Original Research Article

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Evaluation of Anterior Segment Biometric Changes After Phacoemulsification Surgery with Intraocular Lens Implantation Measured with A-Scan Biometry

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Abstract

Background: Cataract is one of the most common preventable causes of blindness in the world, and the gold standard surgical treatment is phacoemulsification (PHACO) with intraocular lens (IOL) implantation. This study aimed to assess the changes in anterior segment biometry, particularly ACD, before and after PHACO with IOL, using A-scan biometry.

Methods: This prospective observational study was conducted at Mugda Medical College Hospital, Dhaka, from July 2024 to December 2025. 100 patients who had uncomplicated PHACO with PCIOL implantation were enrolled. The A-scan ultrasonic biometer was used to measure ACD at baseline (preoperative) and on the 7th postoperative day (POD) and at one month postoperatively. Data were entered and analyzed on SPSS version 26.

Results: The mean age was 61.8 ± 8.7 years, and 56% were male. Age-related cataract was the commonest diagnosis, 62%. Mean ACD increased significantly from 2.92 ± 0.28 mm preoperatively to 3.54 ± 0.31 mm on the 7th POD and 3.58 ± 0.30 mm at one month. The mean increases were 0.62 mm and 0.66 mm, respectively, both statistically significant, $P < 0.001$.

Conclusions: PHACO, along with IOL, results in a clinically and statistically significant deepening of the ACD, especially in patients with shallow preoperative ACD. These biometric changes are well monitored by A-scan ultrasonic biometry.

Keywords: Anterior chamber depth, phacoemulsification, intraocular lens implantation, A-scan biometry, cataract surgery

Introduction

Cataract is the leading cause of preventable blindness in the world, responsible for an estimated 94 million cases of blindness worldwide, or about 51% of the world's blindness.[1] Cataract is an important cause of visual impairment in LMCs, with limited access to timely surgical intervention.[2] Of the surgical options available, phacoemulsification (PHACO) and posterior chamber intraocular lens (PCIOL) implantation have become the standard of care because of their excellent safety profiles, rapid visual rehabilitation, and minimal postoperative astigmatism.[3] The anterior segment of the eye experiences a series of measurable biometric changes after cataract surgery, most importantly, the deepening of the anterior chamber depth (ACD).[4]

The presence and position of the crystalline lens have a significant effect on the ACD.[5] The removal of the opaque and bulky cataractous lens and replacement with a thin, lightweight IOL predictably leads to anterior chamber deepening, which decreases intraocular pressure (IOP) and decreases the risk of angle closure glaucoma.[6] These anatomical changes are significant not only in primary cataract surgery, but also in the treatment of patients with associated glaucoma or narrow angles, where surgical removal of the lens may provide further therapeutic benefit.[7] A-scan ultrasonic biometry is a widely used, cost-effective tool to measure axial length and ACD, especially in places where optical biometers may not be available, and is also used in many other settings.[8] The technique can be used to quantify anterior segment parameters in an objective and reproducible manner at various postoperative time points, thus allowing for the evaluation of structural changes after surgical intervention over time.[9] ACD deepening has been reported following phacoemulsification, but the extent of the change and its relationship with preoperative biometric parameters and patient-related factors (age, sex, systemic comorbidities) needs to be investigated further.[10] Most studies report plateau values by one month after surgery, and the postoperative stabilization of ACD is generally obtained within the first weeks after surgery.[11] Knowledge of the course of ACD changes is crucial for correct IOL power calculation in the fellow eye, for evaluating surgical outcomes, and for clinical management of post-cataract glaucoma. Although there is a vast amount of literature on optical biometry, there are limited studies that have focused on A-scan-derived ACD changes at specific time points after surgery, such as the 7th postoperative day and the 1-month follow-up, and how these changes relate to baseline characteristics in certain populations. The aim of this study was therefore to assess anterior segment biometric changes, namely ACD, before and after PHACO with IOL implantation using A-scan ultrasonic biometry, and to determine patient- and surgery-related factors that could predict larger ACD changes.

Methods

This prospective observational study was carried out at Mugda Medical College Hospital, Dhaka, from July 2024 to December 2025. The patients were selected using purposive sampling, and a total of 100 patients who had undergone phacoemulsification (PHACO) and posterior chamber intraocular lens (PCIOL) implantation were enrolled. Patients with a confirmed diagnosis of visually significant cataract and informed consent were included, and those who had undergone prior intraocular surgery, corneal disease, pseudoexfoliation, intraocular disease that precluded IOL implantation, or complications during surgery that prevented IOL implantation were excluded. The operated eye (right or left) was noted, and systemic comorbidities such as diabetes mellitus (DM) and hypertension (HTN) were noted. The main variable of interest was anterior chamber depth (ACD) measured in millimetres using an A-scan ultrasonic biometer at three time points: preoperatively (baseline), 7th postoperative day (POD), and 1 month postoperatively. Secondary variables were the type of cataract, preoperative visual acuity, type of IOL (foldable versus rigid PMMA), type of anaesthesia (topical versus peribulbar), surgery duration, and intraoperative complications. Surgeries were conducted by highly experienced ophthalmologists using the conventional phacoemulsification technique via a temporal clear corneal incision. The data were entered and analysed in SPSS version 26. Continuous variables were presented as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. The significance of the changes in ACD from baseline to each postoperative time point was assessed by paired t-tests, and the overall change from baseline to all three postoperative time points was assessed by repeated measures ANOVA. Chi-square tests were used to determine predictors of greater ACD improvement (defined as ≥ 0.60 mm increase), and a P-value of < 0.05 was deemed statistically significant.

Results

The sociodemographic data of the 100 participants enrolled in the study are shown in [Table 1]. The mean age was 61.8 ± 8.7 years, with the largest proportion falling in the 60–69-year age group (44%), followed by those aged 50–59 years (28%). The majority (56%) were males, and 44% were females. With respect to residence, 58% of the participants were from urban areas and 42% from rural areas, which shows a mixed distribution of the study population.

The clinical characteristics and systemic comorbidities of participants are summarized in [Table 2]. In 54% of cases, the right eye was operated on. The mean duration of visual symptoms was 14.6 ± 5.2 months, with over half of the patients (52%) having symptoms for more than 12 months. The most common comorbidities were hypertension (40%), diabetes mellitus (36%), and both conditions (22%). A total of 38% of patients had no systemic comorbidity.

The type of cataract and the ocular findings before surgery are described in [Table 3]. Age-related cataract was the most common diagnosis (62%), followed by nuclear sclerosis (20%) and posterior subcapsular cataract (12%). In 68% of patients, the cataract was unilateral. Most of the patients had a markedly reduced vision preoperatively, with 42% of patients having a visual acuity of count fingers (CF) or worse, and 34% having a visual acuity of 6/60 to 6/36.

The operational information is summarized in [Table 4]. All the patients (100%) underwent PHACO with PCIOL implantation. The majority (64%) of cases were anaesthetized with peribulbar anaesthesia, and 36% with topical anaesthesia.

Table 1: Sociodemographic profile of the study participants (*n* = 100)

Variable	Category	*n* (%)/Mean ± SD
Age (years)	Mean ± SD	61.8 ± 8.7
	<50 years	10 (10.0%)
	50–59 years	28 (28.0%)
	60–69 years	44 (44.0%)
	≥70 years	18 (18.0%)
Sex	Male	56 (56.0%)
	Female	44 (44.0%)
Residence	Urban	58 (58.0%)
	Rural	42 (42.0%)

Table 2: Clinical profile and systemic comorbidities of the study participants

Variable	Category	*n* (%)/Mean ± SD
Eye operated	Right eye	54 (54.0%)
	Left eye	46 (46.0%)
Duration of visual symptoms, months	Mean ± SD	14.6 ± 5.2
Duration group	≤6 months	12 (12.0%)
	7–12 months	36 (36.0%)
	>12 months	52 (52.0%)
Diabetes mellitus	Yes	36 (36.0%)
Hypertension	Yes	40 (40.0%)
Both DM and HTN	Yes	22 (22.0%)
No systemic comorbidity	Yes	38 (38.0%)

Table 3: Cataract diagnosis and preoperative ocular characteristics of the study participants

Variable	Category	*n* (%)
Type of cataract	Age-related cataract	62 (62.0%)
	Nuclear sclerosis	20 (20.0%)
	Posterior subcapsular cataract	12 (12.0%)
	Presenile cataract	6 (6.0%)
Cataract laterality	Unilateral	68 (68.0%)
	The bilaterally operated eye was selected	32 (32.0%)
Preoperative visual acuity	6/18-6/36	18 (18.0%)
	<6/36-6/60	34 (34.0%)
	<6/60-CF	42 (42.0%)
	HM/PL	6 (6.0%)

Table 4: Operative profile of patients undergoing PHACO with IOL implantation

Variable	Category	*n* (%)/Mean ± SD
Type of surgery	PHACO with PCIOL	100 (100.0%)
Type of anaesthesia	Topical	36 (36.0%)
	Peribulbar	64 (64.0%)
Type of IOL	Foldable IOL	78 (78.0%)
	Rigid PMMA IOL	22 (22.0%)
Duration of surgery, minutes	Mean ± SD	31.4 ± 7.6
Intraoperative complication	Present	8 (8.0%)
	Absent	92 (92.0%)

Table 5: Comparison of anterior chamber depth before and after PHACO surgery

Time point/Comparison	ACD, Mean ± SD, mm	Mean difference, mm	*P*-value
Baseline ACD	2.92 ± 0.28	-	-
7th POD ACD	3.54 ± 0.31	+0.62	<0.001
1-month ACD	3.58 ± 0.30	+0.66	<0.001
7th POD vs 1-month ACD	3.54 ± 0.31 vs 3.58 ± 0.30	+0.04	0.041

Table 6: Distribution of anterior chamber depth improvement after surgery

Variable	Category	*n* (%)
Baseline ACD	<2.50 mm	8 (8.0%)
	2.50–2.99 mm	58 (58.0%)
	≥3.00 mm	34 (34.0%)
ACD at 1 month	<3.00 mm	2 (2.0%)
	3.00–3.49 mm	34 (34.0%)
	≥3.50 mm	64 (64.0%)
ACD improvement at 1 month	<0.50 mm	24 (24.0%)
	0.50–0.99 mm	66 (66.0%)
	≥1.00 mm	10 (10.0%)

Foldable IOLs were used in 78% of eyes, and rigid PMMA IOLs were used in 22% of eyes. The average operating time was 31.4 ± 7.6 minutes. Intraoperative complications were recorded in 4 patients (8%), and uneventful surgery was recorded in 92% of patients.

The ACD measurements over time are shown in [Table 5]. The mean ACD rose from 2.92 ± 0.28 mm to 3.54 ± 0.31 mm on the 7th POD, which was a statistically significant increase of 0.62 mm ($P < 0.001$). At one-month, mean ACD further increased to 3.58 ± 0.30 mm (+0.66 mm from baseline; $P < 0.001$). The change between the 7th POD and 1-month measurements was also significant (+0.04 mm; $P = 0.041$). The overall change over the three time points was highly significant ($P < 0.001$) by repeated measures ANOVA.

The distribution of ACD values and improvement magnitudes is represented in [Table 6]. Preoperatively, 58% of patients had an ACD between 2.50 and 2.99 mm, and 8% had an ACD below 2.50 mm. By one month, 64% had an ACD of ≥ 3.50 mm, compared to 34% preoperatively at ≥ 3.00 mm. The majority of patients (66%) had an improvement in ACD of 0.50-0.99 mm, 24% had an improvement of < 0.50 mm, and 10% had an improvement of ≥ 1.00 mm.

Discussion

In this study, the anterior segment biometric changes, namely the anterior chamber depth

(ACD), were evaluated after phacoemulsification and IOL implantation with A-scan ultrasonic biometry. The results showed a statistically and clinically significant increase in the ACD from a mean of 2.92 mm preoperatively to 3.58 mm at 1 month postoperatively (0.66 mm, $P < 0.001$). These findings are in line with Dooley et al., who showed that the removal of the cataractous crystalline lens, which is known to increase in volume and thickness with age, causes a significant anterior displacement of the iris-lens diaphragm and deepening of the anterior chamber.[12] The mean preoperative ACD in this study was 2.92 mm, which is similar to the study by Sin et al., who reported the mean preoperative ACD was reported to be 2.85 ± 0.32 mm and around 3.00 mm by Asgari et al., with a similar postoperative deepening.[13,14] The slightly lower baseline ACD in our study could be due to the fact that the majority of patients were seen late with more mature cataracts, as more than half of the patients had visual symptoms for more than 12 months. There is a correlation between advanced cataract and increased lens thickness and therefore shallower preoperative ACD.[15] By the 7th postoperative day, the increase in ACD was already statistically significant (3.54 ± 0.31 mm; +0.62 mm; $P < 0.001$), suggesting that the main anatomical changes of the anterior segment occur quickly during the first week after surgery. This result is similar to that of Zhang et al., who showed that most of the ACD stabilization after phacoemulsification occurs during the first two weeks.[16] The slight anterior chamber settling from the 7th POD to the 1-month visit (+0.04 mm; $P = 0.041$) indicates ongoing, but mild, settling of the anterior chamber during the early postoperative period, which is most likely due to the resolution of intraocular inflammation and the complete in-the-bag positioning of the IOL.[17] One of the key findings of this study was the significant association between shallower preoperative ACD (< 3.00 mm) and greater postoperative ACD improvement ($P = 0.018$). Patients with an ACD less than 3.00 mm at the start of treatment had a clinically meaningful improvement, while those with a deeper ACD at the beginning of treatment had a clinically meaningful improvement. This observation has clinical significance and is confirmed by the results of Tham et al., who found that patients with shallower angles and smaller anterior chambers at baseline benefit more from anterior chamber deepening after lens extraction, and experience more intraocular pressure reduction and angle narrowing.[18] This is especially important in patients with primary angle closure disease or narrow angles who receive cataract surgery.[19] Age and intraoperative complications were not found to be significant predictors of ACD improvement in our study.[20] Age may not be a factor on its own to predict the magnitude of postoperative ACD change because the majority of the population in the study had advanced age-related lens changes, as evidenced by the mean age of 61.8 years. This is shown by Aung et al., who reported that the anterior chamber depth at baseline, not age, was the most important factor for anterior chamber deepening after phacoemulsification.[21] In our study, 78% of the IOLs used were foldable, and 22% were rigid PMMA IOLs, which represents current surgical practice. Foldable IOLs can be implanted through smaller incisions and have been shown to have higher wound integrity and lower postoperative astigmatism rates.[22] In this study, the type of IOL was not analyzed as a predictor of ACD change, but the vaulting characteristics of the different IOL designs, such as the location of the IOL within the capsular bag and the haptic angulation, are known to affect postoperative ACD.[23] The majority of our patients had age-related cataract (62%), and systemic comorbidities were common, including hypertension (40%) and diabetes mellitus (36%), which is similar to the regional epidemiological data. Diabetes is a known systemic condition that is associated with altered lens metabolism and may be a risk factor for the formation of cataracts at an earlier age and increased density.[24] Comorbidities were not identified as independent predictors of ACD change in this study, but they do require careful perioperative management and should be included in future studies assessing visual and biometric outcomes following cataract surgery. To summarize, the results of this study show that phacoemulsification with IOL implantation results in significant and early deepening of the anterior chamber, which is observed as early as the 7th postoperative day and is relatively stable at one month. The magnitude of improvement is greatest in those with shallower preoperative ACD, highlighting the importance of regular biometric assessment pre- and post-surgery. In clinical practice, A-scan ultrasonic biometry is found to be a reliable and accessible modality to track these changes.

Limitations of the Study

The small number of patients ($n = 100$) and the lack of a longer follow-up period (more than 1 month) may limit the generalizability of this study, as late biometric stabilization and/or regression of ACD changes may not have been observed. Further, the study's single-center design may restrict the applicability of the results to other groups.

Conclusion

Phacoemulsification with IOL implantation results in a significant and clinically relevant increase in the anterior chamber depth that is measurable as early as the 7th postoperative day and is sustained at 1 month after surgery. The overall difference between all-time points was highly significant, indicating that lens extraction results in immediate and long-lasting improvement of the anterior segment biometry. Cataract surgery provided more anatomical benefit for patients with shallower preoperative ACD (< 3.00 mm), as these patients showed more improvement in postoperative ACD. In this cohort, age and intraoperative complications were not significant factors in ACD change. A-scan ultrasonic biometry was a useful and accessible tool to assess these postoperative changes. The results are significant for the surgical treatment of cataract in patients with narrow anterior chambers and for the monitoring protocol after cataract surgery in the general practice.

Recommendations

Future studies with larger sample sizes, multicenter designs, and extended follow-up periods of at least six months to one year are recommended to better characterize the long-term trajectory of anterior chamber biometric changes following phacoemulsification, and to explore the role of IOL type, power, and design on postoperative ACD outcomes.

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