principles of the Declaration of Helsinki**.** They were divided into 2 groups:

Group (1) was measured by optical biometry

Group (2) was measured by contact ultrasonic biometry

2.1.1.1. *Inclusion criteria*

The study included patients with cataract not associated with other pathologies suitable for phacoemulsification and 1ry. IOL implantation With AL equal to or greater than 26. .

2.1.1.2. *Exclusion criteria*

We excluded patients with history of trauma, associated post segment pathologies such as (optic neuropathy, age related macular degeneration, macular edema, retinal detachment, retinitis pigmentosa or proliferative diabetic retinopathy), ocular inflammation, Corneal opacities or irregularities, scars, dystrophy or ectasia, previous ocular surgeries as refractive surgery, we also excluded patients in whom intraoperative complications as Posterior capsule tear, IOL decentration, vitreous loss, zonular dehiscence or wound suturing had occurred.

2.2. *Methods*

2.2.1. Patient evaluation

Each participant was subjected to:

a) Full history

b) Full ophthalmological examination including:

***)** Un and Best-corrected visual acuity (measured by Landolt C chart).
***)** IOP measurement using Goldman applanation tonometer.
***)** Ant. Segment examination by slit lamp bio-microscopy.
***)** Fundus examination by auxiliary lens and/or indirect ophthalmoscope

2.2.2. Methods of study

Patients were divided randomly into 2 groups: *Group (1)*: included 25 eyes who carry odd number in order. Axial length, keratometric readings and ACD were measured automatically optical biometry (TOPCON, ALADDIN HW 3.0, San Giovanni, Italy). *Group (2)*: included 25 eyes who carry even number in order. Axial length was measured by contact ultrasonic biometry (PacScan, Sonomed Inc, Lake Success, NY 11042) and keratometric measurements were obtained using auto-kerato-refractometre (TOPCON, 75-1, Hasunuma-cho, itabashi-ku, Tokyo, Japan. Intraocular lens power calculation: done by Haigis formula with intended post-operative refraction of emmetropia to mild myopia (-1) except for those with negative powered IOL in whom intended myopia of (-2 or -3) was planned. Surgery: Phaco-emulsification surgery was done through a 2.4 mm clear corneal incision, and intrabagal posterior chamber 1-piece hydrophilic acrylic foldable IOL (I-Vision, aurolab, No. 1, Maduri-625020, India) was implanted. Postoperative follow up: was scheduled 1 day postoperatively then weekly for 1 month with assessment of postoperative refraction one month following the surgery.

2.2.3. Statistical analysis

Data was analyzed using STATA version 14.2 (Stata Statistical Software: Release 14.2 College Station, TX: StataCorp LP.). Quantitative data was represented as mean, SD, median and range. Data was analyzed using student t-test to compare means of two groups. When the data was not normally distributed Mann-Whitney test was used. Qualitative data was presented as number and percentage and compared using either Chi square test or fisher exact test. Spearman's correlation analysis was used for correlation between MAE and other variables. Graphs were produced by using Excel or STATA program. P value was considered significant if it was less than 0.05.

3. Results

This study was conducted on 50 eyes of 50 highly myopic patients presenting with cataract (14 male (28%) and 36 females (72%)], of whom 25 patients were measured by optical biometry and 25 patients by applanation ultrasonic biometry

3.1. *Demographic characteristics*

The mean age in optical group was 49.56 ±8.21 years, and in ultrasonic group it was 59.48±10.28 years. In the optical group 19 patients (76%) were females and 6 patients (24 %) were males, while ultrasonic group included 17 females (68%) and 8 males (32%), tab. (1)

Table 1: Demographic criteria of studied groups

Variable	Optical biometry group N=25	Ultrasonic biometry group N= 25
Age/year		
▪ Mean ± SD	49.56±8.21	59.48±10.28
▪ Median (range)	48 (40:73)	58 (40:80)
Gender		
▪ Female	19 (76 %)	17 (68%)
▪ Male	6 (24%)	8 (32%)

3.2. *Preoperative data*

UCVA in the optical group ranged from 1/60 to 5/60 whereas in the ultrasonic group ranged from CF 50 cm to 4/60. *BCVA* in the optical group ranged from 3/60 to 6/24 whereas in the ultrasonic group ranged from 1/60 to 6/60. Statistically insignificant difference was found between 2 groups as regard mean *k1* and *k2*, mean ACD and mean IOL used (P>0.05). However, there was statistically significance difference between 2 groups in the measured axial length (P<0.05) as shown in tab. (2)

Table 2: Preoperative measurements in optical and ultrasonic biometry groups

Preoperative measurements	Optical biometry group N=25	Ultrasonic biometry group N= 25	P value
K 1			
▪ Mean ± SD	43.75±2.42	44.67±2.69	0.21
▪ Median (range)	43.78 (35.41:47.14)	44.75 (40.5:50.25)	
K 2			
▪ Mean ± SD	45.39±1.83	45.3±2.61	0.88
▪ Median (range)	45.24 (42.72:49.27)	45.25 (40.75:51.75)	
ACD			
▪ Mean ± SD	3.43±0.30	3.38±0.33	0.59
▪ Median (range)	3.43 (2.91:3.95)	3.3 (2.7:3.94)	
AL			
▪ Mean ± SD	28.76±1.56	28.58±1.55	0.003
▪ Median (range)	29.02 (26.5:31.7)	28.74 (26.32:31.3)	
Absolute power of IOL used			
▪ Mean ± SD	5.92±3.75	5.68±3.69	0.91
▪ Median (range	5 (0:14)	6 (0:16)	

3.3. *Postoperative data*

The 1ry outcome of the study was *postoperative SE* measured 1 month postoperatively and its analysis in the form of: Prediction error (PE) and its deviation from intended refraction and mean absolute error (MAE). *Postoperative spherical equivalent*: On follow up, we noticed statistically insignificant difference in postoperative spherical equivalent between both groups (P was0.24), tab. (3)**.** Prediction error: On calculating prediction error of Haigis formula with each group (which is *actual postoperative spherical equivalent-target postoperative refraction)*, we found statistically insignificant difference between both groups (P was0.57), tab. (4).

Table 3: Postoperative Spherical Equivalent in both groups

Variable	Optical biometry group N=25	Ultrasonic biometry group N= 25	P value
Spherical equivalent			
▪ Mean ± SD	-0.81±0.96	-0.61±1.33	0.24
▪ Median (range)	-0.75 (-2.75:1.25)	-0.5 (-2.50:1.5)	

Table (4): Prediction Error for Haigis in optical and ultrasonic biometry groups

Variable	IOL master group N=25	A scan biometry group N= 25	P value
Prediction error (PE)			
▪ Mean ± SD	0.35±0.87	0.47±0.81	0.57
▪ Median (range)	0 (-1.25:2)	0.25 (-0.75:2.5)	

For further analysis of postoperative refractive outcomes, we measured the degree of deviation from the intended refraction relying on: **1-** The sign of prediction error which donates in which direction that deviation from intended refraction occurs

so a negative PE value means more myopic outcome than intended and vice viscera [4]. It was negative in 14 patients (56%) in the optical group but only in 9 patients (36%) in the ultrasonic group, indicating *more myopic deviation* with optical biometry, fig. (1). **2-**We also calculated the percentage of patients with PE within ± 0.25, ± 0.50 and = > ± 1.00 D from target refraction, we found it about 12 (48%), 7 (28%) and 6 (24%) respectively in optical group whereas, it was about 10 (40%), 8 (32%) and 7 (28%) respectively in ultrasonic group, fig. (2). Mean absolute error: as regard MAE (absolute value of the PE) we also found it statistically insignificant different between both groups (P was 0.65), tab. (5)

Table 5: Mean Absolute Error in optical and ultrasonic biometry groups.

Variable	Optical biometry group N=25	Ultrasonic biometry group N= 25	P value
Mean absolute error (MAE)			
▪ Mean ± SD	0.69±0.62	0.63±0.65	0.65
▪ Median (range)	0.5 (0:2)	0.3 (0:2.25)	

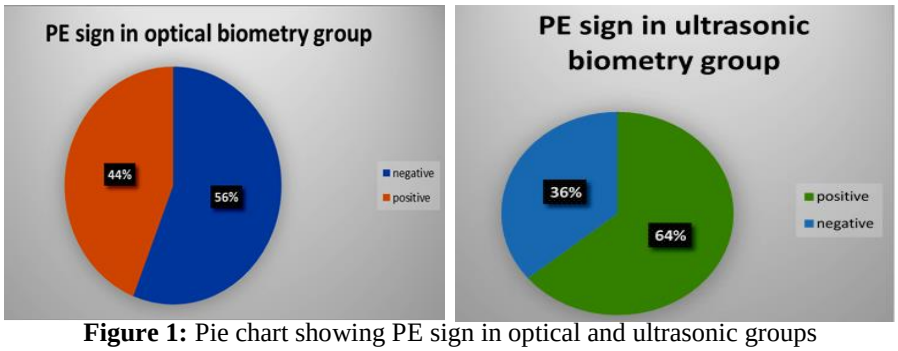

Figure 1: Pie chart showing PE sign in optical and ultrasonic groups

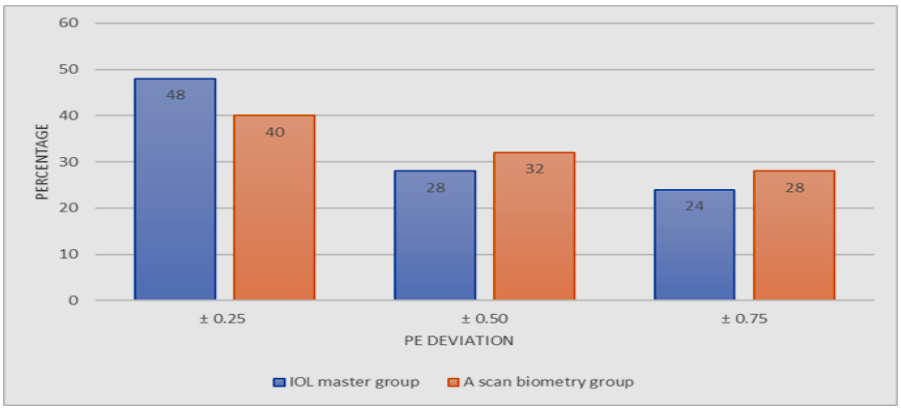

Figure 2: The percentage of patients with PE within ± 0.25, ± 0.50 and =>± 1.00 D from target refraction

4. Discussion

Postoperative refraction becomes the cornerstone of cataract surgery nowadays depending on many factors of them intraocular (IOL) power calculation is considered critical to achieve adequate results. Preoperative axial length (AL) measurement is the most important parameter in IOL calculation [1]. Studies based on preoperative and postoperative ultrasound biometry revealed that 54% of errors in predicted refraction after IOL implantation can be attributed to AL measurement errors, 8% to corneal power measurement errors and 38% to incorrect measurement of postoperative anterior chamber depth [5]. High myopia represents one of the difficult conditions for IOL calculation with high tendency to postoperative refractive surprises that can be

attributed partly to changes in the anatomy of the posterior pole [6]. In our study, We compared accuracy of optical and ultrasonic biometry in IOL calculation in high myopic cataractous patients through assessment of postoperative spherical equivalent On analysis of *the Preoperative measurements*, we found mean AL measured with optical biometry was 28.76±1.56 mm (range: 26. 5:31.7) and that measured with ultrasonic biometry was 28.58±1.55 mm (range: 26. 32:31.3), with difference of 0.18±0.27(-0.38:0.75)mm, (*P* was 0.003) which was statistically significant (P> 0.05). This agreed with Jia Wang (2008) who conducted comparative study on both optical and ultrasonic biometers in high myopic patients. with the use of many formulas including Haigis in which the mean AL was significantly longer in (Group 1… optical) 28.06 mm than in (Group 2…. Ultrasonic) 27.96 mm (P= .03) [7]. Another study was conducted by Rimple Gobi, Sanitha Sathyan.(2017) who assessed the AL length for 211 patients with wide range of AL with IOL master 500 and A-scan biometry dividing them into 4 groups, in extremely long eye group (AL>27.0MM), AL measured by IOL master was significantly longer than that measured by A-scan (P= 0.001) [8]. This also agreed with Wang et al. (2016) who assessed the AL for 49 high myopic eyes with the Lenstar LS 900, IOL master and A-scan ultrasound biometry devices, it was found that AL measured by both Lenstar and IOL master was signify-cantly longer than that measured by A scan (P <0.0001 for both) [9]. Also, Shen et al. (2004) results concluded that optical biometry provided more accurate measurements of biometric parameters, including AL and ACD than applanation US biometry in highly myopic eyes with AL longer than 25 mm [10]. As regard the other parameters: k readings, ACD, were nearly comparable in both groups [P>0.05] For IOL calculation, we chose Haigis formula which is one of the fourth generations formula, characterized by the use of three constants: *a*0, *a*1 and *a*2 to calculate the effective lens position [11]. The a0 constant is similar to the constants for the other formulas. The *a*1 constant refers to ACD (anterior corneal vertex to anterior vertex of crystalline lens), and the *a*2 constant to the measured axial length. Many studies supported the efficacy of such formula. Ghanem et al (2010) found that Haigis formula showed the least deviation towards hyperopia as compared by other formulas [6]. Also, Bang et al. [12]. reported that Haggis formula was the most accurate in predicting postoperative refractive error compared with the Hoffer Q, Holladay 1, Holladay 2, and SRK/T for 53 eyes with AL more than 27 mm, the same was concluded by MacLaren et al. who compared Haigis with SRK/T and Holladay 1 for 37 eyes with AL more than 26.5 mm [13]. Postoperative refraction was our primary outcome being measured one month postoperatively, and on assessment, it was -0.81±0.96D (range: -2.75:1.25) for optical group and was -0. 61±1.33 (range: -5:1.5) in ultrasonic group with difference between them was -0.2 which was statistically insignificant (p= 0.24). This can be explained by that the difference in AL measurements by the 2 methods, in spite of being statistically significant, yet, was not large enough to cause a significant difference in refractive outcomes. For further assessment, both PE & MAE for Haigis were calculated in each group. As regard PE, It was 0.35±0.87 (range: -1.25:2) in optical group and 0.47±0.81 (range: -0.75:2.5) in ultrasonic group with the difference between them -0.12D, which is statistically insignificant (p=0.57). For MAE, it was about 0.69 ±0.62 (range: 0:2) for optical group and 0.63±0.65 (range: 0:2.25) for ultrasonic biometry, the difference between them is 0.06 which was also statistically insignificant. Although refractive results were comparable between 2 groups, better outcomes were observed with optical biometry than ultrasonic biometry through Sign of PE for Haigis with each method (which means

the deviation occurs in which direction (myopia or hyperopia)), in our study, it was negative in 14 patients (56%) in the optical group but only in 9 patients (36%) in the ultrasonic group, indicating significant *myopic deviation* with optical biometry. And percentage of pts with SE ±1.00 of intended refraction, in our study, about 80% of patients in optical group about (78%) in ultrasonic group were within ±1.00 of intended refraction, This agreed with Roessler et al (2012) and associates in which 81% of the patients showed a prediction within ±1.00D with optical biometry [14]. In Jia-Kang Wang (2008) study, Use of the Haigis formula also resulted in the highest percentage of eyes (83.3%) within ±1.00 D of the intended postoperative refraction [7]. Based on our findings, optical biometry was found to provide more precise measurements of biometric parameters, especially AL than applanation ultrasonic biometric in highly myopic patients with the use of Haigis formula that provided acceptable postoperative refractive outcomes with both methods. Yet, ultrasound biometry may be still needed in case of poor fixation and dense media

5. Conclusion

optical biometry provides more accurate measurements of biometric parameters, especially axial length than applanation ultrasonic biometric in high myopic patients, also Haigis formula is preferred with high myopia, providing acceptable postoperative refractive outcomes with both methods

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