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Ophthalmology Section

Comparative Evaluation of Accuracy of Immersion A-scan Ultrasound Biometry and Optical Biometry in Cases Undergoing Small Incision Cataract Surgery

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ABSTRACT

Introduction: At present, refractive accuracy is the demand of cataract surgery which can be achieved by providing precise post-operative vision without spectacles. One of the important factors required to give spectacle free vision is calculation of accurate biometry. In developing countries like India, Small Incision Cataract Surgery (SICS) is done more commonly than phacoemulsification with foldable Intraocular Lenses (IOLs).

Aim: To evaluate the accuracy of Immersion A-scan and Optical biometry in patients undergoing SICS with foldable IOLs by assessing their one month post-operative refraction and converting these values in predicted emmetropic IOL powers.

Materials and Methods: Prospective study was conducted on 60 patients to be posted for cataract extraction in Department of Ophthalmology, Bharati Medical College and Hospital (Deemed to be university), Sangli, Maharashtra, India, for two months from the period of January 1, 2019 to March 1, 2019. Preoperatively patients were randomly divided in two groups containing 30 patients each, Group A was subjected to Immersion A-scan and Group B to Optical biometry. Patients included in the study preoperatively also underwent Best Corrected Visual Acuity (BCVA) estimation, applanation tonometry, slit lamp examination of anterior and posterior segment and Keratometry. Patients were examined post-operatively on 1st, 7th, and 30th day, for slit lamp examination of anterior and posterior segments and also their BCVA was noted. Final refraction was given on 30th post-operative day based on their auto-refractometer readings. Post-operative refraction and actual IOL power placed was used to calculate IOL power that would have produced emmetropia in that particular patient by the help of regression formula. Difference in actual IOL power placed and predicted emmetropic IOL power was also noted in each patient of both groups.

Unpaired t-test was used for the statistical analysis.

Results: The mean Axial Length (AXL) measured by immersion A-scan in group A was lesser (22.91 mm) than that with IOL master (23.15 mm) with a mean difference of 0.24 mm (p=0.133). Mean actual post-operative refraction at one month in group A was higher (0.90) than that of group B (0.70) with a mean difference of 0.20 (p=0.166). Mean difference between actual IOL (aIOL) placed and predicted emmetropic IOL (eIOL) was higher in group A (1.35) than that of group B (0.96) with a mean difference of both group was 0.39 (p=0.021).

Conclusion: In the range of AXL 22 mm to 24.50 mm, used in this study, there is no statistically significant difference in axial length measurements between two methods of Ultrasound biometry and Optical biometry.

Patients in Group A of present study had significant post-operative residual refraction as compared to Group B patients, which can be attributed to inaccurate Keratometry as two different methods of Keratometry were done in two groups. Keratometry values can influence post-operative refraction and inaccurate Keratometry may land with post-operative refractive errors.

Current study showed certain advantages of optical biometry over USG biometry in that Optical biometry is Non-contact, fast and accurate, but optical biometry cannot be done in mature cataracts and dense posterior subcapsular cataract where immersion USG biometry is required.

Keywords: Auto-refractokeratometry, Axial length, Cataract, Intraocular lens, Phacoemulsification

INTRODUCTION

Cataract is the major cause of blindness in the world and the most prevalent ocular disease. In India, cataract is the cause of bilateral blindness in 50% to 80% of patients [1]. Causes of cataract include ageing and other secondary causes like hereditary factors, exposure to radiation, inflammation, metabolic, nutritional disorders or trauma. Senile cataracts are seen most commonly.

Symptomatic cases need surgical removal of the lens with IOL implantation. Off late, aim of cataract surgery is no longer only sight restoration but spectacle free post-operative vision, due to advancement of cataract surgery. In view of which refractive accuracy with cataract surgery is the demand of present era.

One of the important factors required to give spectacle free post-operative vision is calculation of accurate IOL power before cataract surgery. Gale RP et al., in his study concluded that 87% of patients could achieve an outcome within ±1 Diopter (D) of target with appropriate formula selection, optical AXL measurement, and optimization of IOL constants [2]. The Royal College of Ophthalmologists, in the year 2010 published Guidelines on cataract surgery, adopted a standard of 85% within ±1 D of target and 55% within ±0.5 D of target [3].

Measurement of AXLs can be done either by A-scan Ultrasound biometry which includes contact and immersion methods or by Optical biometry. In ultrasound methods, Immersion method of A-scan is supposed to have greater accuracy as compared to contact method because of absence of corneal compression induced error in the former [4].

Non-contact optical biometry is user friendly, more accurate and having good reproducibility in its results [5]. The main disadvantage of the optical methods is their inability to obtain AXL measurements in approximately 10% of eyes, typically those with dense posterior subcapsular cataracts, mature cataract, vitreous haemorrhage,

maculopathy, or retinal detachment, for these eyes ultrasonic AXL measurement is required [5,6].

Gaballa SH et al., has compared two biometric methods in same group of patients who underwent phacoemulsification with foldable IOLs [7]. No literature is available where two types of biometry methods are compared in SICS with foldable IOLs. Joshi AK et al., in their study on patients undergoing SICS with foldable IOLs have evaluated visual outcome and also studied intra and post-operative surgical complications [8].

SICS is a type of extra-capsular cataract surgery which involves 5.5 to 6 mm self-sealing incision from which cataractous lens is extracted out, whereas phacoemulsification involves 2.8 mm incision from which emulsification probe is passed to emulsify the nucleus within the bag [9]. In developing world like India, SICS is done more commonly than phacoemulsification with foldable IOLs. SICS is also evolving in recent past and attempts are being made to achieve near phacoemulsification effects. In view of this, it becomes important to have minimum refractive error after SICS and to achieve this, accurate biometry is equally important. SICS has emerged as a cost effective alternative to phacoemulsification for developing countries. As the present study is conducted in a charitable teaching hospital, percentage of SICS is more than Phacoemulsification.

Kolega MS et al., in their study have compared Optical biometry and ultrasound (USG) biometry in two groups of patients and have compared post-operative mean absolute refractive errors [10]. Foldable IOLs have advantage over rigid IOLs as far as post-operative Posterior Capsular Opacification rate is concerned due to their ensured in the bag placement [11,12]. In order to give advantages of foldable IOLs, we do many cases of SICS with foldable IOL who cannot afford the cost of phaco with foldable IOL in our institute. This technique gives equally good results. Manual SICS with foldable IOLs can be indicated in patients in whom SICS can be done with <5 mm incision and if the patients in this group can bear the cost of foldable IOLs [13].

To make a cataract free world with enhanced quality of vision is every Ophthalmologist's dream. Up till now Phacoemulsification with foldable IOLs was considered the only surgery which gives post-operative quality vision. But now SICS which is affordable technique in developing countries, is also emerging as a quality surgery with its new smart outlook. In order to give quality visual output to SICS patients, attempt has been made in this study to apply the better biometric method preoperatively in order to achieve minimal refraction error post-operatively. With this background, this study was aimed to compare Ultrasonic biometry with Optical biometry method of IOL calculation. Objectives were to assess post-operative refraction at one month follow-up, and based on the post-operative refraction; predicted emmetropic IOL power was calculated using regression formula. This predicted emmetropic IOL power was then compared to Actual IOL power placed. Minimum difference between these two powers is indicative of more accurate method of biometry.

MATERIALS AND METHODS

The present study was a prospective study which was conducted on 60 eyes of 60 patients with cataract who were divided in two groups subjected to manual SICS with foldable IOL implantation under local anaesthesia in a teaching hospital between the period of January 1, 2019 to March 1, 2019.

Written and informed consent was taken from all the patients. Approval from ethical committee was also taken to conduct the study (ethical committee approval letter number-334/18). All patients were followed-up for a period of one month post-operative.

The patients with clinically normal cornea, age group of 50-90 years, preoperative keratometric astigmatism of 1.5 D or less were included in the study. The patients with any posterior segment pathology, glaucoma, scleral diseases, connective tissue disorders, corneal degeneration, with axial length less than 22 mm and more than 24.5 mm, traumatic cataract, pseudo-exfoliations, and nuclear sclerosis more than grade 4 were excluded from the study.

Study patients were randomly divided in two groups of 30 patients each. Randomization was done on the basis of odd and even numbers, where group A contained odd number patients and group B contained even number patients.

Group A: Patients were subjected to Immersion A-scan USG biometry with a Prager shell. The Prager shell is a small plastic cylinder with a curved rim that conforms to the contour of the eye. The shell is placed between the eyelids and is then filled with Balanced Salt Solution (BSS). The ultrasonic probe is then immersed into the fluid without contacting the cornea. The BSS acts as an ultrasonic coupling media, permitting scans to be taken without compressing the cornea. Patients were examined in a sitting position on the chair with head reclined gently against the head rest. Five readings were required within an acceptable standard deviation. Average of these five readings gives average AXL. By inserting the keratometric readings, which were calculated by Auto-refractokeratometry machine, IOL power was calculated.

Group B: Patients were subjected to Optical biometry, which is based on the principle of dual beam of partial coherence interferometry. It uses infrared light (λ=780 nm) of short coherence for the measurement of the optical AXL, which is then converted to geometric AXL by using a group refractive index. Optical biometry also gives Keratometry readings which are used to calculate IOL power. These measurements were taken with the patient in a sitting position using phakic eye mode.

Other preoperative examination of patients which included, visual acuity by Snellens's chart [14], Detailed Slit Lamp Examination (DSLE) to determine cataract type and grade and to rule out any pathologies of anterior segment like corneal pathologies etc., Applanation Tonometry (AT) to rule out raised IOP was done. Fundus examination was also done to rule out any posterior segment pathology like macular degeneration, etc.

To avoid the bias, same surgeon performed Immersion A-scan and optical biometry. The Sanders Retzlaff Kraff/Theoretical (SRK/T) a 3rd generation IOL calculation formula, (combination of linear regression and theoretical formula) was used to calculate the IOL power in all 60 patients. The study included only those cases having AXLs in the range of 22 mm to 24.50 mm, as SRK/T formula is universally accepted in this range of AXL lengths [15,16].

Sanders Retzlaff Kraff/Theoretical formula states:

P=A-2.5L-0.9K

Where, P is implant IOL power for emmetropia.

L is AXL in millimeter.

K is average Keratometry.

Optimised A constant was used in both groups for that surgeon. Required IOL power was selected showing targeted post-operative refraction nearest to emmetropia in both groups. IOL powers are available with 0.5 ascending range like 20D, 20.5D etc.

Preoperatively, Xylocaine sensitivity, blood sugar, urine routine and microscopic examination, Human immunodeficiency virus test, and Hepatitis B tests were done. Before surgery, Peribulbar block was given by using a combination of local anaesthetic drug viz., 3 milliliter of 2% Xylocaine with adrenaline 1:200000, mixed with injection hyaluronidase (1500 International Units) and 1 milliliter (mL) 0.5% Bupivacaine. In peribulbar block, one inch needle of 24 G, was used to inject drug at the junction of medial two-third and lateral one-third of inferior orbital margin in peribulbar space. Same surgeon performed all the surgeries with same surgical technique. Periocular area was painted with povidone iodine solution and

draped. Superior rectus suture i.e., bridle suture was taken after placing universal eye speculum. Conjunctival peritomy done from 11 to 1o'clock, frown incision of 5.5 mm width was taken at a distance of 1.5 mm from limbus with a 15 number blade. With the help of crescent knife sclero-corneal tunnel was made. At 9o'clock position of limbus a side port was made with 15 degree sideport entry blade. Through the side port, trypan blue dye was injected to stain anterior capsule and washed after 30 seconds. Ninety degree bent was made in 26 number needle with the help of needle holder and base was bent 45 degrees to form a cystitome which was used to make Continuous Curvilinear Capsulorhexis (CCC) after which 3.2 mm keratome used to enter the anterior chamber and sclerocorneal incision was widened, to facilitate the delivery of nucleus. Hydrodelination and Hydro-dissection both was done and nucleus was delivered by the method of viscoexpression. Remaining cortical matter was aspirated with Simcoe's two way cannula and a foldable single piece hydrophilic acrylic IOL was placed within the bag. All the Visco-elastic material which was remaining was removed.0.1 to 0.2 mL of Moxifloxacin (0.5%) was injected into the anterior chamber. Sideport hydrated and wound checked for any leak. Conjunctival flap approximated and subconjunctival injection containing gentamycin (5 milligram in 0.5 mL) and dexamethasone (1 milligram in 0.5 mL) was given. Eye was padded after putting chloramphenicol (10 milligram per gram) eye ointment.

Post-operatively combination of topical steroid (prednisolone 1%) and antibiotic (moxifloxacin 0.5%) were prescribed and tapered weekly for one month. At all follow-up visits i.e., at (one week and one month): Uncorrected Visual Acuity (UCVA) and Best Corrected Visual Acuity (BCVA) on Snellens's chart were noted. No significant post-operative complication was noted in both groups. At one month follow-up, final post-operative refractive correction was prescribed based on their Autorefractometry readings in patients of both groups.

Olsen T in his study, described a regression formula which used actual IOL power placed and post-operative refraction, to calculate IOL power that would have produced emmetropia in that particular patient [17].

According to this formula, Po=Pi+1.5*Rx, where Po is Predicted IOL power that would have produced emmetropia, Pi is actual power of the implanted lens, Rx is actual post-operative refraction which is multiplied by 1.5 (1.5*Rx).

Utilising this formula in present study, predicted emmetropic IOL power was calculated by following means.

PoA=PiA+1.5*RxA for group A patients where PoA-Predicted Emmetropic IOL power, PiA-Actual IOL placed, RxA-actual post-operative refraction.

PoB=PiB+1.5*RxB for group B patients where PoB=Predicted Emmetropic IOL power, PiB-Average of Actual IOL placed in group B, RxB-actual post-operative refraction.

STATISTICAL ANALYSIS

A statistical analysis was performed comparing AXL preoperatively; actual refraction and difference between IOL powers placed and predicted Emmetropic IOL at 30th post-operative day in two groups. Mean and standard deviation was obtained.

Unpaired t-test was used to compare mean of above mentioned variables in two group's viz., group A and B, with MS Excel and SPSS-22 were used for the statistical analysis.

RESULTS

Sixty patients (60 eyes) were included in our study with male to female ratio in group A was 3:2 and in group B, was 2.3:1 Group A consist of 18 (60%) male and 12 (40%) female patients whereas in group B, 21 (70%) were male and 9 (30%) were female [Table/Fig-1].

	Group A Immersion A-scan ultrasound biometry	Group B Optical biometry
Male	18 (60%)	21 (70%)
Female	12 (40%)	9 (30%)
Total	30 (100%)	30 (100%)

[Table/Fig-1]: Genderwise distribution of cases in two groups.

Age wise distribution of cases in two groups are depicted in [Table/Fig-2]. Age groups of patients ranged from 50-90 years, of which maximum within the range of 61-70 years containing 13 patients (43.33%) in group A whereas 18 (60%) in group B.

Patients age (in years)	Number of patients	
	Group A (%)	Group B (%)
50-60	7 (23.3%)	4 (13.33%)
61-70	13 (43.33%)	18 (60%)
71-80	6 (20%)	6 (20%)
81-90	4 (13.33%)	2 (6.66%)
Total	30 (100%)	30 (100%)

[Table/Fig-2]: Age wise distribution of cases in two groups.

Visual acuity was assessed preoperatively and 30 days post operatively, the distribution of patients according to visual acuity is shown in [Table/Fig-3]. The preoperative visual acuity in the patients was significantly low. Out of the total 60 patients, 4 had the visual acuity of Perception of Light (PL), Projection of Rays (PR). Majority of patients i.e., 32 had visual acuity ranging from less than 3/60 to 1/60. Sixteen patients had visual acuity of less than 6/60-3/60. Four patients in both the groups having visual acuity less than 6/18 to 6/60 and 6/12 to 6/18 respectively. Post-operatively on 30th day 54 patients had BCVA in range of 6/6 to 6/9, 4 in range of 6/12 to 6/18, 2 in range of less than 6/18 to 6/60.

	Preoperative	30th day post-operative
<1/60 to PL+	4	0
Less than 3/60 to 1/60	32	0
Less than 6/60 to 3/60	16	0
Less than 6/18 to 6/60	4	2
6/12 to 6/18	4	4
6/6 to 6/9	0	54

[Table/Fig-3]: Distribution of patients according to unaided visual acuity.

Mean preoperative Keratometry readings in group A calculated by AR was 43.75D against 44.25D in group B calculated by optical biometry.

The mean AXL measured by immersion A-scan in group A was lesser (22.91 mm) than that with IOL master (23.15 mm) with a mean difference of 0.24 mm (p=0.133) which was not statistically significant [Table/Fig-4].

Axial length No. of patients-30	Group A (Immersion A-scan)	Group B (Optical biometry)
Mean	22.91	23.15
SD	0.62	0.60
p-value=0.133		

[Table/Fig-4]: Mean axial length compared in two groups.

The mean actual refraction after cataract surgery at one month in group A was higher (0.90) than that of group B (0.70) with a mean difference of 0.20 (p=0.166) which was not statistically significant [Table/Fig-5].

Actual post-operative refraction No. of patients-30	Group A (Immersion A-scan)	Group B (Optical biometry)
Mean	0.90D	0.70D
SD	0.50	0.60
p-value=0.166		

[Table/Fig-5]: Actual post-operative refraction compared in two groups.

The mean difference between actual IOL (aIOL) placed and predicted emmetropic IOL (eIOL) was higher in group A (1.35) than that of group B (0.96) with a mean difference of both group was 0.39 (p=0.021) which was statistically significant [Table/Fig-6].

Difference between Actual IOL and emmetropic IOL	Group A (Immersion A-scan) Diff. bet. Mean PiA and mean PoA	Group B (Optical biometry) Diff. bet. Mean PiB and mean PoB
Mean	1.35	0.96
SD	0.75	0.49
p-value=0.021		

[Table/Fig-6]: Comparison of difference between actual IOL placed and predicted emmetropic IOL.
PiA: Average of actual IOL placed in group A; PoA: Average of predicted emmetropic IOL in group A; PiB: Average of actual IOL placed in group B; PoB: Average of predicted emmetropic IOL in group B

DISCUSSION

SICS with foldable IOL implantation, has gained popularity in developing countries where finance is a constraint to the patient and the technique has been evolving to a great extent and satisfactory post-operative surgical outcome can be achievable.

Accurate biometry plays an important role in post-operative visual outcome. Ultrasound (USG) A scans biometry measures the distance from corneal vertex to the internal limiting membrane of fovea whereas Optical biometry measures the distance between second principal planes of cornea to photoreceptor layer of fovea. Also, Optical biometry seems to be more accurate because of accurate fixation by the patient but it is possible to have eccentric fixation by the patient who undergo USG A-scan biometry giving wrong AXL. The factor obviously noted in high myopic eyes, where precise localization of fovea by Optical biometry makes it superior over USG A-scan [18].

Optical biometry is non-contact technique so it is easy to use; chances of infection and corneal trauma like abrasion etc. are less and also well accepted by patients as compared to immersion A scan which is contact method [19].

Current study compares two different biometric methods viz., USG Immersion A scan biometry and Optical biometry in 2 groups of patients undergoing SICS with foldable IOL.

Gaballa SH et al., has compared two biometric methods in same group of patients who underwent phacoemulsification with foldable IOLs. As against this, two different groups of patients subjected to two different group of biometries were compared in present study who underwent SICS with Foldable IOLs [7].

Gaballa SH et al., have employed SRK/T formula in all patients having wide range of AXLs other than emmetropic range. Actually validity of Sanders Retzlaff Kraff/Theoretical (SRK/T) formula is doubtful in eyes with short AXLs [7].

Gaballa SH et al., also utilised predicted IOL power and actual post-operative refraction to find out efficacy of two biometric methods, present study utilises regression formula to compare two biometric methods [7]. They also noted that Mean Numerical Error (MNE) measured by IOL master between -0.16±0.18 D which was less against MNE measured by A-scan as -0.17±0.43. Present study also shows that mean post-operative refraction in optical biometry group as 0.70D which is less against immersion A scan group as 0.90D [7].

Gaballa SH et al., in their study have observed AXLs measured by optical biometry to be more in the range of 150 to 350 micrometer than AXLs measured by USG method similar to present study (refer to [Table/Fig-4] [7].

Nakhli FR in his study has compared Optical biometry and USG biometry on the same group of patients [18]. He calculated mean AXL by optical biometry as 23.548 whereas by USG biometry as 23.665, with difference of 0.117. But in present study, Mean AXL length calculated by optical biometry was 23.15 and with USG Immersion A scan was 22.91, with difference of 0.24 which was opposite to Nakhli FR study [18].

Landers J et al., has compared two techniques retrospectively with the use of SRK/T formula and concluded that biometry performed using IOL master produces more predictable refractive outcome than USG immersion A-scan also it was found in his study that eyes are measured longer by IOL master method compared with immersion USG. Similar to this, in present study also it was found that mean AXL of patients who underwent optical biometry (group B) to be longer than mean AXL of patients who underwent USG immersion A-scan (group A) [20].

No studies are available in literature where accuracy of biometry is compared in two groups, one group receiving USG immersion A-scan and other group receiving Optical biometry like our study. Above mentioned all studies by Gaballa SH et al., Nakhli FR et al., Landers J et al., have compared two biometric methods in same group of patients [7,18, 20].

Hwang YH, in his study has compared different keratometric techniques and concluded that values of Keratometry by IOL master are different from those of auto-keratometer [21]. Present study involves Auto-keratometry method for group A patients whereas for Group B patients IOL master method giving Keratometry values. So, different keratometric methods can also have impact on actual post-operative refraction of two groups.

As per the guidelines of American academy of ophthalmology (reviewed on November 2018), the present study included patients having axial lengths between 22 mm and 24.50 mm and used SRK/T formula for calculation of IOL power in both the groups [15].

From post-operative refraction, Predicted Emmetropic IOL power was calculated for each patient of both groups and difference between actual IOL placed and predicted emmetropic IOL was calculated with its mean. Actual post-operative refractive errors in 2 groups and also their predicted emmetropic IOL power were compared.

LIMITATION

Small sample size in present study was the limitation of the study. Further studies involving large sample size will be very useful in comparing two biometry techniques in SICS with foldable IOLs implantation cases. The Keratometry method used in USG method involves auto-Keratometry whereas Optical biometry involves in-built Keratometry, this can have some bearing on the output of our study.

CONCLUSION

In the range of AXL 22 mm to 24.50 mm, used in this study, there is no statistically significant difference in axial length measurements between two methods of USG biometry and Optical biometry.

USG biometry group in present study had significant post-operative residual refraction as compared to optical biometry group, which can be attributed to inaccurate Keratometry as two different methods of Keratometry were done in two groups. Different techniques of Keratometry in two groups can influence post-operative refraction.

Advantages of optical biometry over USG biometry noted are as under-Optical biometry is non-contact, fast and accurate, but it cannot be done in mature cataracts and dense posterior subcapsular cataract where immersion USG biometry is required.

SICS with foldable IOLs implantation can be a good alternative to phacoemulsification cases in developing world where patients can have economic constraints and there is inadequate infrastructure and shortage of enough trained manpower doing Phacoemulsification. Better biometry in SICS foldable IOL cases will be helpful in those patients giving results comparable to phacoemulsification foldable IOL.

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