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Original Research Article

# Association Between Phacoemulsification Parameters and Anterior Chamber Depth in Uncomplicated Cataract Surgery

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**Abstract**

**Background:** Cataract surgery, primarily performed through phacoemulsification, aims to restore vision in patients affected by cataracts. Phacomorphic angle closure (PMAC) represents a challenge in cataract surgery, particularly in managing patients with shallow anterior chambers. This study focuses on the impact of anterior chamber depth (ACD) on phacoemulsification ultrasound times and surgical outcomes.

**Aim:** The primary objective of this study was to correlate phacoemulsification ultrasound times with ACD in patients undergoing uncomplicated cataract surgery.

**Methodology:** The Department of Ophthalmology at Darbhanga Medical College and Hospital conducted this prospective observational study for a single center, over a specified period. A total of 80 patients with nuclear grade 3 cataracts were included, divided into two groups based on their preoperative ACD measurements. Various preoperative assessments were performed, including ACD, intraocular pressure (IOP), and other ocular parameters. Standardized phacoemulsification techniques were employed, and ultrasound times were recorded for analysis.

**Results:** The majority of the study sample was male, with a mean age of 65. Group A (ACD 2.20–2.50 mm) demonstrated a significantly longer total ultrasound time (mean: 35 seconds) compared to Group B (ACD 2.51–3.00 mm; mean: 30 seconds). Complications such as posterior capsular rupture were observed in Group A (2.5%), while corneal edema cleared in a mean of 3 days for Group A versus 2 days for Group B, indicating a significant difference ($p = 0.03$).

**Conclusion:** The study established a clear relationship between deeper ACD and shorter phacoemulsification ultrasound times, leading to improved surgical outcomes. These findings emphasize the importance of preoperative ACD assessment in optimizing cataract surgery and patient care.

**Keywords:** Anterior Chamber Depth, Cataract Surgery, Complications, Phacoemulsification, Postoperative Outcomes, Ultrasound Time.



## Introduction

Cataract surgery is predominantly conducted today using the phacoemulsification technique, which effectively restores vision in patients experiencing cataracts from various etiologies. This technique was initially introduced by Charles D. Kelman in 1948, gaining acceptance in 1967. Kelman's innovation stemmed from observing a dental procedure where ultrasound energy was employed to remove dental enamel and debris. He adapted this principle to develop a hollow 1 mm titanium needle powered by ultrasound to excise the lens at a remarkable speed of 40,000 oscillations per second [1].

Phacomorphic glaucoma, a type of secondary acute angle closure, is characterized by a rapid rise in intraocular pressure (IOP) and the shallowing of the anterior chamber resulting from mature or hyper-mature cataracts. Historically termed phacomorphic glaucoma, the use of "glaucoma" implies optic neuropathy, which is not typically present in most patients. Therefore, the term "phacomorphic angle closure" (PMAC) has been suggested as a more appropriate designation. PMAC is less prevalent in Western nations; however, in India during the 1980s, it accounted for 3.9% of cataract extraction cases, predominantly in females [2].

In patients with PMAC, an acute clinical presentation is often preceded by a gradual, painless decline in vision. The initial management of PMAC focuses on alleviating corneal edema and lowering IOP, with cataract extraction serving as the definitive treatment [3]. Performing cataract surgery in the context of PMAC presents challenges due to a shallow anterior chamber and elevated IOP resulting from a swollen lens. Therefore, minimizing the duration of the acute episode, effectively controlling IOP, and ensuring smooth cataract extraction are essential for enhancing visual outcomes. As cataract extraction techniques have evolved, Patients with PMAC are now receiving phacoemulsification and manual small incision cataract surgery (MSICS) instead of sutured extra capsular cataract extraction (ECCE) [4].

Phacoemulsification employs an automated irrigation and aspiration system directed by the surgeon to effectively remove cortical and nuclear fragments. Initially, there was a hesitance to embrace this technique due to its association with a high complication rate and the need to make a larger incision to fit the PMMA intraocular lens (IOL). However, the technique gained prominence in the 1980s, driven by several advancements, including the introduction of ophthalmic Visco surgical devices (OVDs), the development of foldable intraocular lenses (IOLs), the continuous curvilinear capsulorhexis technique, and enhancements in the quality and performance of phaco machines [5].

At present, phacoemulsification coupled with intraocular lens implantation is considered the gold standard for cataract management [6]. Nonetheless, various factors can affect surgical success, resulting in intraoperative and postoperative problems. Among these, the stability of the anterior chamber (AC) during phacoemulsification is a critical factor. The stability of the AC is mostly determined by the equilibrium between irrigation fluid outflow and inflow. Contemporary phacoemulsification devices can sustain a relatively stable alternating current when both the phaco tip and the irrigation/aspiration (I/A) tip are introduced into the eye [7]. However, after surgical devices are removed, the AC usually gets shallow or even collapses.

Refractive outcomes after cataract surgery are affected by multiple factors, including crucial ocular parameters like medically generated astigmatism, intraoperative techniques, keratometry, axial length, lens thickness, IOL (intraocular lens) power calculation method, and IOL positioning after establishment, all of which have a major impact on refractive outcomes [8]. IOL power is identified as the most significant and adjustable factor among these variables. The SRK/T formula, frequently employed for IOL power calculation, incorporates the axial length, keratometry, and lens constant. The established reliability of keratometry and axial length indicates that effective lens position (ELP) is a critical factor in predicting the expected refractive error [9].

Ophthalmic surgeons use keratomes with exact measurements ranging from 2.8 to 3.2 mm to create a corneal incision during phacoemulsification, which is followed by one or two paracenteses. Following the staining of the anterior lens capsule, a capsulorhexis of specified proportions is performed, succeeded by the emulsification and suction of the nucleus utilizing an ultrasonic phaco probe inserted through the main incision. After extracting the remaining cortical material from the capsular bag, a foldable intraocular lens is inserted. This treatment is typically conducted under local or topical anesthesia, allowing for same-day release of the patient. When the surgery is uncomplicated, the patient's vision usually improves on the first postoperative day and continues to improve over the next four to six weeks as the eye remodels [10]. This study aims to investigate the relationship between anterior chamber depth and phacoemulsification effective time in simple cataract surgery.

## Methodology

### Study Design

This study was prospective observational study conducted over a 12 month A total of 80 patients with clinically suspected nuclear sclerosis grade 3 cataract with phacoemulsification were in involved. The study aimed to assess the correlation between anterior chamber depth (ACD) and phacoemulsification ultrasound time during cataract surgeries. Patients undergoing cataract surgery were grouped based on their preoperative ACD.

### Study Area

The research was conducted at the Department of Ophthalmology at Darbhanga Medical College and Hospital, located in Laheriasarai, Darbhanga, Bihar, India. Participants for this study were selected from the hospital's Ophthalmology outpatient department (OPD), and the surgeries were performed in the hospital's surgical facilities.

### Inclusion Criteria

- Patients with age-related cataracts.
- Patients scheduled to undergo phacoemulsification surgery.
- In the afflicted eye, the best-corrected visual acuity is less than 6/18.

### Exclusion Criteria

Patients with ocular comorbidities like:

- Prior invasive surgical intervention.

- Complications related to cataract surgery encompass vitreous loss and posterior capsular rupture.
- Glaucoma can be primary or secondary.
- Glaucomatous optic neuropathy denotes optic nerve damage linked to glaucoma, marked by the progressive degeneration of retinal ganglion cells, and associated visual field impairments.
- Peripheral anterior synechiae.

**Procedure**

The procedure started with a comprehensive preoperative evaluation, which included an extensive medical history and documented informed consent from all patients. Intraocular pressure (IOP) was assessed utilizing a Goldmann applanation tonometer, while anterior chamber depth (ACD) was evaluated through A-scan biometry employing an Echorule 2 Biomedix device in immersion non-contact mode. Ten readings were obtained, and the mean was computed, contingent upon the standard deviation (SD) being less than 0.1. After pupillary dilatation, preoperative exams included slit lamp biomicroscopy in addition to standard workups that included blood pressure monitoring, postprandial and fasting blood sugar assessments, keratometry readings, intraocular lens (IOL) power calculations, and pre-anesthetic evaluations.

Cataract surgeries were conducted by a skilled surgeon employing a standardized phacoemulsification technique. Phenylephrine hydrochloride, 10% and tropicamide 0.5% were administered prior to surgery to induce pupil dilation. Five milliliters of 2.0% lignocaine hydrochloride were administered for peribulbar anesthesia. A cystotome was employed to perform a continuous curvilinear capsulorrhexis, which was approximately 5 mm in diameter, following a 2.8-mm superior clear corneal tunnel incision to access the eye. Hydrodissection was performed to detach the cataract from the capsule, followed by in-the-bag phacoemulsification utilizing the stop and chop technique. Cortical aspiration was performed, followed by the insertion of a foldable acrylic intraocular lens into the capsular bag. During the surgery, the phacoemulsification ultrasound durations (US 1, US 2, and total ultrasound time) were documented.

**Statistical Analysis**

Data analysis was conducted utilizing MS Excel 2021. Descriptive statistics for ACD and total ultrasound time were computed, with all data presented as mean (SD). Ultrasound time differences among groups with varying ACD were assessed utilizing paired t-tests, with a consequence threshold of $P < 0.001$ deemed statistically significant.

**Result**

The demographic information of the study population is presented in Table 1, which includes 80 individuals. The average age is reported as 65 years, with an average deviation of ±8 years. Among the participants, 45 were male (56.25%) and 35 were female (43.75%), indicating a predominance of male patients. All individuals had clinically significant cataracts, as demonstrated by BCVA (best-corrected visual acuity) of less than 6/18 in the affected eye, with 100% of the cases categorized as nuclear grade 3 cataracts. This indicates that all participants were dealing with a similar severity of cataract, providing a uniform basis for evaluating the outcomes of phacoemulsification surgery.

**Table 1: Demographic Characteristics of the Study Population (N = 80)**

| Characteristic | Value |
|---|---|
| Age (years) | Mean (SD): 65 (±8) |
| **Gender** | |
| Male | 45 (56.25%) |
| Female | 35 (43.75%) |
| Best-Corrected Visual Acuity (BCVA) | <6/18 in affected eye (100%) |
| Nuclear Grade | Grade 3 (100%) |

Table 2 presents the preoperative characteristics of patients involved in the study. The mean anterior chamber depth (ACD) was measured at 2.60 mm with a mean deviation of ±0.2 mm, falling within a range of 2.2 mm to 3.0 mm. The intraocular pressure (IOP) averaged 14.0 mmHg (±2.0 mmHg), with values spanning from 10 mmHg to 20 mmHg, indicating stable pressure levels. Lens thickness was recorded at a mean of 4.50 mm (±0.4 mm), with a range of 4.0 mm to 5.0 mm, suggesting a consistent thickness across the cohort. Additionally, blood pressure measurements revealed an average of 130/80 mmHg (±15/10), with diastolic values from 70 to 90 mmHg and systolic values ranging from 110 to 150 mmHg, indicating a generally healthy cardiovascular status among the participants prior to surgery.

**Table 2: Preoperative Characteristics of Patients**

| Characteristic | Mean (SD) | Range |
|---|---|---|
| Anterior Chamber Depth (ACD) | 2.60 (±0.2) mm | 2.2 – 3.0 mm |
| Intraocular Pressure (IOP) | 14.0 (±2.0) mmHg | 10 – 20 mmHg |
| Lens Thickness | 4.50 (±0.4) mm | 4.0 – 5.0 mm |
| Blood Pressure (Systolic/Diastolic) | 130/80 mmHg (±15/10) | 110/70 – 150/90 mmHg |

Table 3 compares the phacoemulsification ultrasound times between two groups of patients categorized by anterior chamber depth (ACD). Group A, consisting of 40 patients with ACD ranging from 2.20 to 2.50 mm, exhibited a mean ultrasound time of 15 seconds (±3 seconds) for US Time 1 and 20 seconds (±4 seconds) for US Time 2, resulting in a total mean ultrasound time of 35 seconds (±6 seconds). In contrast, Group B, also comprising 40 patients but with ACD ranging from 2.51 to 3.00 mm, recorded shorter mean ultrasound times of 12 seconds (±2 seconds) for US Time 1 and 18 seconds (±3 seconds) for US Time 2, leading to a total mean ultrasound time of 30 seconds (±4 seconds). This data indicates that patients with greater ACD have shorter overall ultrasound times during phacoemulsification surgery.

**Table 3: Comparison of Phacoemulsification Ultrasound Time Based on Anterior Chamber Depth**

| Group | ACD (mm) | US Time 1 (Seconds) | US Time 2 (Seconds) | Total US Time (Seconds) |
|---|---|---|---|---|
| Group A (n = 40) | 2.20 – 2.50 mm | Mean: 15 (±3) | Mean: 20 (±4) | Mean: 35 (±6) |
| Group B (n = 40) | 2.51 – 3.00 mm | Mean: 12 (±2) | Mean: 18 (±3) | Mean: 30 (±4) |

Table 4 displays the complications and postoperative outcomes for the two groups involved in the study. In Group A, consisting of 40 patients, there was one incident of posterior capsular rupture, accounting for 2.5% of the group, while Group B, also with 40 patients, reported no cases of this complication, resulting in a p-value of 0.5, indicating no statistically significant difference. The mean postoperative intraocular pressure (IOP) for Group A was 15 mmHg (±2 mmHg), slightly higher than Group B's mean IOP of 14 mmHg (±2 mmHg), with a p-value of 0.2, representing that there is little variation among the groups. However, concerning corneal edema, Group A experienced a mean recovery time of 3 days (±1 day), compared to just 2 days (±1 day) for Group B, with a p-value of 0.03, representing a statistically important difference that suggests patients in Group B had better outcomes in terms of corneal clarity post-surgery.

**Table 4: Complications and Postoperative Outcomes**

| Outcome/Complication | Group A (n = 40) | Group B (n = 40) | P-value |
|---|---|---|---|
| Posterior Capsular Rupture | 1 (2.5%) | 0 (0%) | 0.5 |
| Postoperative IOP (mmHg) | Mean: 15 (±2) | Mean: 14 (±2) | 0.2 |
| Corneal Edema (Days to Clear) | Mean: 3 (±1) | Mean: 2 (±1) | 0.03* |

## Discussion

The findings of this study reveal that the demographic analysis indicates a mean age of 65 years for the study population, aligning with the established age range associated with cataract development, which is predominantly age-related. Additionally, the gender distribution—56.25% male and 43.75% female—mirrors similar demographic patterns observed in other research, which also indicates no significant gender bias in cataract prevalence. Notably, previous studies have shown that phacoemulsification performed in deeper anterior chambers tends to result in reduced losses of corneal endothelial cells, diminished postoperative inflammation, and accelerated recovery [11]. Other research supports these findings, emphasizing the complications associated with shallow anterior chamber depths (ACDs) during surgical procedures, including increased intraoperative ultrasound energy and postoperative corneal edema [12].

The preoperative characteristics of the study population revealed a mean ACD of 2.60 mm, within the physiological range of 2.2–3.0 mm, and normal intraocular pressure (IOP) values (10–20 mmHg). These parameters suggest the absence of significant preexisting ocular hypertension, a known factor that complicates the outcomes of phacoemulsification surgery. Previous research indicates that elevated IOP can elevate the risk of intraoperative complications and prolong recovery periods following cataract surgery [13]. Furthermore, the studies indicate that a shallower ACD complicates the phacoemulsification process by increasing the risk of damage to adjacent ocular structures, thereby raising the incidence of complications [14]. Consequently, these preoperative characteristics are vital for evaluating surgical risks and potential outcomes in cataract surgery.

The primary focus of the study was on the phacoemulsification ultrasound durations, which were found to vary based on preoperative ACD. As detailed in Table 3, patients with shallower ACDs (Group A: 2.20–2.50 mm) exhibited a significantly longer total ultrasound duration (mean: 35 seconds) in comparison to those with deeper ACDs (Group B: 2.51–3.00 mm, mean: 30 seconds). This variation in ultrasound duration is likely attributed to the restricted surgical space encountered in patients with shallow anterior chambers, which increases the complexity of the surgery and extends the emulsification process. This observation corroborates findings from previous studies, which have documented longer phacoemulsification times and elevated complication rates in eyes with shallower ACDs. In a similar way, Ahmed and Olson established a significant correlation between shallow ACD and increased energy expenditure during phacoemulsification, indicating compromised surgical maneuverability in such instances [15]. Moreover, Blumenthal et al. reported that patients with shallow anterior chambers were more prone to delayed visual recovery postoperatively, thereby underscoring the necessity of evaluating ACD prior to surgical intervention [16].

Regarding complications, the current study indicates that Group A experienced a marginally higher incidence of posterior capsular rupture (2.5%) compared to Group B (0%), though P = 0.5 indicates that this difference was not statistically significant. The elevated complication rate in the shallow ACD group is consistent with the challenges of performing phacoemulsification in such cases, where the proximity of the lens to the cornea raises the risk of posterior capsule damage. Furthermore, postoperative results revealed that corneal edema resolved more slowly in Group A (mean: 3 days) compared to Group B (mean: 2 days), with this difference being statistically significant (P = 0.03). This delay may be linked to the greater ultrasound energy utilized in Group A, as increased ultrasound duration is known to correlate with higher corneal endothelial cell loss and prolonged corneal recovery. Similarly, Gołaszewska et al. (2019) observed that patients with an ACD of less than 2.5 mm faced a considerably elevated risk of posterior capsule rupture relative to those with deeper chambers (P < 0.001) [17]. Additionally, Porter et al. (2021) found a correlation between shallower ACDs and longer ultrasound durations as well as higher complication rates, reinforcing the significance of anatomical considerations in surgical outcomes [18].

## Conclusion

In conclusion, this study investigated the association between phacoemulsification parameters and anterior chamber depth in patients undergoing uncomplicated cataract surgery. The findings suggest that deeper anterior chambers are correlated with reduced ultrasound times during phacoemulsification, indicating a potential for more efficient surgical procedures in such cases. The results also highlight the importance of preoperative assessment of anterior chamber depth, as it may influence surgical outcomes and postoperative recovery. Overall, these insights can guide ophthalmic surgeons in optimizing surgical strategies and improving patient care in cataract surgeries.

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