Original Article

Phacoemulsification In Eyes with High and Normal Axial Length: A Study of 100 Cases

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Abstract

Background: Axial length plays a critical role in cataract surgery outcomes. Patients with high axial length are often at increased risk of intraoperative complications and suboptimal visual recovery. This study aimed to evaluate the intraoperative complications of cataract surgery with phacoemulsification in eyes with high and normal axial length. **Methods:** A total of 100 cataract patients were divided into two groups: Group I (normal axial length, 21–24.5 mm) and Group II (high axial length, ≥26 mm), with 50 patients in each group. Data on age, gender, occupation, axial length, intraoperative complications, refractive error, and visual acuity on the first postoperative day and after six weeks were collected and analyzed. **Results:** The majority of patients were aged 61–80 years (55%) and male (66%). Group I had a mean axial length of 22.95 ± 0.90 mm, while Group II had a significantly longer mean of 27.76 ± 1.10 mm ($p < 0.05$). Intraoperative complications were more frequent in Group II (6.00%) compared to Group I (4.00%), with posterior capsule tear being significantly higher in the high axial length group ($p = 0.03$). Refractive status differed significantly between the groups, with Group II showing higher degrees of myopia ($p < 0.05$). Postoperative visual acuity was better in Group I at both the 1st POD and 6-week follow-up, with more patients achieving 6/6–6/9 vision compared to Group II. **Conclusion:** Patients with high axial length undergoing phacoemulsification are more prone to intraoperative complications and demonstrate poorer visual and refractive outcomes compared to those with normal axial length. Proper preoperative assessment and surgical precautions are essential to optimize outcomes in high axial length eyes.

Keywords: Phacoemulsification, Axial length, Cataract surgery, Visual acuity, Refractive status

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Introduction

Cataract surgery is among the most frequently performed procedures in ophthalmology and remains a key strategy in combating preventable blindness. Cataract is recognized as the leading cause of blindness and visual impairment worldwide, and its prevalence is expected to rise with the aging global population [1-5]. Over recent years, patient expectations have grown considerably due to the advent of advanced surgical tools and techniques. While modern cataract surgeries generally yield excellent outcomes, both patients and surgeons often have low tolerance for even minor complications [5-7].

The two primary surgical approaches to cataract removal are extracapsular cataract extraction and phacoemulsification. Phacoemulsification utilizes an ultrasonically driven tip to break up the cataractous lens, which is then aspirated. An intraocular lens (IOL) made from biocompatible material is subsequently implanted into the lens capsule to replace the removed natural lens [8]. Achieving a state of emmetropia, where the image of a distant object is sharply focused on the retina without corrective lenses, is the desired outcome. To reach this goal, various formulas have been developed over the past few decades to calculate the appropriate IOL power. These

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formulas fall into two main categories: theoretical models based on geometric optics of the eye, and empirical or regression models derived from data analysis of eyes that underwent IOL implantation [8].

Cataract surgery in patients with high myopia presents unique challenges [6,7]. Anticipating and managing potential complications is crucial for achieving favorable outcomes. IOL implantation in such cases can offer a significant refractive benefit, often surpassing the results obtained through glasses, contact lenses, or corneal refractive surgeries. However, intraoperative complications may compromise these benefits. In some difficult cases, implanting a posterior chamber IOL within the capsular bag may not be possible. Placing an IOL outside the bag, or improperly positioning it, can lead to suboptimal visual results. The introduction of the Kelman phacoemulsification technique marked a significant advancement in cataract surgery, revolutionizing the field [5, 9-11].

Despite being a technically demanding procedure requiring significant skill and experience, phacoemulsification has become the standard of care due to its many advantages. These include a smaller, sutureless incision, reduced surgically induced astigmatism, faster postoperative recovery, fewer follow-up visits, and decreased postoperative inflammation [12–15]. However, certain complications, such as vitreous loss or nucleus drop, can drastically impact surgical outcomes and require prompt, skilled management. Surgeons' experience, early recognition of complications, and effective intraoperative decision-making are critical to ensuring favorable results [5,16].

Several studies have also identified specific preoperative and intraoperative risk factors that may contribute to endothelial cell density (ECD) loss during phacoemulsification. These include Nucleus Opalescence (NO), phaco time and energy, anterior chamber depth (ACD), axial length (AL), irrigation turbulence, and mechanical trauma from surgical instruments [17,18]. Assessing these parameters preoperatively is essential for surgical planning and complication prevention. Notably, a shallow ACD and short AL reduce the available working space during surgery, increasing the risk of thermal or mechanical damage to the corneal endothelium. While some studies have downplayed the significance of ACD in endothelial cell loss after surgery, it remains an important consideration in the overall surgical strategy [19-21].

In the present study, we aimed to evaluate the intraoperative complications of cataract surgery with phacoemulsification in eyes with high and normal axial length.

Methodology & Materials

This comparative observational study was conducted in the Department of Ophthalmology, National Institute of Ophthalmology and Hospital, Dhaka, Bangladesh, from January 2013 to June 2013. In this study, 100 cataract patients attending the National Institute of Ophthalmology and Hospital were included. The patients were divided into two groups based on axial length.

Group I: Cataract patients with normal axial length (21 mm to 24.5 mm)
Group II: Cataract patients with high axial length (26 mm or more)
These were the following criteria for eligibility as study participants:

Inclusion Criteria:
- Patients with normal axial length between 21 mm and 24.5 mm
- Patients with axial length equal to or greater than 26 mm
- Patients with age-related cataract of nuclear grading II and III
- Patients of both sexes

Exclusion Criteria:
- Patients with a history of ocular surgery or ocular trauma
- Patients with known corneal curvature abnormalities or any vision-threatening ocular condition (e.g., glaucoma, age-related macular degeneration [ARMD], diabetic retinopathy)
- Patients currently using topical eye drops or systemic medications for other diseases
- Patients who were unwilling to participate in the study.

Data Collection Procedure: A total of 100 cataract patients were selected for the study from the Cataract Department of the National Institute of Ophthalmology and Hospital, Dhaka. Patient selection was based on a provisional diagnosis established through detailed history-taking and thorough clinical examination. All necessary preoperative investigations were conducted before surgical intervention. Written informed consent was obtained from each participant.

A total of 100 eyes with age-related cataracts of the same nuclear grade (Grade II and III) were included. All surgeries were performed at the same center by a single experienced surgeon to maintain consistency in surgical technique.

Preoperative axial length measurements were obtained using both contact and immersion A-scan biometry methods. Based on axial length, patients were divided into two groups:

- **Group I:** Patients with normal axial length (21 mm to 24.5 mm)
- **Group II:** Patients with high axial length (26 mm or more)

For intraocular lens (IOL) power calculation, the SRK-T formula was used in Group I, while the Holladay formula was applied for Group II. All surgeries were performed under peribulbar anesthesia using a standardized technique. A self-sealing, near-clear corneal uniplanar incision measuring 2.8 mm was made using a keratome, starting at the center of the vascular arcade. A side-port incision was created at the 2 o'clock position or 70–90 degrees away from the main incision using a 1.2 mm side-port knife. The keratome blade was oriented parallel to the iris, introduced into the anterior chamber at an angle of approximately 10 degrees to the iris plane in one continuous, smooth motion. Phacoemulsification was performed using a modified stop-and-chop step-down nucleofractis technique. A foldable intraocular lens was implanted into the capsular bag in all cases.

Statistical Analysis: All data were recorded systematically in a pre-formatted data collection form. Quantitative data were expressed as mean and standard deviation, and qualitative data were expressed as frequency distribution and percentage. The data were analyzed using the chi-square test. An unpaired t-test was used to compare the mean axial lengths between the two groups, and to compare the difference in refractive status. A p-value <0.05 was considered significant. Statistical analysis was performed by using SPSS 19 (Statistical Package for Social Sciences) for Windows version 10. This study was ethically approved by the Institutional Review Committee of the National Institute of Ophthalmology and Hospital.

Results

Table 1: Demographic characteristics of study participants

Age group	Number (n)	Percentage (%)
40-60 years	22	22.0
61-80 years	55	55.0
>80 years	23	23.0
Mean age (years)	65±8.65	
Gender		
Male	66	66.0
Female	34	34.0
Occupation		
Service	47	47.0
Housewife	33	33.0
Teacher	17	17.0
Others	3	3.0

Table 1 presents the demographic profile of the study participants. A total of 100 individuals were included in the study. The majority of participants (55%) were in the age group of 61–80 years, followed by 23% above 80 years, and 22% between 40–60 years. Regarding gender distribution, 66% of the participants were male, while 34% were female. In terms of occupation, the highest proportion of participants were service holders (47%), followed by housewives (33%), teachers (17%), and a small percentage (3%) involved in other professions.

Table 2: Comparison of Age and Gender Distribution Between Cataract Patients With Normal and High Axial Length

Age group	Group-I N=50	Group-II N=50
40-60 years	10(10.0%)	12(12.0%)
61-80 years	26(26.0%)	29(29.0%)
>80 years	14(14.0%)	09(9.0%)
Mean age (years)	65±8.65	
Sex group		
Male	32(32.0%)	34(34.0%)
Female	18(18.0%)	16(16.0%)

Group I: Cataract patients having normal axial length, 21mm to 24.5mm, Group II: Cataract patients having high axial length, 26mm or more.

In Table 2, the majority of participants in both groups belonged to the 61–80 years category: 26 (26.0%) in Group I and 29 (29.0%) in Group II. The 40–60 years age group comprised 10 (10.0%) patients in Group I and 12 (12.0%) in Group II, while the >80 years group had 14 (14.0%) in Group I and 9 (9.0%) in Group II. The mean age in Group I was 65 ± 8.65 years; the mean age for Group II was not reported. Regarding gender distribution, males constituted the majority in both groups, 32 (32.0%) in Group I and 34 (34.0%) in Group II, while females accounted for 18 (18.0%) and 16 (16.0%), respectively.

Table 3: Distribution of Axial length of the study population (N=100)

Axial length in mm	Group-I	Group-II
21.00-24.50	50(50.00%)	0
26.00-30.00	0	50(50.00%)
Mean±SD	22.95±0.90	27.76±1.10
t=2.634; p<0.05		

Table 3 shows the mean axial length in both groups. In Group I (patients with normal axial length), the mean axial length was 22.95 ± 0.90 mm, while in Group II (patients with longer axial length), the mean was 27.76 ± 1.10 mm. The difference between the two groups was statistically significant as determined by an unpaired t-test ($t = 2.634$, $p < 0.05$).

Table 4: Intraoperative complications of the study population

Intraoperative Complications	Group I (n = 50)	Group II (n = 50)	P-value
Posterior capsule tear	01 (2.00%)	02 (4.00%)	0.03
Nucleus drop	0	0	
Vitreous loss	01 (2.00%)	01 (2.00%)	
Total complications	02 (4.00%)	03 (6.00%)	

Table 4 shows that in Group I, 1 patient (2.00%) experienced a posterior capsule tear, and 1 patient (2.00%) had vitreous loss, with no cases of nucleus drop, resulting in a total of 2 complications (4.00%). In Group II, 2 patients (4.00%) had posterior capsule tears, and 1 patient (2.00%) had vitreous loss, also with no cases of nucleus drop, totaling 3 complications (6.00%). The overall number of intraoperative complications was slightly higher in Group II. However, the p-value reported ($p = 0.03$) indicates a statistically significant difference, indicating that patients with high axial length have a higher risk of complications.

Table 5: Postoperative refractive status of the study population.

Group-I, N=50		**Group-II, N=50**	
Refractive Status(Dsph)	**No**	**Refractive Status(Dsph)**	**No**
Emmetropia	26(52.00%)	Emmetropia	05(10.00%)
−0.25−0.50	14(28.00%)	−0.25−0.50	07(14.00%)
0.50−0.75	06(12.00%)	-0.50−0.75	22(44.00%)
−1.00 or less	04(8.00%)	−1.00 or less	16(32.00%)
	t=1.121; p<0.05		

Table 5 shows that the distribution of refractive status (in diopters spherical, Dsph) varied significantly between the two groups. In Group I (patients with normal axial length), the majority of participants (26; 52.0%) had emmetropia, followed by 14 (28.0%) with mild myopia (-0.25 to -0.50 D), 6 (12.0%) with mild hyperopia (0.50 to 0.75 D), and 4 (8.0%) with moderate myopia (-1.00 D or less). In contrast, Group II (patients with high axial length) had a markedly different distribution. Only 5 (10.0%) had emmetropia, while the majority had varying degrees of myopia: 7 (14.0%) with mild myopia (-0.25 to -0.50 D), 22 (44.0%) with moderate myopia (-0.50 to -0.75 D), and 16 (32.0%) with high myopia (-1.00 D or less). The difference in refractive status between the two groups was statistically significant, with an unpaired t-test result $t = 1.121$; $p < 0.05$.

Table 6: Postoperative Visual Acuity of the study population

Group-I, N=50			**Group-II, N=50**		
Visual acuity	**No**		**Visual acuity**	**No**	
	1st POD	**after 6wks**		**1st POD**	**after 6wks**
6/6-6/9	24(48.00%)	30(60.00%)	6/6-6/9	08(16.00%)	12(24.00%)
6/12-6/18	14(28.00%)	24(48.00%)	6/12-6/18	20(40.00%)	22(44.00%)
6/18-6/36	12(24.00%)	18(36.00%)	6/18-6/36	22(44.00%)	26(32.00%)

Table 6 compares the visual acuity of cataract patients in Group I (normal axial length) and Group II (high axial length) at the 1st postoperative day (POD) and 6 weeks after surgery. In Group I, visual acuity showed improvement over time. On the 1st POD, 24 patients (48.0%) had visual acuity between 6/6–6/9, which increased to 30 patients (60.0%) after 6 weeks. Visual acuity of 6/12–6/18 was observed in 14 patients (28.0%) on the 1st POD and increased to 24 (48.0%) after 6 weeks. Those with poorer visual acuity (6/18–6/36) decreased from 12 (24.0%) initially to 18 (36.0%) after 6 weeks. In Group II, outcomes were less favorable. Only 8 patients (16.0%) had visual acuity of 6/6–6/9 on the 1st POD, increasing modestly to 12 patients (24.0%) at 6 weeks. A larger proportion of patients had 6/12–6/18 vision: 20 (40.0%) on the 1st POD and 22 (44.0%) after 6 weeks. Patients with 6/18–6/36 vision made up the highest group: 22 (44.0%) on the 1st POD and 26 (52.0%) after 6 weeks.

Discussion

This study aimed to evaluate and compare the intraoperative complications, refractive outcomes, and postoperative visual acuity following phacoemulsification in patients with normal and high axial lengths. A total of 100 patients were included, with 50 patients each in Group I (normal axial length: 21–24.5 mm) and Group II (high axial length: ≥26 mm). Our results demonstrated important differences between the two groups in terms of axial length, refractive status, intraoperative complications, and visual outcomes.

The mean age of participants was 65 ± 8.65 years, with the majority falling within the 61–80 years age group (55%). There was a male predominance in both groups (66%). These demographic findings are consistent with previous studies, indicating that older age and male sex are common among cataract patients.

This study found a statistically significant difference in the mean axial length between the two groups. Group I had a mean axial length of 22.95 ± 0.90 mm, while Group II had a significantly higher mean of 27.76 ± 1.10 mm ($t = 2.634$, $p < 0.05$). These results are comparable to those reported in a study conducted at the Isfahan Eye Research Centre, which showed a mean axial length of 22.95 ± 0.83 mm in the normal group and 27.83 ± 1.82 mm in the high axial length group [2].

Intraoperative complications were generally low across both groups, but were slightly higher in the high axial length group. In Group I, two cases (4.00%) were reported, consisting of one posterior capsule rupture and one vitreous loss. Group II reported three complications (6.00%)—two posterior capsule ruptures and one vitreous loss. Although this difference was not statistically significant ($p > 0.05$), it aligns with findings from Fesharaki and Peyman et al., who also reported increased intraoperative risks in eyes with longer axial lengths [5].

The Isfahan study similarly demonstrated higher complication rates in the high axial length group, with 18 cases of posterior capsular rupture (2.5%) and 16 cases of vitreous loss (2.3%) versus lower rates in the normal group [2]. Interestingly, that study also reported instances of IOL dislocation into the anterior chamber in both groups, which was not observed in our cohort. This may reflect differences in surgical technique or surgeon expertise.

Our results also support the findings by Fesharaki and Peyman, who identified age and axial length as significant risk factors for intraoperative complications. According to their analysis, each 1-year increase in age raised the risk by 1.04-fold ($p = 0.03$), and each 1 mm increase in axial length raised the risk by 1.22-fold ($p = 0.007$) [5]. They also found no significant relationship between axial length and vitreous loss, but did report a positive correlation between longer axial lengths and increased rates of posterior capsule rupture and dropped nucleus.

We observed no cases of globe perforation during peribulbar anesthesia in either group, whereas Modarres M reported an 8% perforation rate during retrobulbar anesthesia in myopic eyes.[22] The absence of this complication in our study might be attributed to the careful use of the peribulbar technique and experienced hands. Our rate of vitreous loss was lower than that reported by Alldredge CD et al., who found a 7% rate of vitreous loss [3]. This could be due to more advanced surgical techniques and timely intraoperative interventions in our setting. Although Jeff NS and Desai P et al. reported higher complication rates, especially in eyes with long axial lengths [23,24], our study outcomes were more favorable, possibly due to better surgical equipment and technique, including the phacoemulsification method, and surgeon proficiency.

Refractive outcomes also differed significantly between groups. In Group II, 38 individuals had a postoperative refractive error of less than -0.75 D, while only 10 patients in Group I fell into this category. This indicates better refractive outcomes in the normal axial length group, a statistically significant difference ($p < 0.05$). The study findings are supported by studies from Kora Y and Buratto L, which also demonstrated less favorable refractive outcomes in highly myopic eyes following cataract surgery [25,26].

Regarding intraocular lens (IOL) power calculations, our study utilized the SRK II formula for normal axial lengths and the Holladay formula for high axial lengths. This approach aligns with findings by Chang DF and Tan JJ, who reported better accuracy of the SRK II formula for normal axial lengths and recommended the Holladay formula for longer eyes [27].

Postoperative visual acuity also favored Group I. On the first postoperative day, 24 patients (48.00%) in Group I had visual acuity between 6/6 and 6/9, increasing to 30 (60.00%) by six weeks. In contrast, only 8 patients (16.00%) in Group II achieved 6/6–6/9 vision on the first day, rising to just 12 (24.00%) at six weeks. Poorer vision (6/18–6/36) was more frequent in Group II both immediately and after six weeks. These outcomes suggest that normal axial length eyes generally experience faster and better visual recovery compared to those with high axial lengths.

The broader literature confirms that high myopia is associated with degenerative changes such as chorioretinal degeneration and higher risks of retinal detachment (RD) and glaucoma [28]. These comorbidities can negatively influence visual recovery after cataract surgery. Studies such as those by Lim LH and Lee SY identified chorioretinal degeneration, axial length, and age as major predictors of poor postoperative vision in highly myopic eyes [29,30]. In this study, none of the eyes experienced nucleus drop or IOL dislocation, and complications were managed effectively. The lower complication rates, particularly in Group I, may be attributed to the use of advanced phacoemulsification technology, surgical expertise, and preoperative planning.

Limitations of the study

This study has several limitations. First, the sample size was relatively small, with only 50 patients in each group, which may limit the generalizability of the results. Second, the timeframe allocated for data collection was relatively short about the study's scope, which posed a constraint on the depth and breadth of data that could be gathered. Lastly, there is a notable lack of similar studies conducted within Bangladesh, and the limited availability of relevant local literature made it challenging to compare or contextualize the findings within the national framework.

Conclusion and recommendations

The findings of this study suggest that cataract patients with high axial length are at a greater risk for intraoperative complications, particularly posterior capsule tears, compared to those with normal axial length. Refractive status also differed significantly, with high axial length patients showing a higher prevalence of myopia. Postoperative visual acuity outcomes were generally more favorable in patients with normal axial length, indicating better visual recovery. These results emphasize the need for heightened surgical caution and careful preoperative assessment in patients with elongated axial lengths. Incorporating biometric parameters into surgical planning may improve safety and optimize outcomes for this specific group of patients.

Further study with a prospective and longitudinal study design, including a larger sample size, needs to be done to validate the findings of this study.

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