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Research Article

A COMPARATIVE STUDY OF OPTICAL BIOMETRY AND IMMERSION A-SCAN ULTRASOUND IN PATIENTS UNDERGOING PHACOEMULSIFICATION WITH FOLDABLE INTRAOCULAR LENS IMPLANTATION SURGERY

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ABSTRACT

Objectives: The objective of this study was to compare optical biometry with immersion A-scan ultrasound biometry in terms of axial length (AL) and post-operative refractive error by assessing 1-month post-operative refraction in patients undergoing phacoemulsification with foldable intraocular lens (IOL) implantation surgery.

Methods: The study was carried out in the Ophthalmology Department of Bharati Vidyapeeth (Demeed to be University) Medical College and Hospital Sangli, from November 2019 to April 2021. A total of 60 eyes of 60 patients were included in the study. All patients underwent both techniques of biometry, namely, optical and immersion A-scan biometry. Mean AL was calculated and compared between the two methods. Then patients were divided into two groups: Group A and Group B; randomization was done on the basis of odd and even numbers. All patients underwent phacoemulsification with foldable IOL implantation surgery and followed up on 1 week and then on 1 month. All patients were operated by single surgeon and a single technique was used. Actual post-operative refractive error, that is, mean of spherical equivalent was compared between two groups on 1-month follow-up.

Results: At 1-month follow-up, actual post-operative refractive error was obtained after calculating spherical equivalent for all the patients and we found that, the mean of actual post-operative refractive error for Group A was higher (−0.371±0.24 D) compared to Group B (−0.264±0.16 D) and the comparison was statistically significant (p=0.049).

Conclusion: Optical biometry is slightly more accurate than ultrasound biometry, in terms of accuracy and reproducibility of the IOL power calculation, but ultrasound biometry is adequate in case optical biometry is unavailable.

Keywords: Cataract, Phacoemulsification, Optical biometry, Immersion A-scan.

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INTRODUCTION

Cataract is the major cause of blindness in the world and also it is the most prevalent ocular disease [1]. In India, cataract is the cause of bilateral blindness in 50–80% of bilaterally blind patients. Among all types of cataracts, senile cataract is seen most commonly in clinical practice. Other secondary causes include hereditary factors, inflammation, metabolic syndromes, exposure to radiation, nutritional disorders, and trauma. [2].

Cataract extraction and intraocular lens (IOL) implantation is one of the most commonly performed surgical procedures in ophthalmology. The modern technique of cataract extraction is small incision phacoemulsification with foldable lens implantation [3]. It is minimally invasive, rehabilitation is quick, and has a low complication rate. In recent days, cataract surgery not only focuses on visual rehabilitation but is now considered a form of refractive surgery. The success of cataract surgery is determined by post-operative refractive outcomes and patient satisfaction [4].

In the last few decades, revolutionary technological developments have occurred in IOL designs, ocular biometry techniques, phacoemulsification procedures, and IOL calculation formulae [5].

To achieve the desired post-operative refraction, accurate calculation of IOL power is most important. This depends on several factors including axial length (AL) measurement, keratometry, anterior chamber (AC) depth, IOL calculation formula, and quality of IOL [6].

The most important step for accurate calculation of IOL power is the pre-operative measurement of ocular AL which is probably the element with the largest potential for error. Ultrasound biometry reported that 54% of the errors in predicted refraction after IOL implantation can be due to inaccurate AL measurements [7].

AL measurement and IOL power calculation can be done by conventional ultrasound biometry and optical biometry. A-scan ultrasound biometry calculates AL from the time taken for ultrasound waves to reflect back to its receiver from the internal limiting membrane and it includes contact and immersion methods. It requires the use of topical anesthetic and previously done keratometry on a manual or automatic mode [8].

Optical biometry also known as partial coherence interferometry (PCI) is a fast non-contact method which is more precise and accurate than A-scan biometry as it is based on the reflection of interference signal of retinal pigment epithelium (RPE) [9]. Hence, to make the optical biometry results comparable with previous ultrasound measures, a conversion factor has been incorporated into the instrument software. The built in software in this device provides more accurate IOL power calculation and multiple choices for IOL formulae [10].

Modern cataract surgery is characterized by obtaining precise post-operative target refraction as the number of patients opting for premium IOLs is increasing and patient expectations to get independence from glasses are very high [10].

We conducted this study to compare optical biometry and immersion A-scan ultrasound in patients undergoing phacoemulsification with foldable IOL implantation surgery.

METHODS

The study was carried out in the Ophthalmology Department of Bharati Vidyapeeth (Demeed to be University) Medical College and Hospital Sangli, from November 2019 to April 2021 after obtaining the Institutional Ethical Committee Clearance [BV(DU)MC&H/Sangli/IEC/Dissertation2019-20/298]. This was a prospective comparative study which was carried out for 18 months in which the study population consisted of patients having cataract which came to Ophthalmology Department, Bharati Vidyapeeth (Deemed to be University) Medical College and Hospital Sangli, within the study period and were fulfilling the inclusion criteria.

This study was done on 60 eyes of 60 patients having senile immature cataract attending to OPD of the Department of Ophthalmology at Bharati Vidyapeeth (Deemed to be University) Medical College and Hospital, Sangli and underwent phacoemulsification cataract surgery. Patients who were included were in the age group of 40–90 years, with age-related cataract undergoing phacoemulsification, were having preoperative keratometric astigmatism of 1.0D or less, had AL in the range of 22.0–24.5 mm, and were willing to give consent to participate in the study. Patients who were excluded from the study were with posterior segment pathology including all retinal and optic nerve pathologies, with glaucoma, scleral diseases, connective tissue disorders, corneal degeneration, were having uveitis, previous ocular surgeries, or presented with pseudoexfoliations, traumatic cataract, and nuclear sclerosis more than Grade IV.

Written and informed consent was taken from all the patients. Detailed history of ocular symptoms, any prior ocular surgery, and drug history were noted. The ocular examination of the patients included autorefractometry and keratometry, visual acuity measurement by Snellen's chart, anterior segment evaluation using slit lamp biomicroscopy and posterior segment evaluation was done with the help of direct and indirect ophthalmoscopy to rule out any pathology including retinal and optic disc pathologies.

Then, optical biometry was performed in all 60 patients by TOPCON ALADDIN optical biometer which is based on optical low coherence reflectometry. Examination was done with the patient in a sitting position using phakic eye mode.

Intraocular pressure was measured for all the cases by Goldmann applanation tonometry. Grading of nuclear sclerosis was done on the basis of "Oxford Clinical Cataract Classification and Grading system" after dilation of pupil with tropicamide (0.8%) and phenylephrine (5%) eye drops.

All 60 patients underwent immersion A-scan ultrasound biometry. Prager shell was used which is a small plastic cylinder with a curved rim that conforms to the contour of the eye. The shell was placed between the eyelids and was then filled with balanced salt solution (BSS). Here, BSS acts as an ultrasonic coupling media so that scans are taken without compressing cornea. The ultrasonic probe was then immersed into the fluid such that corneal contact was avoided. Patient was in supine position with eyes in primary gaze and asked to fixate on red light source present in the center of the probe. Five readings were taken with an acceptable standard deviation (SD). The average of these five readings gives an average AL. Mean AL was calculated for immersion A-scan and optical biometry and compared. Keratometric readings inserted, which were calculated by auto-refractokeratometry machine, IOL power was calculated.

For all 60 patients, the Sanders Retzlaff Kraff/Theoretical (SRK/T), a third-generation IOL calculation formula was used to calculate IOL power in both immersion A-scan and optical biometry methods. In this study, patients having ALs in the range of 22 mm to 24.5 mm were is taken as SRK/T formula, universally accepted in this range of ALs.

Required IOL power was selected showing targeted post-operative refraction nearest to emmetropia in both immersion A-scan and optical biometry. IOL powers were available with an ascending range of 0.5D (e.g. 20D, 20.5D, etc.).

The study patients were divided into two groups: Group A and Group B. This randomization was done on the basis of odd and even numbers such that Group A included odd number patients and Group B included even number patients. All 60 patients were planned for phacoemulsification with posterior chamber foldable intraocular lens implantation surgery under local anaesthesia.

Preoperatively, written and informed consent was taken and Xylocaine sensitivity test was done. Complete blood count, blood sugar level, human immunodeficiency virus test, Hepatitis B test, urine routine, and microscopic examination were done. All patients were started with Ofloxacin (0.3%) and Flurbiprofen (0.03%) eye drops 1 day before surgery. Dilation of pupils was done by tropicamide (0.8%) and phenylephrine (5%) eye drops on the day of surgery. Peribulbar block was given by using a combination of local anaesthetic drug, namely, 3 milliliter of 2% Xylocaine with adrenaline 1:200000, mixed with injection hyaluronidase (1500 International Units) and 1 milliliter of 0.5% Bupivacaine. The block was injected at the junction of medial two-third and lateral one-third of inferior orbital margin in peribulbar space.

All surgeries were performed by a single ophthalmic surgeon with a single technique. Periocular area was painted with povidone iodine solution and draping was done. Universal eye speculum was placed. A biplanar incision, about 2.8 mm wide, was taken superotemporally at the limbus. In addition to this, side port incisions were made at 4 and 10 o'clock positions of limbus by 15° side port entry blade. Trypan blue dye was injected through the side port to stain anterior capsule and washed after 30 s. Then AC was filled with viscoelastic substance. Cystotome was made with 26 G needle with the help of needle holder. About 5–5.5 mm in diameter, continuous curvilinear capsulorrhexis was made with the help of cystotome. Hydrodissection and hydrodelineation both were performed. Then single deep trench was made and the nucleus was bisected. The two hemi-nuclei were progressively chopped into smaller fragments and emulsified. With the use of fluidics, epinucleus was removed. Cortex removal was done by bimanual automated irrigation and aspiration with a linear foot pedal control. Insertion of foldable IOL was done through the main incision into the bag with the help of injector. Here, IOL power selected for Group A patients was obtained by immersion A-scan biometry and for Group B by optical biometry. Viscoelastic substance, which was remaining, was removed. 0.1–0.2 mL of Moxifloxacin (0.5%) was injected intracamerally. Side ports were hydrated and wound checked for any leak. Subconjunctival injection containing Gentamicin (5 mg in 0.5 mL) and Dexamethasone (1 mg in 0.5 mL) was given. Eye was padded after putting Chloramphenicol (10 mg/g) eye ointment into the inferior fornix.

Postoperatively, topical eye drop was started which was a combination of steroid (Prednisolone 1%) and antibiotic (Moxifloxacin 0.5%), and tapered weekly for 1 month. All patients were followed up at 1 week and then on 1 month. On each follow-up Uncorrected Visual Acuity and Best Corrected Visual Acuity (BCVA) on Snellen's chart were noted. At 1 month follow-up, final post-operative refraction was prescribed on the basis of autorefractometry readings. Spherical equivalent was calculated for each patient on the basis of refraction prescribed. It is calculated by adding a half cylinder value to the spherical power. Mean value of spherical equivalent was calculated for both groups and compared.

The statistical analysis was performed by SPSS 23.0 version. Continuous variables were described as mean and variation of each observation from the mean value (SD) represented as mean ± SD (analyzed using unpaired T-test). Categorical variables were described by taking

percentages and analyzed using Chi-square test and p<0.05 was considered significant.

RESULTS

The study included 60 eyes of 60 patients, 30 in each group. Male-to-female ratio (M: F) in Group A was 1:1 and in Group B, it was 2:3. Group A consisted of 15 (50%) male and 15 (50%) female patients whereas in Group B, 12 (40%) were male and 18 (60%) were female (Table 1).

Age group of patients ranged from 40 to 70 years. No patients were found between the age group of 71 and 80 years and 81–90 years. Maximum number of patients (18) were from 51 to 60 years in both groups (Table 2).

BCVA was assessed preoperatively and 1-month postoperatively. The distribution of patients according to BCVA is depicted in Table 3. It was found that preoperatively visual acuity was significantly low in all 60 patients. Out of the total 60 patients, two patients had BCVA of <3/60–1/60 and one patient had BCVA of <6/60–3/60. The majority of the patients (32) had BCVA ranging from <6/18 to 6/60, while 22 patients had BCVA ranging from 6/12 to 6/18. Remaining three patients had BCVA in range of 6/6–6/9. Postoperatively on 1 month follow-up, 54 patients had BCVA in the range of 6/6–6/9, while the remaining six patients had BCVA ranging from 6/12 to 6/18 (Table 3).

Here, we compared patients having BCVA <6/12 and >6/12, preoperatively and on 1-month follow-up. Preoperatively, 57 patients (95%) had BCVA <6/12 and only 3 patients (5%) had BCVA >6/12. Postoperatively, on 1-month follow-up, the majority of patient's BCVA (54 i.e., 90%) was improved to >6/12, and only 6 patient's (10%) BCVA was below 6/12. Table shows that there is a statistically significant increase in BCVA postoperatively (Table 4).

The mean AL measured by immersion A-scan was 23.03±0.64 mm, while the mean AL measured by optical biometry was slightly higher, at 23.37±0.62 mm. The p=0.04 indicates a statistically significant difference between the two methods. The comparison showed that optical biometry tends to give slightly higher AL measurements compared to Immersion A-scan in this study population and the difference was found to be statistically significant (Table 5).

At 1-month follow-up, actual post-operative refractive error was obtained after calculating spherical equivalent for all the patients and we found that the mean of actual post-operative refractive error for Group A was higher (−0.371±0.24 D) compared to Group B (−0.264±0.16 D) which was also statistically significant (p=0.049) (Table 6).

DISCUSSION

This study included 60 eyes of 60 patients who were planned for phacoemulsification with foldable IOL implantation cataract surgery. Patients were divided into two groups, Group A and Group B and the comparison was made between two different biometric methods, namely, immersion A-scan ultrasound biometry and optical biometry.

In the present study, we found that there is a statistically significant difference in AL measurements between two methods of biometry, namely, immersion A-scan biometry and optical biometry. AL measured by optical biometry is more compared to AL measured by immersion A-scan biometry as in former the light rays are reflected from RPE while in later sound waves get reflected from ILM of the retina. Immersion A-scan biometry group in the present study had significantly more post-operative residual refraction compared to the optical biometry group.

Advantages of optical biometry over ultrasound biometry noted are – optical biometry is a non-contact, user friendly, fast method, corneal indentation does not occur and it has higher precision and greater reproducibility of AL measurement. The main disadvantage is inability to measure AL in dense posterior subcapsular cataracts, mature cataract, vitreous hemorrhage, and retinal detachment. For these patients, ultrasound biometry is used for AL measurement.

In Group A, 15 (50%) male and 15 (50%) female patients were included, while in Group B 12 (40%) were male and 18 (60%) were female. Male: Female ratio for Group A and Group B was 1:1 and 2:3, respectively. Abdelaziz and Mousa [11], in their study, included 39 eyes of 39 patients, of which 21 (53.8%) were male and 18 (46.2%) were

Table 1: Sex distribution in Group A, Group B, and M:F ratio

Gender Distribution	Group A Immersion A-scan ultrasound biometry	Group B Optical biometry
Male	15 (50%)	12 (40%)
Female	15 (50%)	18 (60%)
M:F ratio	1:1	2:3

Table 2: Age distribution of patients in Group A and Group B

Age of patient in years	Number of patients	
	Group A (%)	Group B (%)
40–50	5 (16.7)	7 (23.3)
51–60	18 (60)	18 (60)
61–70	7 (23.3)	5 (16.7)
71–80	0(0)	0(0)
81–90	0(0)	0(0)

Table 3: Distribution of patients according to BCVA in Group A and Group B

BCVA	Pre-operative (%)	Post-operative (on 1 month follow-up) (%)
<1/60 to PL+	0 (0)	0 (0)
<3/60–1/60	2 (3.3)	0 (0)
<6/60–3/60	1 (1.6)	0 (0)
<6/18–6/60	32 (53.4)	0 (0)
6/12–6/18	22 (36.7)	6 (10)
6/6–6/9	3 (5)	54 (90)

Table 4: Comparison of BCVA between preoperatively and on 1-month follow-up

BCVA	Pre-operative	1-month follow-up	p-value*
<6/12	57 (95)	6 (10)	<0.001
>6/12	3 (5)	54 (90)	

Table 5: Comparison of mean axial length (mm) by two different methods, namely, immersion A-scan and optical biometry

Axial length in mm	Immersion A-scan	Optical biometry	p-value*
Mean	23.03	23.37	0.04 (Significant)
SD	0.64	0.62	

Table 6: Comparison of actual post-operative refraction between Group A and Group B

Actual post-operative refraction (Spherical equivalent in diopters)	Group A	Group B	p-value*
Mean	−0.371	−0.264	0.049 (Significant)
SD	0.24	0.16	

female. A similar study done by Joshi *et al*. [12] also included 60 eyes of 60 patients with a male-to-female ratio for Group A at 3:2 and for Group B, it was 2.3:1.

In the present study, it was found that the majority of patients are within age group of 51–60 years, containing 18 (60%) patients in each group. A study done by Fontes *et al*. [13], included 50 eyes of 33 patients in Group 1, underwent biometry with PCI (IOL Master Carl zeiss Meditec), and 70 eyes of 46 patients in Group 2, who underwent immersion A-scan biometry. The mean age of patients was 69.8±13.1 years in the group 1 and 70.0±9.3 in the Group 2.

In this study, BCVA was assessed preoperatively and postoperatively on 1-month follow-up. Preoperatively, the majority of the patients (32 out of 60) had BCVA ranging from <6/18 to 6/60, while 22 patients had BCVA ranging from 6/12 to 6/18. Postoperatively on 1-month follow-up, BCVA was significantly increased in 54 patients, in the range of 6/6 to 6/9, while remaining six patients had BCVA ranging from 6/12 to 6/18. Out of these six patients, four patients had developed pseudophakic cystoid macular edema postoperatively while two patients had primary posterior capsular plaques.

The comparison of patients having BCVA <6/12 with patients having BCVA > 6/12, preoperatively and on 1-month follow-up was done. Preoperatively, 57 patients (95%) had BCVA <6/12 and only 3 patients (5%) had BCVA >6/12. Postoperatively on 1-month follow-up, majority of patient's BCVA (54 i.e., 90%) was improved to >6/12, and only 6 patient's (10%) BCVA was below 6/12. The comparison is statistically significant ($p<0.001$).

Attar [14], in his study, included 150 eyes and had BCVA ranging from counting fingers to 6/18 preoperatively. Postoperatively, 84% of patient's BCVA was improved to 6/9. Joshi *et al*. [12], in their study, observed BCVA preoperatively and at 30th day follow-up. Thirty-two patients had BCVA in the range of <3/60–1/60 preoperatively, while 54 patients had BCVA in the range of 6/6–6/9 postoperatively.

In this study, the mean AL measured by optical biometry (23.03±0.64 mm) was longer by 0.34 mm compared to the mean AL measured by ultrasound biometry (23.37±0.62 mm) which was statistically significant ($p<0.05$). This result agrees with that of a study done by Németh *et al*. [15], in which mean AL by ultrasound biometer (23.34±1.95 mm) was significantly lower than that measured by IOL master (23.73±2.05 mm).

Eleftheriadis [16] also found that AL measured by IOL master is longer than that measured by ultrasound method by an average of (0.47 mm) which was more compared to the present study.

CONCLUSION

The optical biometry is more accurate than ultrasound biometry, in terms of accuracy and reproducibility of the IOL power calculation, but ultrasound biometry is acceptable in case where optical biometry cannot be used.

CONFLICTS OF INTEREST

None.

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