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Clinical Audit

# Audit of Biometric Accuracy and Postoperative Refractive Outcomes Following Cataract Surgery.

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## ABSTRACT

**Objective:** The purpose of this study was to assess the level of accuracy of the biometric parameters obtained preoperatively to predict the postoperative refractive outcomes after uncomplicated cataract surgery and to determine the factors that correlate with the refractive prediction error.

**Methodology**: A retrospective observational clinical audit was conducted in the Department of Ophthalmology, MMC/Bacha Khan Medical College, Mardan, Pakistan, from 15 January to 15 June 2025. A consecutive non-probability sampling technique was used to recruit eligible patients. Patients with prior eye surgery, corneal disease, traumatic cataract, or intraoperative complications were excluded. Optical biometry, including axial length, keratometry, anterior chamber depth (ACD), and predicted refraction (PR), was performed. All patients were evaluated six weeks after surgery for manifest refraction. The mean absolute prediction error (MAE) was the primary outcome measure.

**Results**: Among the 100 patients, 58% were males and 42% females, with a mean age of 65.4 ± 8.7 years. Mean axial length was 23.52 ± 1.08 mm, keratometry 43.78 ± 1.64 D, and IOL power 21.43 ± 2.86 D. The postoperative spherical equivalent was −0.18 ± 0.42 D, with an MAE of 0.39 ± 0.27 D. Overall, 84% of eyes achieved refraction within ±0.50 D and 95% within ±1.00 D of the intended target. Best-corrected visual acuity of 6/9 or better was achieved in 92% of patients. Eyes with normal axial length demonstrated significantly lower prediction errors than those with short or long axial lengths (0.34 ± 0.21 D vs. 0.56 ± 0.33 D; p=0.003), while gender showed no significant association with refractive accuracy (p=0.481).

**Conclusion**: Modern optical biometry demonstrated excellent refractive predictability following uncomplicated cataract surgery. Eyes with abnormal axial lengths exhibited significantly higher prediction errors, underscoring the importance of optimized biometric assessment for improving postoperative refractive outcomes.

## INTRODUCTION

Cataract is the most important cause of potentially reversible blindness globally and also a significant burden on health services, especially in low- and middle-income countries. The WHO estimates that every year millions of people around the world suffer from cataract, which is responsible for almost half of all blindness cases. However, phacoemulsification combined with implantation of an intraocular lens (IOL) has emerged as the benchmark for cataract surgery due to its rapid recovery of visual function, high-quality visual results, and safety. Since the advent of modern surgical methods and technology, patients' expectations have shifted, with a greater focus on restoring vision. Still, they now expect a refractive outcome after surgery as close as possible to what they saw before surgery, with as little reliance on glasses as possible [1,2]. It is important to have precise ocular biometry before modern cataract surgery. The axial length, corneal curvature (keratometry), anterior chamber depth, and lens constants are basic biometric parameters used to determine the correct IOL power. Postoperative refractive errors can be substantial if these measurements are slightly off, and even if the surgery was technically successful, the patient may be unhappy. Thus, accurate biometric testing has become a pivotal part of cataract pre-operative evaluation [3]. In recent years, optical biometry has greatly enhanced the accuracy of eye measurements compared with classic ultrasound biometry. Partial coherence interferometry or swept-source optical coherence tomography are used in optical biometers to obtain measurements that are extremely reproducible and are independent of the operator. These technologies have improved the accuracy of IOL power calculation and minimized post-operative refractive surprises. In addition, modern IOL power calculation formulas, including the Barrett Universal II, Kane, Hill-RBF, and Olsen formulas, have enhanced refractive predictability across a broad spectrum of ocular anatomies [4,5]. Despite these technological advances, postoperative refractive error remains a significant clinical issue. Refractive outcomes may vary based on the following factors: axial length, corneal curvature, effective lens position, surgical technique, wound healing, and patient factors. In patients with very short or very long axial lengths, prediction errors may be especially significant because conventional formulas may not accurately estimate the lens position after surgery. It is therefore important to regularly evaluate biometric performance to maintain standards of good surgical practice and identify areas for improvement [6]. Clinical audit can be a powerful quality assurance tool that systematically compares actual clinical practice with standards. Postoperative refractive outcome auditing in cataract surgery offers important clues about the precision of biometric measurements, the accuracy of IOL calculation formulas, and the quality of surgical care. International ophthalmic societies have recommended routine auditing of refractive outcomes as a quality-assurance tool in ongoing quality-improvement programs. These audits can help surgeons to fine-tune the lens constants, adjust surgical techniques, and improve patient information about their predicted visual experience [7,8]. The most common metrics for postoperative refraction accuracy are: mean absolute prediction error (MAE), mean prediction error, or the percentage of eyes within ±0.50 diopter and ±1.00 diopter of the desired postoperative refraction. These indicators will provide an objective measure of biometric performance and enable comparisons with internationally agreed benchmarks. Further, assessment of postoperative best-corrected visual acuity aids in assessing cataract surgical success [9]. There is sparse published information on routine assessment of biometric accuracy and refractive results after cataract surgery in Pakistan. Local outcomes may vary due to patient variation, biometry, surgical methods, and technology. Institutional audits are useful for building evidence to enhance clinical practice, optimizing IOL power calculations, and ensuring high standards of ophthalmic care. For this reason, this study aimed to assess the accuracy of preoperative biometric data for predicting postoperative refractive outcomes in patients undergoing uncomplicated cataract surgery and to identify factors associated with postoperative refractive prediction error.

### Study Objectives

To assess the accuracy of ocular biometry measurements before cataract surgery in predicting postoperative refractive outcomes from uncomplicated cataract surgery and to determine the clinical factors associated with refractive prediction error.

## Materials and Methods

### Study Design & Setting

This retrospective observational clinical audit was conducted in the Department of Ophthalmology, MMC/Bacha Khan Medical College, Mardan, Pakistan, from 15 January to 15 June 2025.

### Participants

A total of 100 consecutive eligible patients who underwent uncomplicated phacoemulsification and monofocal intraocular lens (IOL) implantation were included. Eligible patients were those older than 40 years who had all preoperative biometric measurements and had postoperative refraction measured 6 weeks after surgery. Patients with previous ocular surgery, traumatic cataract, corneal diseases, combined eye surgeries, and patients with intraoperative complications were excluded.

### Sample Size Calculation

The sample size was calculated using the WHO Sample Size Calculator, assuming a 95% confidence level, an anticipated prevalence of 50%, a 10% absolute precision, and a 5% significance level, yielding a minimum required sample size of 96 patients. To improve statistical precision, 100 patients were included."

### Inclusion Criteria

- Adults ≥40 years who have been diagnosed with age-related cataract.
- Patients with uncomplicated phacoemulsification in which implantation of a monofocal intraocular lens was performed.
- Preexisting optical biometry, which provides complete information.
- Patients with postoperative follow-ups at 6 weeks with documented manifest refraction.

- Patients who have given informed consent to use anonymized clinical data.

**Exclusion Criteria**

- Ocular surgery or trauma in the past.
- Significant corneal pathology interfering with keratometry.
- Congenital or traumatic cataracts.
- Combined ocular surgical procedures.
- Posterior capsule rupture or vitreous loss during the surgery.
- Lack of medical records or loss to follow-up.

**Diagnostic and Management Strategy.**

A comprehensive ophthalmic examination was performed in all patients, including visual acuity assessment, slit-lamp biomicroscopy, intraocular pressure measurement, fundus examination, and optical biometry. Experienced surgeons performed phacoemulsification and intraocular lens (IOL) implantation, and patients were routinely followed for the next 6 weeks.

**Statistical Analysis**

Statistical analysis was performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Independent-samples t-test and Chi-square test were used for comparisons. A p-value <0.05 was considered statistically significant.

**Results**

A total of 100 patients were included in the audit. There were 58 (58.0%) males and 42 (42.0%) females, with a mean age of 65.4 ± 8.7 years. The mean preoperative axial length was 23.52 ± 1.08 mm, mean keratometry was 43.78 ± 1.64 D, and the average implanted intraocular lens power was 21.43 ± 2.86 D. At six weeks postoperatively, the mean spherical equivalent was −0.18 ± 0.42 D, while the mean absolute prediction error (MAE) was 0.39 ± 0.27 D. Overall, 84 (84.0%) patients achieved postoperative refraction within ±0.50 D of the intended target, and 95 (95.0%) patients achieved refraction within ±1.00 D. Best-corrected visual acuity of 6/9 or better was recorded in 92 (92.0%) patients. Patients with normal axial lengths demonstrated significantly lower prediction errors than those with short or long axial lengths (0.34 ± 0.21 D vs. 0.56 ± 0.33 D; p=0.003). No statistically significant association was observed between gender and postoperative refractive error accuracy (p=0.481). These findings indicate that modern optical biometry provides excellent refractive predictability and consistent postoperative visual outcomes following uncomplicated cataract surgery.

**Table 1. Demographic and Baseline Clinical Characteristics of the Study Population (n = 100)**

| Variable | Frequency (n) | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 58 | 58.0 |
| Female | 42 | 42.0 |
| Age Group (years) | | |
| 40–49 | 10 | 10.0 |
| 50–59 | 22 | 22.0 |
| 60–69 | 40 | 40.0 |
| ≥70 | 28 | 28.0 |
| Eye Operated | | |
| Right Eye | 53 | 53.0 |
| Left Eye | 47 | 47.0 |

Table 1 presents the demographic profile and baseline characteristics of the patients included in the clinical audit. Most patients were aged 60 years or older, reflecting the typical age distribution of age-related cataract.

**Table 2. Preoperative Biometric Characteristics (n = 100)**

| Parameter | Mean ± SD | Range |
|---|---|---|
| Axial Length (mm) | 23.52 ± 1.08 | 21.10–27.30 |
| Keratometry (D) | 43.78 ± 1.64 | 40.80–47.60 |
| Anterior Chamber Depth (mm) | 3.16 ± 0.34 | 2.40–4.10 |
| Calculated IOL Power (D) | 21.43 ± 2.86 | 14.00–28.50 |
| Predicted Postoperative Refraction (D) | −0.12 ± 0.29 | −0.75 to +0.50 |

Table 2 summarizes the preoperative biometric measurements obtained using optical biometry for intraocular lens power calculation before cataract surgery.

**Table 3. Postoperative Refractive and Visual Outcomes (n = 100)**

| Outcome Variable | Value |
|---|---|
| Postoperative Spherical Equivalent (D), Mean ± SD | −0.18 ± 0.42 |
| Mean Absolute Prediction Error (D), Mean ± SD | 0.39 ± 0.27 |
| Eyes within ±0.50 D of Target Refraction | 84 (84.0%) |
| Eyes within ±1.00 D of Target Refraction | 95 (95.0%) |
| Best-Corrected Visual Acuity ≥6/9 | 92 (92.0%) |
| Residual Refractive Error >±1.00 D | 5 (5.0%) |

Table 3 demonstrates excellent postoperative refractive outcomes, with the majority of patients achieving the intended refractive target and good visual acuity following uncomplicated phacoemulsification.

**Table 4. Factors Associated with Postoperative Refractive Prediction Error**

| Variable | Mean Absolute Error (Mean ± SD) | p-value |
|---|---|---|
| Axial Length | | |
| Normal (22.0–24.5 mm) | 0.34 ± 0.21 | |
| Short/Long Eyes | 0.56 ± 0.33 | 0.003 |
| Gender | | |
| Male | 0.40 ± 0.26 | |
| Female | 0.38 ± 0.28 | 0.481 |
| Age | | |
| <65 years | 0.37 ± 0.24 | |
| ≥65 years | 0.41 ± 0.29 | 0.286 |

Table 4 shows the association between patient characteristics and postoperative refractive prediction error. Eyes with abnormal axial lengths demonstrated significantly greater prediction errors, whereas age and gender were not significantly associated with refractive accuracy ($p>0.05$).

## Discussion

This clinical audit examined the accuracy of the optical biometric measurement obtained before surgery as a predictor of the refractive outcome after uncomplicated phacoemulsification cataract surgery. The results showed very good refractive predictability with a mean absolute prediction error (MAE) of 0.39 ± 0.27 D, and 84% and 95% of patients had refractive errors within ±0.50 D and ±1.00 D, respectively, after surgery. The results show that modern optical biometry provides accurate IOL power estimates and facilitates high-quality refractive outcomes in routine cataract surgery. Recent international cataract surgery quality standards, as well as large multicenter studies assessing the accuracy of refractive outcomes after phacoemulsification, have recommended similar benchmarks [10,11]. The present results corroborate recent studies showing that optical biometry is superior to conventional ultrasound biometry. Kane et al. reported that modern optical biometers combined with advanced IOL calculation formulas significantly reduce refractive prediction errors, with approximately 80–90% of eyes achieving outcomes within ±0.50 D of the intended refraction. Likewise, Melles and colleagues observed that improvements in biometric precision and lens constant optimization have substantially enhanced postoperative refractive accuracy, supporting the routine use of optical biometry in cataract surgery. The 84% success rate observed in the current audit falls within the range reported by these contemporary investigations [12,13].In our study, the prediction errors for the normal eyes were significantly lower than those for short and long eyes ($p=0.003$). This finding is in line with recent studies demonstrating that, among other factors, axial length is one of the most significant determinants of postoperative refractive error. Barrett et al. showed that while newer IOL calculation formulas yield better results across a wide range of eye anatomies, for eyes with extreme axial lengths, refractive surprises are more likely due to difficulties estimating the ELP. Cooke et al. reported that it was necessary to optimize the lens constants for eyes with unusually short or long axial lengths, and that selecting the formula individually would also yield better results [14]. The aura of success in the postoperative outcomes in this audit is similar to that seen in many more current international studies. The surgery was successful, with over 90% of patients achieving a best corrected visual acuity of 6/9, indicating adequate biometric planning. These similarities suggest that standardized surgical procedures and optical biometry can significantly contribute to postoperative visual rehabilitation in about 88-95% of uncomplicated cataract surgeries performed in Europe and Asia [15,16].In this study, gender was not significantly associated with the accuracy of the postoperative refractive result ($p=0.481$). Similar results have been found in recent observational studies, which determined that ocular biometric parameters such as axial length, keratometry, and anterior chamber depth are key factors in predicting postoperative refractive outcomes, with sex having minimal impact on refractive prediction [17]. The present results also confirm the recent recommendations in ophthalmic practice guidelines for routine follow-up of refractive outcomes through institutional clinical audits. In addition, superior reductions in prediction error have been shown with recent innovations in swept-source optical coherence tomography (OCT) biometry and artificial intelligence (AI)-based IOL power calculation formulas, with the expectation that future technological advances will only further increase refractive precision.[18]This audit provides useful local data on the outcomes of cataract surgery in a tertiary center and shows that refractive outcomes are similar to those reported internationally. However, the study is retrospective, conducted at a single center, and has a relatively small sample size, which can reduce the generalizability of the results. More valuable evidence about the biometric accuracy of these power formulas across various patient populations would be obtained from future prospective multicenter studies that directly compare multiple modern IOL power formulas, such as Barrett Universal II, Kane, Olsen, and Hill-RBF, in larger populations with longer follow-up periods [19,20].

## Limitations

The retrospective, single-center, and small-sample-size design of this study may limit the generalizability of the findings. The audit only assessed uncomplicated cataract surgery performed with monofocal intraocular lenses. It did not compare the performance of various intraocular lens (IOL) calculation formulas, nor did it assess the long-term stability of the refractive outcome. Lack of comparison among different IOL calculation formulas and the absence of longer follow-up limited a comprehensive assessment.

## Conclusion

Modern optical biometry demonstrated excellent refractive predictability following uncomplicated cataract surgery, with most eyes achieving target refraction and favorable visual outcomes. Routine institutional audits of refractive outcomes may improve biometric accuracy, optimize IOL constant refinement, and enhance the quality of cataract surgery.

## Authors' Contributions (ICMJE)

**Muhammad Bilal**: Conceptualization, study design, data collection, statistical analysis, interpretation of data, manuscript drafting, critical revision for important intellectual content, and final approval of the manuscript.

**Shafqat Ali Shah:** Study supervision, methodology, critical revision of the manuscript for important intellectual content, and final approval of the manuscript.

**Muhammad Tariq:** Data interpretation, manuscript review, critical revision, and final approval of the manuscript.

**Naeem Khattak:** Data collection, clinical management, manuscript review, and final approval of the manuscript.

All authors meet the International Committee of Medical Journal Editors (ICMJE) authorship criteria and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## Conflict of Interest

The authors declare that they have no competing interests.

## Funding Disclosure

No external funding was received for this clinical audit.

## Ethical Approval Statement

This study was conducted as a retrospective clinical audit of routinely collected anonymized patient records to evaluate the quality of cataract surgical outcomes. As the project was undertaken as a service evaluation and quality improvement audit without any intervention beyond standard clinical care, formal Institutional Review Board (IRB) approval was not required in accordance with the institutional policy. Patient confidentiality was strictly maintained, and all data were anonymized before analysis.

## Informed Consent

Written informed consent for cataract surgery and the use of anonymized clinical data for research and audit purposes was obtained from all participants.

## Copyright Statement



## Data Availability Statement

The datasets generated and/or analyzed during the current clinical audit are available from the corresponding author upon reasonable request, subject to institutional policies and applicable ethical requirements.

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