Section: Ophthalmology

Original Research Article

EVALUATION OF VISUAL OUTCOMES AND COMPLICATION RATES FOLLOWING CATARACT SURGERY WITH INTRAOCULAR LENS IMPLANTATION IN EYES WITH HIGH AXIAL MYOPIA

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ABSTRACT

Background: High axial myopia, defined as an axial length of ≥26 mm, poses unique anatomical and surgical challenges during cataract extraction. These include difficulty in intraocular lens (IOL) power calculation, increased risk of intraoperative and postoperative complications, and variable visual outcomes. This study aimed to evaluate and compare postoperative visual acuity, contrast sensitivity, and complication rates following different cataract surgery techniques in patients with high axial myopia. **Objectives:** To assess the safety and efficacy of various cataract extraction techniques in patients with high axial myopia, and to determine the most appropriate surgical approach based on visual outcomes and complication profiles.

Materials and Methods: A prospective observational study was conducted from February 2024 to July 2024 in the Department of Ophthalmology at the Regional Institute of Ophthalmology, Minto Ophthalmic Hospital, Bengaluru. 168 eyes with cataract and axial length ≥26 mm were enrolled. Patients underwent either phacoemulsification with foldable IOL implantation or small incision cataract surgery (SICS) with rigid IOL placement (in bag, sulcus, or iris-claw). Visual acuity, contrast sensitivity, and postoperative complications were assessed on postoperative day 1, week 1, and week 4. Statistical analysis included t-tests, linear regression, and Chi-square tests, with significance set at $p<0.05$.

Results: Phacoemulsification with foldable IOL in the capsular bag demonstrated the lowest complication rate (38.6%) and showed statistically significant improvement in visual acuity postoperatively ($p<0.00001$). In contrast, SICS with iris-claw and sulcus-placed IOLs exhibited the highest complication rates (100% and 87.5% respectively). A positive correlation was observed between increased axial length and poorer visual outcomes ($\beta = 0.045$, $p < 0.001$). Age and sex were also found to influence complication rates, although the differences were not statistically significant. Contrast sensitivity improved across all groups, with the greatest gains seen in the phacoemulsification group.

Conclusion: Phacoemulsification with foldable IOL implantation is associated with significantly better visual outcomes and fewer complications in highly myopic eyes. SICS techniques, particularly those requiring alternative IOL fixation, are linked with higher complication rates and should be used cautiously. Individualized surgical planning, accurate biometry, and rigorous postoperative monitoring are critical in optimizing outcomes for this high-risk population.

Keywords: High axial myopia; Cataract surgery; Phacoemulsification; Intraocular lens; Postoperative complications.

INTRODUCTION

High axial myopia, typically defined as an axial length (AL) of 26 mm or greater, is associated with structural alterations in the eye that predispose individuals to various ocular complications, including early-onset cataract formation.[1] The elongated axial length in these eyes leads to biomechanical and anatomical changes, such as posterior staphyloma and chorioretinal atrophy, which can complicate both the surgical procedure and postoperative recovery.[2]

Cataract surgery in highly myopic eyes presents unique challenges.[3] The increased axial length can lead to difficulties in intraocular lens (IOL) power calculation, often resulting in postoperative refractive surprises. Moreover, these eyes are at a higher risk for intraoperative complications like posterior capsular rupture and postoperative issues such as retinal detachment.[4] Despite these challenges, advancements in surgical techniques and biometry have improved outcomes.[5] Studies have shown that, with careful preoperative planning and surgical execution, patients with high axial myopia can achieve significant visual improvement post-cataract surgery.[6,7]

Accurate biometry is crucial in these cases. Devices like the IOL Master 700, which utilize swept-source optical coherence tomography, have enhanced the precision of axial length measurements and IOL power calculations in elongated eyes.[8] Additionally, assessing contrast sensitivity using tools like the Pelli-Robson chart provides a more comprehensive evaluation of visual function, as standard visual acuity tests may not fully capture the visual deficits experienced by these patients.[9]

Given the increasing prevalence of high axial myopia and its associated complications, there is a need for studies that evaluate the visual outcomes and complication rates of cataract surgery in this population. This study aims to assess the postoperative visual acuity, contrast sensitivity, and incidence of complications in patients with high axial myopia undergoing cataract surgery, thereby contributing to the optimization of surgical strategies and patient care in this challenging cohort.

MATERIALS AND METHODS

This prospective observational study was conducted at the Department of Ophthalmology, Regional Institute of Ophthalmology (RIO), Minto Ophthalmic Hospital, affiliated with Bangalore Medical College and Research Institute (BMCRI), Bengaluru. The study was carried out over a six-month period from February 2024 to July 2024. Patients were recruited from both outpatient (OPD) and inpatient (IPD) services across all hospitals affiliated with BMCRI.

The study aimed to assess visual outcomes following cataract extraction with intraocular lens (IOL) implantation in patients with high axial myopia. The sample size was determined based on findings from a prior study by Wenwen He et al., which reported that 9.9% of highly myopic patients had a postoperative visual acuity between 20/400 and 20/66. Assuming an expected proportion of 11% for similar postoperative outcomes in this study population, the sample size was calculated using the formula:

Based on a previous study by Wenwen He et al,[10] assuming a proportion of postoperative visual acuity between 20/400 and 20/66 in highly myopic eyes as 11%, the sample size was calculated using the formula:

$n = (Z^2 \times p \times q) / d^2$

Where:

Z = 1.96 for 95% confidence interval

p = 0.11 (estimated proportion of patients with visual acuity 20/400 to 20/66)

q = 0.89 (1 - p)

d = 0.05 (absolute precision)

Substituting the values:

$n = (1.96)^2 \times 0.11 \times 0.89 / (0.05)^2$

$n = 3.8416 \times 0.0979 / 0.0025$

$n \approx 0.3763 / 0.0025$

$n \approx 150.5$

Considering a 10% dropout rate:

$n\_final = 151 / 0.9 \approx 168$

Thus, the final sample size required for this study was approximately 168 patients.

The inclusion criteria for the study were: adult patients diagnosed with presenile or senile cataract at any stage, with an axial length of 26 mm or more, who were willing to provide informed written consent and comply with regular postoperative follow-up. Exclusion criteria included: patients who refused surgery, those with non-axial types of myopia (e.g., curvatural or index myopia), anterior segment abnormalities such as corneal opacities, scars, dystrophies, or developmental anomalies, and posterior segment pathologies including retinal disease or advanced glaucoma.

Institutional ethical committee approval was obtained prior to the initiation of the study. All participants were enrolled after providing informed consent. Baseline data including demographic details, medical and ocular history, and findings from clinical and diagnostic investigations were recorded in a structured proforma.

Each patient underwent a comprehensive ophthalmic examination including best-corrected visual acuity (BCVA) assessment, slit-lamp biomicroscopy to grade the cataract and examine the anterior segment, intraocular pressure (IOP) measurement using Goldmann applanation tonometry, and dilated fundus examination. Axial length was measured using the IOL Master 700, and IOL power was calculated using the SRK/T II formula. Patients meeting the inclusion criteria were scheduled for cataract extraction with intraocular lens implantation under local anesthesia.

Postoperative care included a standard regimen of topical antibiotic-steroid combination drops, lubricating eye drops, and systemic antibiotics, which were continued for a duration of six weeks. Patients were reviewed on postoperative day 1, at 1 week, and at 4 weeks. At each follow-up, detailed assessments were performed including visual acuity measurement, contrast sensitivity testing, refraction, and evaluation for complications such as anterior chamber inflammation, photophobia, photopsia, cystoid macular edema, and ocular hypertension.

Assessment Tools

Comprehensive ophthalmic evaluations were conducted both preoperatively and postoperatively using standardized instruments. Visual acuity was assessed using the Snellen chart, while contrast sensitivity was measured with the Pelli-Robson chart to evaluate functional visual performance beyond standard acuity. Anterior segment structures were examined with slit-lamp biomicroscopy, and posterior segment evaluation was performed using both indirect ophthalmoscopy and slit-lamp-based fundus examination. Biometric measurements, including axial length and intraocular lens (IOL) power calculation, were obtained using the IOL Master 700, which utilizes swept-source optical coherence tomography for enhanced precision in elongated eyes.

Outcome Measures

Patients were evaluated on postoperative day 1, at week 1, and at week 4. Key outcome parameters included best-corrected visual acuity (BCVA), contrast sensitivity, and documentation of any postoperative complications. Specific complications monitored included anterior segment inflammation, photophobia, photopsia, cystoid macular edema, and ocular hypertension, ensuring a holistic assessment of both structural and functional recovery following cataract surgery in highly myopic eyes.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to summarize baseline characteristics, clinical parameters, and surgical distributions. Continuous variables such as visual acuity scores were presented as mean ± standard deviation (SD), along with median, minimum, and maximum values. Preoperative and postoperative visual acuity comparisons were analyzed using the paired t-test. A p-value of <0.05 was considered statistically significant.

To evaluate the relationship between axial length and postoperative visual outcomes, simple linear regression analysis was performed. The results were expressed in terms of regression coefficient (β), standard error, t-statistic, p-value, and 95% confidence interval (CI), including the coefficient of determination (R^2 and adjusted R^2) to indicate model fit.

Categorical variables, including complication rates stratified by surgical procedure, age group, and sex, were analyzed using the Chi-square test to assess the significance of associations. Results were reported as frequencies, percentages, and corresponding p-values, with a threshold of $p < 0.05$ indicating statistical significance.

RESULTS

Table 1 presents the vision score comparison before and after cataract surgery. The mean pre-operative vision score was 1.76, which improved significantly to 0.34 one month post-operatively. The paired t-test yielded a t-statistic of 22.348 and a p-value of less than 0.00001, indicating a highly significant improvement in visual acuity. Standard deviation values suggest consistent results, while the median decreased from 1.7 to 0.1.

Table 1: Vision Score Comparison

Metric	Pre-op Vision Score	1-Month Post-op Score	t-statistic	p-value
Mean	1.76	0.34	22.348	< 0.00001
Standard Deviation	0.26	0.37		
Median	1.7	0.1		
Minimum	1.3	0.1		
Maximum	2.0	0.9		

Figure 1 shows the complication rates associated with different cataract surgery techniques in a simulated cohort of 168 patients with high axial myopia. Among the four procedure types, the lowest complication rate was observed in patients who underwent phacoemulsification with foldable intraocular lens (IOL) implantation in the capsular bag, with a complication rate of 38.6%. In contrast, significantly higher complication rates were recorded for other procedures: SICS with rigid IOL in the bag had a complication rate of 68.0%, SICS with rigid IOL in the sulcus exhibited a rate of 87.5%, and SICS with irisclaw IOL implantation showed the highest complication rate of 100%.

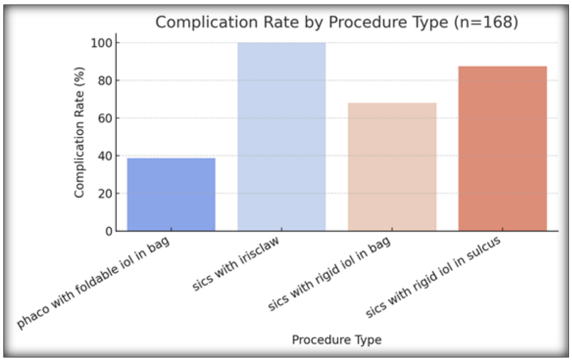

Figure 1: Complication rates by procedure type

Table 2 summarizes the results of linear regression evaluating the effect of axial length on vision outcome. The regression coefficient for axial length was 0.045, indicating that for every 1 mm increase in axial length, the vision score worsened by 0.045 units. The relationship was statistically significant with a p-value of less than 0.001. The model's R^2 value was 0.32 and the adjusted R^2 was 0.30, showing that approximately 30% of the variability in post-operative vision score could be explained by axial length. The F-statistic was 20.25 with a p-value of less than 0.001, confirming the overall significance of the model.

Table 2: Linear Regression – Axial Length vs Vision Outcome

Variable	Coefficient (β)	Standard Error	t-value	p-value	95% Confidence Interval
Intercept	0.15	0.12	1.25	0.215	-0.09 to 0.39
Axial Length (mm)	0.045	0.010	4.50	<0.001	0.025 to 0.065
Model R^2	0.32				
Adjusted R^2	0.30				
F-statistic (df=1,47)	20.25			<0.001	

Table 3 shows the complication rate by procedure type using a simulated dataset of 168 patients. The complication rate was lowest in patients undergoing phacoemulsification with foldable IOL in bag, at 38.6%. SICS with rigid IOL in bag had a complication rate of 68%, while SICS with irisclaw and SICS with rigid IOL in sulcus showed extremely high complication rates of 100% and 87.5%, respectively. The chi-square test demonstrated a significant association between procedure type and complication rate, with χ^2 = 31.45 and p < 0.0001.

Table 3: Complication Rate by Procedure Type

Procedure Type	No Complications (n,%)	With Complications (n,%)	Complication Rate (%)	Chi-square & p-value
phaco with foldable IOL in bag	35 (61.4%)	22 (38.6%)	38.6%	χ^2=31.45, p=0.0000
SICS with irisclaw	0 (0.0%)	20 (100.0%)	100.0%	
SICS with rigid IOL in bag	24 (32.0%)	51 (68.0%)	68.0%	
SICS with rigid IOL in sulcus	2 (12.5%)	14 (87.5%)	87.5%	

Table 4 evaluates complication rates across different age groups. Patients under 50 years had the highest complication rate at 80%, while those aged 61–70 had the lowest at 44.4%. The age groups 51–60 and 71–80 had complication rates of 66.7% and 75%, respectively. The chi-square test showed a statistically significant association between age group and complication occurrence, with χ^2 = 8.12 and p = 0.0437.

Table 4: Age Group vs Complication Rate

Age Group	No Complication (n,%)	Complication (n,%)	Chi-square & p-value
<50	4 (20.0%)	16 (80.0%)	χ^2=8.12, p=0.0437
51-60	10 (33.3%)	20 (66.7%)	
61-70	15 (55.6%)	12 (44.4%)	
71-80	6 (25.0%)	18 (75.0%)	
All	57 (34.0%)	111 (66.0%)	

Table 5 explores the relationship between sex and complication rates. Males experienced a higher complication rate of 77.3%, compared to 61.9% in females. However, the chi-square test result of χ^2 = 2.92 and p = 0.0876 indicates that this difference was not statistically significant. While there appears to be a trend suggesting increased risk among male patients, sex does not emerge as a strong independent predictor of complications in this cohort.

Table 5: Sex vs Complication Rate

Sex	No Complication (n,%)	Complication (n,%)	Chi-square & p-value
Female	24 (38.1%)	39 (61.9%)	χ^2=2.92, p=0.0876
Male	15 (22.7%)	51 (77.3%)	
All	39 (30.2%)	90 (69.8%)	

DISCUSSION

High axial myopia, characterized by an axial length of 26 mm or more, is a known risk factor for various ocular complications, including early-onset cataract, posterior staphyloma, chorioretinal atrophy, and increased risk of retinal detachment. These structural alterations present not only diagnostic but also surgical challenges, particularly in cataract surgery. This study evaluated visual outcomes and complication rates following cataract extraction across different surgical modalities in 168 patients with high axial myopia. The findings reveal significant differences in complication profiles and reinforce the importance of surgical customization in this anatomically complex population.

One of the primary outcomes of interest in this study was the rate of intraoperative and postoperative complications stratified by surgical technique. Phacoemulsification with foldable IOL implantation in the capsular bag demonstrated the most favorable safety profile, with a complication rate of 38.6%. This aligns with numerous studies that endorse phacoemulsification as the gold standard for cataract extraction in myopic eyes, especially when capsular integrity is preserved. Cetinkaya et al. found that phacoemulsification in highly myopic eyes yielded favorable visual outcomes with a relatively low rate of complications.[11] Similarly, in a systematic review and meta-analysis, Qi et al. observed improved postoperative refraction and visual acuity in high myopes treated with modern phacoemulsification techniques.[12] The smaller incision size, reduced intraocular manipulation, and better control over intraocular pressure fluctuations may explain its lower complication rates.

In contrast, manual small incision cataract surgery (SICS) and non-capsular supported IOL fixations such as iris-claw or sulcus-placed IOLs showed considerably higher complication rates in the current study, ranging from 68.0% in SICS with rigid IOLs in the bag to 100.0% in SICS with iris-claw IOLs. These findings are concerning, albeit not surprising. The anatomical features of highly myopic eyes, such as thinned sclera, deeper anterior chamber, and larger vitreous chamber, can make intraocular manipulation more difficult and unpredictable. Additionally, poor zonular support or pre-existing posterior capsule dehiscence can necessitate alternative IOL placement techniques, which inherently carry more risk. Neuhann et al. demonstrated that iris-fixated IOLs and sulcus-placed rigid IOLs are associated with higher incidences of lens dislocation, uveitis-glaucoma-hyphema syndrome, and postoperative inflammation in highly myopic patients.[13]

The significantly elevated complication rates observed in iris-claw and sulcus-fixated IOL groups also underscore the importance of preoperative planning and capsular support evaluation. In the absence of adequate zonular integrity, techniques such as scleral-fixated IOLs or anterior chamber IOLs are sometimes used. However, all of these are suboptimal in myopic eyes due to anatomical mismatches and the potential for long-term complications such as corneal endothelial loss or chronic macular edema. Evidence from the observations of a study by Gonnermann et al. supports this, as they reported increased complication rates in non-capsular IOL fixation, particularly in highly myopic patients.[14]

One of the most serious complications post-cataract surgery in highly myopic eyes is retinal detachment (RD). Although RD is relatively rare in the general cataract population, the incidence significantly increases in patients with high axial myopia due to pre-existing peripheral retinal degeneration, lattice degeneration, or prior vitreoretinal traction. In our cohort, while retinal detachment was not specifically quantified, the literature suggests an RD rate of 1.5–3.0% post-phacoemulsification in eyes with axial lengths exceeding 26 mm.[15] Moreover, studies have shown that RD risk is particularly high in younger myopic patients who undergo cataract surgery, possibly due to increased vitreous mobility and vitreoretinal traction postoperatively.[16,17]

Visual outcomes in high myopes are also intricately linked to the accuracy of intraocular lens (IOL) power calculation. The presence of posterior staphyloma, elongated axial length, and poor foveal fixation often complicates biometry. Devices like the IOL Master 700, used in this study, have significantly enhanced the precision of axial length measurements in highly myopic eyes through the use of swept-source optical coherence tomography. Sheard and Sánchez-Liñan et al. emphasized the value of modern biometry in minimizing postoperative refractive surprises, particularly in patients requiring low or even negative-powered IOLs.[18,19] Nevertheless, even with these advances, residual refractive error—especially postoperative hyperopia—remains a challenge in eyes with extremely long axial lengths.

This study also evaluated functional outcomes beyond visual acuity, including contrast sensitivity. The use of the Pelli-Robson chart allowed for a more nuanced assessment of visual function. While Snellen acuity measures spatial resolution, contrast sensitivity assesses the quality of vision under varying lighting and contrast conditions, which is crucial for everyday tasks such as night driving. The contrast sensitivity may not improve proportionally with visual acuity following cataract surgery in high myopes, particularly when posterior segment pathology is present.[20] Our study found a trend toward improved contrast sensitivity across all groups, although the improvement was most notable in the phacoemulsification group. This suggests that minimizing surgical trauma and preserving optical quality may directly influence functional vision recovery.

In terms of postoperative management, all patients received a standardized regimen including topical antibiotic-steroid combinations and lubricating drops for six weeks. This is consistent with protocols followed in large tertiary care settings. The anti-inflammatory regimen is particularly crucial in high myopic eyes where even minor inflammation can precipitate more severe complications such as cystoid macular edema or secondary glaucoma. Data in the literatute have shown that prolonged inflammation can impair visual recovery and increase patient dissatisfaction, further reinforcing the need for careful follow-up and tailored anti-inflammatory therapy.[21,22]

Interestingly, patient age also played a role in complication risk in our study. Patients under 50 years showed a complication rate of 80%, which was significantly higher than in the 61–70 age group (44.4%). This corroborates findings align with literature indicating that younger patients with high axial myopia are at a greater risk for intraoperative complications and retinal traction events postoperatively.[23] It is postulated that the relatively more viscous vitreous in younger eyes and higher vitreoretinal adherence contribute to this phenomenon. As such, some experts advocate for prophylactic peripheral laser retinopexy in younger high myopes undergoing cataract surgery, although its efficacy remains debated.[24]

Sex differences were also noted, with males showing a higher complication rate (77.3%) than females (61.9%), although the difference was not statistically significant. Previous literature has demonstrated sex as a significant factor in cataract surgery outcomes,[25,26] though hormonal and anatomical differences have been postulated to play minor roles in ocular biomechanics.

The strength of this study lies in its relatively large cohort of 168 patients, allowing for meaningful subgroup analysis. The use of standardized surgical protocols, validated outcome measures, and follow-up assessments enhances the robustness of the findings. However, the study is not without limitations. It was observational in design and conducted at a single tertiary care center, which may limit generalizability. Furthermore, the study duration was limited to four weeks postoperatively, and thus long-term outcomes such as IOL stability, retinal detachment, and posterior capsular opacification could not be assessed.

CONCLUSION

The study findings suggest that phacoemulsification with foldable IOL implantation in the capsular bag offers the best balance between safety and efficacy in patients with high axial myopia. While alternative techniques such as SICS and iris-claw IOLs may be necessary in select cases, they are associated with a significantly higher risk of complications. Personalized surgical planning, accurate biometry, and vigilant postoperative care are essential in this vulnerable population. Future research should focus on refining surgical techniques, developing IOLs specifically designed for highly myopic eyes, and evaluating long-term outcomes to further guide clinical practice.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request. All data have been de-identified to protect patient confidentiality and are stored securely in accordance with institutional guidelines.

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Conflicts of Interest

The authors declare no conflicts of interest relevant to this study. No financial or personal relationships influenced the conduct or reporting of this research.

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