Section: Ophthalmology

Original Research Article

# STUDY OF BIOMETRIC STABILITY AND REFRACTIVE PREDICTABILITY FOLLOWING AGE-BASED IOL UNDERCORRECTION IN PEDIATRIC CATARACT SURGERY

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ABSTRACT

**Background:** Pediatric cataract poses unique challenges due to ongoing ocular growth and the need for precise refractive planning. Age-based undercorrection of intraocular lens (IOL) power is commonly employed to accommodate future axial elongation. The aim is to evaluate biometric changes, refractive outcomes, and IOL power strategies in pediatric cataract patients over a six-month postoperative period.

**Materials and Methods:** A prospective observational study was conducted on 116 children (155 eyes) undergoing cataract surgery. Biometric parameters (K1, K2, axial length) and refractive status were assessed at baseline, 1, 3, and 6 months. IOL power was calculated using SRK/T and Holladay II formulas, with undercorrection applied using the [7 − age] formula in children ≤7 years.

**Results:** Axial length remained stable in most eyes, with only 17.07% showing mild elongation at 6 months. K1 showed a significant increase at 1 month ($p = 0.033$), while K2 remained unchanged. A strong correlation was observed between expected and achieved refractive status ($r = 0.93$, $p = 0.001$). Children ≤7 years received greater undercorrection (mean 1.85 D) compared to older children (0.18 D).

**Conclusion:** Pediatric cataract surgery with age-based IOL undercorrection yields stable biometric outcomes and reliable refractive predictability. Early intervention and tailored IOL planning are key to optimizing visual rehabilitation.

**Keywords:** Pediatric cataract, axial length, keratometry.

## INTRODUCTION

Pediatric cataract is a leading cause of treatable childhood blindness, accounting for a substantial proportion of visual disability in developing countries.[1] Unlike adult cataracts, pediatric cases demand early diagnosis and timely surgical intervention to prevent irreversible amblyopia and ensure optimal visual development.[2] The management of pediatric cataract is inherently complex due to ongoing ocular growth, variability in biometric parameters, and the need for long-term refractive planning.[3] Accurate intraocular lens (IOL) power calculation in children is particularly challenging. The dynamic nature of axial length and corneal curvature during early childhood introduces uncertainty in predicting postoperative refractive outcomes.[4] To mitigate this, surgeons often employ age-based undercorrection strategies, especially in children under 7 years, to accommodate anticipated axial elongation and reduce the risk of postoperative myopia.[5] However, the long-term biometric stability and refractive predictability of such approaches remain areas of active investigation. Furthermore, postoperative changes in keratometry (K1 and K2) and axial length can influence visual rehabilitation and the timing of amblyopia therapy. Understanding the trajectory of these parameters over time is essential for refining surgical protocols and follow-up regimens.[6] Correlating expected and achieved

refractive status also provides insight into the reliability of current IOL power formulas in pediatric eyes.[7] This study aims to evaluate the demographic distribution, biometric changes, refractive outcomes, and IOL power strategies in pediatric cataract patients over a six-month postoperative period. By analyzing keratometric shifts, axial length progression, and refractive correlations, the study seeks to inform evidence-based refinements in pediatric cataract management and contribute to improved visual outcomes in this vulnerable population.

**Aim:** To evaluate biometric changes, refractive outcomes, and intraocular lens (IOL) power strategies in pediatric cataract patients over a six-month postoperative period, with emphasis on the correlation between expected and achieved refractive status and age-based undercorrection protocols.

**Objectives**

1. To analyze the demographic and laterality profile of pediatric cataract cases undergoing surgical intervention.
2. To compare expected versus achieved refractive status and assess the strength of correlation and statistical significance.
3. To evaluate longitudinal changes in keratometric readings (K1 and K2) at 1, 3, and 6 months postoperatively.
4. To monitor axial length progression over the same follow-up period and determine its statistical relevance.
5. To assess the impact of age-based IOL undercorrection strategies by comparing emmetropic targets and implanted powers in children ≤7 years and >7 years.
6. To interpret biometric stability and refractive predictability in the context of pediatric ocular growth and surgical planning.

## MATERIALS AND METHODS

**Study Design and Setting:** This prospective observational study was conducted at a tertiary eye care center. Institutional Ethics Committee approval was obtained prior to the commencement of the study. Written informed consent was obtained from the parents or legal guardians of all participants.

**Study Population:** A total of 116 pediatric patients (155 eyes) diagnosed with congenital or developmental cataract were included. All patients underwent standardized preoperative evaluation, surgical intervention, and postoperative follow-up for a minimum of six months.

**Inclusion Criteria**

1. Children aged ≤16 years with congenital or developmental cataract
2. Underwent primary cataract surgery with intraocular lens (IOL) implantation
3. Complete biometric and refractive data available at baseline and follow-up (1, 3, and 6 months)
4. Minimum postoperative follow-up of 6 months

**Exclusion Criteria**

1. Traumatic cataracts or cataracts secondary to systemic/metabolic disorders
2. Associated ocular anomalies (e.g., microphthalmos, aniridia, persistent fetal vasculature)
3. Previous intraocular surgery or coexisting glaucoma
4. Incomplete follow-up or missing biometric/refractive data
5. Intraoperative complications affecting biometric reliability

**Preoperative Workup**

**History and Systemic Evaluation**

Detailed history included age of onset, visual behavior (e.g., leukocoria, photophobia, nystagmus), antenatal infections (e.g., TORCH), systemic syndromes (e.g., galactosemia, Lowe syndrome), and family history of cataract or consanguinity. Pediatric consultation was obtained to rule out systemic or genetic associations. Head circumference and dysmorphic features were assessed to exclude syndromic conditions.

**Ocular Examination**

Visual acuity was assessed using age-appropriate methods:

A. Preverbal children: Bruckner test, fixation preference, Teller acuity cards, OKN drum, pattern VEP.[8]
B. Verbal children: STYCAR balls, Snellen E chart, Allen picture cards, Cardiff acuity test.[9]

Slit-lamp examination was performed to classify cataract morphology (e.g., lamellar, total, posterior lenticonus). Ocular motility was assessed for strabismus or nystagmus. Fundus evaluation was done using direct and indirect ophthalmoscopy to rule out posterior segment anomalies.

**Biometry and IOL Power Calculation:** Keratometry (K1, K2) and axial length were measured using keratometer, ZeissIOL Master 700, and immersion A-scan. IOL power was calculated using SRK/T and Holladay II formulas. Undercorrection was applied in children ≤7 years using the formula:[10]

Undercorrection (D) = 7 - Age (years)

This approach is based on established pediatric pseudophakia strategies[11].For children >7 years, the first myopic reading from IOL Master 700 was selected.

**Surgical Procedure:** All surgeries were performed by a single experienced surgeon under general anesthesia.

a. Age 2–5 years: Lens aspiration + IOL implantation + posterior continuous curvilinear capsulorhexis (PCCC) + limited anterior vitrectomy (LAV)
b. Age 5–8 years: Lens aspiration + IOL implantation + PCCC (without LAV)
c. Age >8 years: Phacoaspiration + IOL implantation (adult technique)

**Postoperative Care and Follow-up:** Postoperative regimen included topical antibiotics, steroids, and

cycloplegics. Refractive correction was provided using spectacles or contact lenses. Amblyopia therapy and low vision aids were prescribed as needed. Follow-up visits were scheduled at 1, 3, and 6 months postoperatively.

**Outcome Measures:** Primary outcomes: Correlation between expected and achieved refractive status at 1 month

Secondary outcomes: Longitudinal changes in K1, K2, and axial length at 1, 3, and 6 months

**Statistical Analysis:** Data were analyzed using descriptive statistics. Paired t-tests were used to compare pre- and postoperative biometric parameters. Pearson correlation coefficient was used to assess the relationship between expected and achieved refractive status. A p-value <0.05 was considered statistically significant.

## RESULTS

This table outlines the demographic distribution of 155 eyes from 116 pediatric patients undergoing cataract surgery. The majority of cases were observed in the 5–10 year age group (49.7%), followed by equal proportions in the 0–5 and >10 year groups (25.2% each). Male patients constituted 71% of the cohort, indicating a male predominance. Right eyes were more frequently affected (58.1%) compared to left eyes (41.9%). Regarding laterality, unilateral cataracts were more common (66.4%) than bilateral cases (33.6%), suggesting a predominance of single-eye involvement in this population.

**Table 1: Demographic and Laterality Profile of Paediatric Cataract Cases**

| Sr No | Variable | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | Age Group (years) | | |
| | a. 0–5 | 39 | 25.2 % |
| | b. 5–10 | 77 | 49.7 % |
| | c. >10 | 39 | 25.2 % |
| 2 | Gender | | |
| | a. Male | 110 | 71.0 % |
| | b. Female | 45 | 29.0 % |
| 3 | Eye Involved | | |
| | a. Right | 90 | 58.1 % |
| | b. Left | 65 | 41.9 % |
| 4 | Laterality | | |
| | a. Unilateral | 77 | 66.4 % |
| | b. Bilateral | 39 | 33.6 % |

**Table 2: Refractive Outcomes and Correlation Analysis**

| Sr No | Parameter | Mean | SD | Pearson Correlation | Paired t-Test |
|---|---|---|---|---|---|
| 1 | Expected Refractive Status (D) | -0.74 | 1.41 | R=0.93 | t=-3.14 |
| 2 | Achieved Refractive Status (D) | -0.59 | 1.56 | P=0.001 (S) | P=0.002 (S) |

This table presents the comparison between expected and achieved postoperative refractive status. The mean expected refractive error was -0.74 ± 1.41 D, while the achieved mean was -0.59 ± 1.56 D. A strong positive correlation was found between the two parameters (Pearson's r = 0.93, p = 0.001), indicating that the achieved refractive outcomes closely aligned with preoperative expectations. Furthermore, a paired t-test revealed a statistically significant difference between expected and achieved values (t = -3.14, p = 0.002), suggesting that despite the correlation, the achieved refractive status deviated meaningfully from the predicted values.

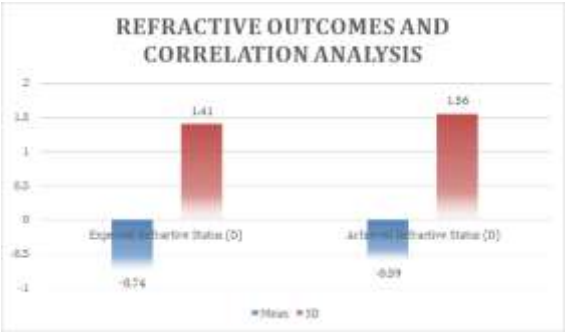


**Table 3: Longitudinal Changes in Keratometry (K1 and K2) Over Time**

| Sr No | Change Category (D) | 1 Month (%) | | 3 Months (%) | | 6 Months (%) | |
|---|---|---|---|---|---|---|---|
| | | K1 | K2 | K1 | K2 | K1 | K2 |
| 1 | > -1.0 | 5.41 | 1.35 | 2.44 | 2.44 | 0.00 | 2.44 |
| 2 | -1.0 to -0.5 | 17.57 | 9.46 | 17.07 | 4.88 | 12.20 | 2.44 |
| 3 | No change (-0.5 to +0.5) | 68.92 | 83.78 | 73.17 | 75.61 | 75.61 | 68.29 |
| 4 | +0.51 to +1.0 | 5.41 | 4.05 | 4.88 | 14.63 | 4.88 | 19.51 |
| 5 | > +1.0 | 2.70 | 1.35 | 2.44 | 2.44 | 7.32 | 7.32 |

This table summarizes the percentage distribution of changes in K1 and K2 values at 1, 3, and 6 months postoperatively. The majority of eyes showed minimal change (±0.5 D) in both K1 and K2 readings

across all time points, with 68.9–75.6% stability in K1 and 68.3–83.8% in K2. Notably, the proportion of eyes showing significant positive shifts (>+1.0 D) in K2 increased over time, reaching 7.3% at 6 months. These findings suggest that while most eyes maintain stable keratometric profiles post-surgery, a subset may experience progressive steepening, particularly in K2.

**Table 4: Axial Length Change Distribution Over Time**

| Sr No | Change Category (mm) | 1 Month (n = 74) | 3 Months (n = 41) | 6 Months (n = 41) |
|---|---|---|---|---|
| 1 | No change / <0.10 mm | 74 (100%) | 38 (92.68%) | 34 (82.92%) |
| 2 | 0.10 mm to 0.25 mm | 0 (0.00%) | 2 (4.87%) | 7 (17.07%) |
| 3 | >0.25 mm | 0 (0.00%) | 0 (0.00%) | 0 (0.00%) |

This table details the axial length changes from baseline to 6 months. At 1 month, all 74 eyes showed either no change or minimal increase (<0.10 mm). By 3 months, 4.87% of eyes exhibited a mild increase (0.10–0.25 mm), and this proportion rose to 17.07% at 6 months. No eyes demonstrated an increase >0.25 mm at any time point. These results indicate that axial elongation postoperatively is generally minimal and slow, with most eyes remaining stable over the 6-month follow-up period.

**Table 5: Biometric Parameters Over Time and Statistical Significance**

| Sr No | Change Category (D) | K1Readings | K2Readings | Axial Length |
|---|---|---|---|---|
| 1 | Baseline | 43.60 ± 1.56 | 44.40 ± 4.98 | 22.21 ± 1.35 |
| 2 | 1 Month | 43.71 ± 1.55 | 44.99 ± 1.65 | 22.25 ± 1.44 |
| 3 | 3 Months | - | - | 22.33 ± 1.37 |
| 4 | 6 Months | - | - | 22.41 ± 1.35 |
| p-value | | 0.033 (S) | 0.284 (NS) | 0.506 (NS) |

This table compares mean values of K1, K2, and axial length at baseline and follow-up intervals. K1 showed a statistically significant increase from baseline to 1 month (p = 0.033), while K2 changes were not significant (p = 0.284). Axial length increased from 22.21 mm at baseline to 22.41 mm at 6 months, but this change was not statistically significant (p = 0.506). These findings reinforce that while corneal curvature (K1) may undergo early postoperative changes, axial length remains largely stable over time.

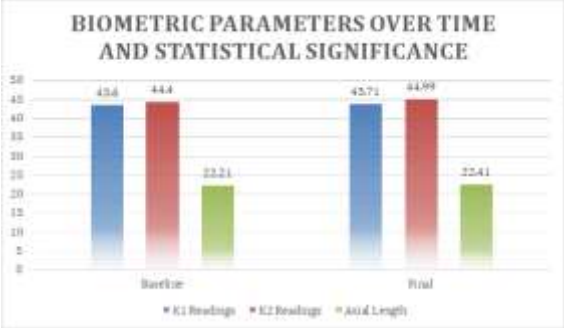


**Table 6: IOL Power and Undercorrection by Age Group**

| Sr No | Parameter | Age ≤7 years (Mean ± SD) | Age >7 years (Mean ± SD) |
|---|---|---|---|
| 1 | IOL Power for Emmetropia | 24.71 ± 3.80 | 23.76 ± 4.58 |
| 2 | IOL Power Implanted | 22.89 ± 3.54 | 23.75 ± 4.60 |
| 3 | Undercorrection (D) | 1.85 ± 1.60 | 0.18 ± 0.11 |

This table compares intraocular lens (IOL) power metrics between children aged ≤7 years and those >7 years. Younger children had a higher mean emmetropic IOL power (24.71 ± 3.80 D) and received lower implanted power (22.89 ± 3.54 D), resulting in greater undercorrection (1.85 ± 1.60 D). In contrast, older children had nearly matched emmetropic and implanted powers (23.76 ± 4.58 D vs. 23.75 ± 4.60 D), with minimal undercorrection (0.18 ± 0.11 D). These results reflect the clinical strategy of intentional undercorrection in younger children to accommodate future ocular growth.

## DISCUSSION

The present study evaluated biometric changes and refractive outcomes in 116 pediatric cataract patients, revealing that axial length remained largely stable over six months, with only 17.07% of eyes showing mild elongation (0.10–0.25 mm) and none exceeding 0.25 mm. These findings are consistent with Khokhar et al. (2019), who reported minimal axial elongation in Indian pediatric cohorts, particularly in children undergoing early surgery with posterior capsulotomy and anterior vitrectomy.[12] The stability observed here may be attributed to early surgical intervention during the plateau phase of ocular growth and the use of in-the-bag IOL implantation, which minimizes postoperative inflammation and mechanical stimulus for elongation. Keratometric readings (K1 and K2) showed >68% stability across all time points, with K1 demonstrating a statistically significant increase at 1 month (p = 0.033). This transient steepening may reflect early corneal remodeling post-surgery, possibly due to wound healing and changes in corneal hydration. Schwarzenbacher et al. (2024) noted similar early shifts in K1 values, especially in younger children, attributing them to corneal elasticity and surgical manipulation during lens aspiration.[13]

The strong correlation between expected and achieved refractive status ($r = 0.93$, $p = 0.001$) and the significant difference on paired t-test ($p = 0.002$) underscore the reliability of SRK/T and Holladay II formulas in pediatric eyes when biometric inputs are accurate. Enyedi et al. (2003) emphasized the importance of precise axial length and keratometry in achieving refractive targets, particularly when undercorrection strategies are applied.[14] [Table 6] highlights the impact of age-based undercorrection: children ≤7 years received lower IOL powers (mean 22.89 D) compared to their emmetropic targets (24.71 D), resulting in a mean undercorrection of 1.85 D. This approach aligns with the [7 − age] formula and reflects the anticipated axial elongation in younger eyes. In contrast, children >7 years showed minimal undercorrection (0.18 D), consistent with slower ocular growth beyond this age. These findings support the rationale for age-stratified IOL planning, as previously advocated by Dahan and Drusedau.[15] Mechanistically, the limited axial elongation and stable keratometry may result from a combination of factors: early surgical timing, posterior capsulotomy reducing visual axis opacification, and reduced inflammatory stimulus due to standardized technique. Additionally, the use of modern biometry tools (IOL Master 700, Pentacam) likely contributed to the precision of IOL power selection and refractive predictability.

In summary, this study reinforces the value of early intervention, age-based IOL undercorrection, and meticulous biometric planning in optimizing outcomes for pediatric cataract patients. Future studies with longer follow-up may further elucidate the trajectory of biometric changes and refine undercorrection algorithms.

## CONCLUSION

Pediatric cataract surgery with age-based IOL undercorrection and standardized techniques yielded stable biometric outcomes and strong refractive predictability over six months. Minimal axial elongation and consistent keratometry support early intervention and tailored IOL planning. These findings validate current undercorrection strategies and highlight the importance of precise biometry in optimizing visual outcomes.

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