

Post-lensectomy Refractive Status and Visual Outcomes in Children with Non-Traumatic Ectopia Lentis: A Prospective Longitudinal Study

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Abstract

Background: Ectopia lentis in children leads to significant refractive errors and visual impairment, often requiring surgical intervention. However, there is limited research in Pakistan on the surgical interventions and visual outcomes of pediatric patients with ectopia lentis. Furthermore, limited data exist regarding postoperative refractive status and visual outcomes following lensectomy in such cases.

Objective: To evaluate refractive outcomes, visual acuity, and intraocular pressure changes following in-the-bag lensectomy in children with non-traumatic ectopia lentis.

Methods: This prospective longitudinal observational study was conducted at Al-Shifa Trust Eye Hospital, Rawalpindi from 15 March to 15 September 2025. A total of 44 eyes of children aged 3–15 years undergoing lensectomy were included. Visual acuity, intraocular pressure, and spherical equivalent were assessed preoperatively and at 3 and 6 months postoperatively. Data were analyzed using repeated-measures ANOVA with Greenhouse–Geisser correction and Dunnett's post hoc test.

Results Visual acuity improved significantly, with poor vision decreasing from 52.3% preoperatively to 22.7% at 6 months, while good visual acuity increased from 29.6% to 40.9%. Mean IOP decreased from 16.57 ± 1.50 to 14.82 ± 1.40 mmHg ($p = 0.001$). Mean SE shifted from -1.38 ± 13.56 D to $+12.18 \pm 3.41$ D ($p < 0.001$), stabilizing after 3 months. Systemic associations were present in 36.4% of patients, with Marfan syndrome being the most common.

Conclusion: In-the-bag lensectomy is a safe procedure for non-traumatic ectopia lentis in children, resulting in significant visual improvement, stable refractive outcomes, reduced IOP, and effective postoperative rehabilitation with aphakic spectacles.

Key words: Ectopia lentis, pediatric aphakia, lensectomy, refractive outcomes.

Introduction

Ectopia lentis is characterized by displacement of the crystalline lens due to congenital or acquired zonular weakness. In children, non-traumatic ectopia lentis is typically bilateral and may occur either as an isolated ocular condition or in

association with systemic connective tissue and metabolic disorders such as Marfan syndrome, Weill–Marchesani syndrome, and homocystinuria.^{1,2} Progressive zonular insufficiency results in lens subluxation or dislocation, producing significant refractive errors including lenticular myopia, irregular astigmatism, and anisometropia. These refractive disturbances, particularly during critical periods of visual maturation, predispose affected children to amblyopia and permanent visual impairment if not managed promptly.³ Furthermore, anterior lens displacement may precipitate pupillary block glaucoma, while posterior dislocation can lead to vitreoretinal complications.⁴

Modern microsurgical and vitreoretinal techniques have refined the management of ectopia lentis. Contemporary approaches such as limbal or pars plana lensectomy combined with anterior vitrectomy provide improved intraoperative stability and reduced complication rates compared with

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Authors Contribution

SA conceptualized the project. RZ & AA performed the statistical analysis. SA & SA* did the data collection. RZ did the literature search. Drafting, revision & writing of manuscript were done by SA, WA & SNM.

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earlier extraction techniques.^{5,6} Recent studies report significant BCVA improvement after pediatric lensectomy with appropriate refractive correction and amblyopia therapy.⁷

Postoperative refractive rehabilitation remains an area of ongoing debate. Despite favorable short-term outcomes with scleral-fixated IOLs, concerns about long-term complications, including suture degradation, glaucoma, inflammation, and IOL decentration, favor aphakic correction with spectacles or contact lenses in younger children.^{8,9}

Despite improved surgical techniques, evidence on post-lensectomy refractive status and visual outcomes in pediatric non-traumatic ectopia lentis is limited. Understanding postoperative refractive trends and determinants of final visual acuity is essential for optimizing individualized visual rehabilitation. Therefore, the present study aims to evaluate post-lensectomy refractive status and visual outcomes in children with non-traumatic ectopia lentis.

Methods

This study was designed as a prospective longitudinal observational study, conducted at Al-Shifa Trust Eye Hospital, Rawalpindi, over a period of six months from 15 March 2025 to 15 September 2025.

A non-random purposive sampling technique was used, and 44 eligible eyes were recruited consecutively from the Children Eye Outpatient Department or admission office after informed consent. Children aged 3-5 years with non-traumatic ectopia lentis scheduled for lensectomy were eligible if they completed ≥ 6 months of postoperative follow-up. Patients with traumatic ectopia lentis, congenital glaucoma, aniridia, anterior segment dysgenesis, or pre-existing retinal detachment were excluded.

Sample size was estimated using the single-population proportion formula, based on a reported prevalence of ectopia lentis of 6%, with a 95% confidence level and 7% absolute precision. The calculated sample size was approximately 45 eyes. Due to the rarity of the condition and the limited number of eligible cases presenting during the study period, 44 eyes fulfilling the predefined eligibility criteria were included.

All patients underwent comprehensive ophthalmic evaluation, with clinical, demographic, and systemic data recorded using a structured proforma. Visual acuity was assessed using age-appropriate visual acuity charts (picture charts and ETDRS chart) and recorded in logMAR. For clinical

analysis, visual acuity was categorized as very poor ($\log\text{MAR} \geq 2.70$), poor (1.00-1.78), moderate (0.48-0.78), and good (0.00-0.40). Every patient underwent cycloplegic refraction with streak retinoscopy, in the optometrist's clinic without sedation. Children were categorized into 3 groups according to age bracket 3-5, 6-8, 9-15 years.

All patients underwent in-the-bag lensectomy without IOL implantation via a closed-chamber limbal approach. Two side ports were created with an MVR blade; an AC maintainer cannula and 25-gauge vitrector were introduced through separate ports. Anterior capsulotomy and lens aspiration were performed using the vitrector at high cut rate (1800 cuts/min) with medium-to-low aspiration, preserving the posterior capsule until lens removal. The capsular bag was then removed using high cut rate and low aspiration, followed by limited anterior vitrectomy. Limbal ports were closed with 1-2 10/0 absorbable Vicryl sutures.

Postoperative follow-up examinations were scheduled at 3 months and 6 months after surgery. Intraocular pressure (IOP) was measured using age-appropriate methods: a Perkins tonometer was used in younger children, while Goldmann applanation tonometry was used in older children. An IOP >21 mmHg was considered elevated and was used as a threshold for identifying eyes requiring evaluation for possible glaucoma. Axial length was measured by A-scan ultrasonography and interpreted using age-specific reference values to identify axial elongation consistent with myopia.

Data were analyzed using SPSS version 21. Continuous variables were summarized as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Changes in IOP and spherical equivalent (SE) across preoperative, 3-month, and 6-month measurements were assessed using repeated-measures ANOVA. For each eye, the preoperative value was used as baseline, with follow-up calculated from its date of surgery. The Greenhouse-Geisser correction was applied when sphericity was violated, and Dunnett's test was used for post-hoc comparisons with baseline. A p -value <0.05 was considered statistically significant.

Results

Twenty-seven children contributed 44 eyes; 17 children had bilateral involvement (34 eyes), while 10 children contributed a single eye (10 eyes). Table-1 summarizes patient age (mean $\pm$ SD), age group distribution, gender, and laterality of lensectomy. Age presented as mean $\pm$ SD: 9.23 $\pm$ 3.24 years.

Table 1. Demographic and surgical characteristics of the study. (n=44)

Variable	Category	Frequency (n)	%
Age groups	3-5	9	20.5
	6-8	18	40.9
	9-15	17	38.6
Gender	Male	24	54.5
	Female	20	45.5
Laterality	Left eye	21	47.7
	Right eye	23	52.3

Table-2 demonstrates a progressive improvement in visual acuity over time, reflected by a shift from higher to lower LogMAR categories. Preoperatively, the majority of eyes were in the poor vision category (52.3%), which decreased substantially to 29.5% at 3 months and 22.7% at 6 months. Conversely, the proportion of eyes with moderate and good vision increased, with good visual acuity rising from 29.6% preoperatively to 40.9% at 6 months. Very poor vision (PL/HM) remained minimal throughout. Overall, these findings indicate significant postoperative visual recovery with sustained improvement up to 6 months as shown in Figure-1.

Table 2: Distribution of VA preoperatively and at 3 and 6 month follow-up.

LogMAR Category (Approx.)	Clinical Category	Pre-OP VA n (%)	VA at 3M n (%)	VA at 6M n (%)
≥ 2.7	PL / HM (Very Poor)	2 (4.5)	1 (2.3)	1 (2.3)
1.78-1.00	Poor	23 (52.3)	13 (29.5)	10 (22.7)
0.78-0.48	Moderate	6 (13.6)	15 (34.1)	15 (34.1)
0.40-0.00	Good	13 (29.6)	15 (34.1)	18 (40.9)

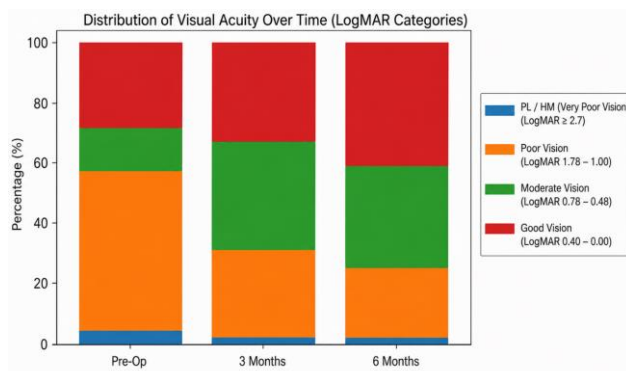


Figure: 1. Stacked bar graph showing distribution of visual acuity.

The increasing proportion of the good vision and moderate sections over time indicates improvement in postoperative visual outcomes,

while the poor vision section decreases, reflecting reduction in poor vision cases.

Table-3 shows that axial myopia was slightly more prevalent (52.3%) than normal axial length (47.7%). All eyes in the 3-5-year group were myopic, while the 6-8-year group showed an equal distribution between normal axial length and myopia. In the 9-15-year group, normal axial length was more prevalent than myopia. Overall, axial myopia appears common in children with ectopia lentis, particularly in the younger age group.

Table 3: Age-stratified prevalence of axial myopia in children with non-traumatic ectopia lentis.

Age Group	Normal n (%)	Myopia n (%)
	n=21	n=23
3-5 Years (Cutoff 21.8 mm)	0 (0%)	9(39.1%)
6-8 Years (Cutoff 22.4 mm)	9 (42.9%)	9(39.1%)
9-15 Years (Cutoff 23.1 mm)	12 (57.1%)	5(21.7%)

Raised intraocular pressure (>21 mmHg) suggestive of glaucoma was observed in 8 eyes (18.2%), whereas 36 eyes (81.8%) had normal preoperative IOP.

IOP showed a significant decrease following surgery (repeated-measures ANOVA: $F_{1,280,55.04} = 9.95$; $p = 0.001$; $\epsilon = 0.640$; $R^2 = 0.188$), declining from 16.57 ± 1.50 mmHg preoperatively to 15.30 ± 1.30 mmHg at 3 months and 14.82 ± 1.40 mmHg at 6 months. Dunnett's test confirmed significantly lower IOP at both 3 months (adjusted $p = 0.011$) and 6 months (adjusted $p = 0.002$) compared with baseline.

Spherical equivalent (SE) changed significantly following surgical intervention. Preoperatively, the mean SE was -1.38 ± 13.56 D, reflecting the wide variability in refractive error associated with ectopia lentis. Postoperatively, a marked hyperopic shift was observed, with the mean SE increasing to $+12.32 \pm 3.27$ D at 3 months and $+12.18 \pm 3.41$ D at 6 months. Repeated-measures ANOVA demonstrated a statistically significant change in SE over time ($p < 0.001$). Post-hoc comparisons showed that both postoperative measurements were significantly different from the preoperative baseline ($p < 0.001$), whereas the difference between the 3 and 6 month measurements was not statistically significant, indicating stabilization of refractive status after the early postoperative period.

Among the 44 participants, 28 (63.6%) had no systemic association, making this the most common finding. Marfan syndrome was present in 11 (25.0%), while homocystinuria and

craniosynostosis were reported in 3 (6.8%) and 2 (4.5%) participants, respectively.

Discussion

This study evaluated the refractive status and visual outcomes following in-the-bag lensectomy in children with non-traumatic ectopia lentis. The findings demonstrate significant improvement in visual acuity, a predictable postoperative hyperopic shift with early stabilization, and a statistically significant reduction in intraocular pressure (IOP) over a six-month follow-up period. These results underscore the effectiveness and safety of lensectomy with aphakic spectacle correction in pediatric patients.

A key finding of the present study is the progressive improvement in visual acuity across all postoperative intervals. The proportion of eyes with poor vision decreased from 52.3% preoperatively to 22.7% at six months, while eyes achieving good visual acuity increased from 29.6% to 40.9%. These findings indicate a substantial visual rehabilitation following removal of the subluxated lens. Similar improvements have been reported in contemporary studies.¹⁰ Our findings align with Chattannavar et al.¹¹, who reported BCVA improvement in aphakic eyes from 1.19 ± 0.19 to 0.52 ± 0.09 after lensectomy. In our study, the mean preoperative visual acuity was 1.24 ± 0.45 logMAR, which improved to 0.87 ± 0.50 logMAR at 3 months and further improved to 0.45 ± 0.48 logMAR at 6 months postoperatively. This demonstrates a marked improvement in visual outcomes following lensectomy.¹² The sustained improvement observed up to six months highlights the importance of timely surgical intervention and appropriate postoperative refractive correction. Furthermore, continued improvement between 3 and 6 months suggests ongoing visual rehabilitation and emphasizes the role of postoperative amblyopia therapy.¹³

Age at surgery is an important determinant of visual prognosis. The mean age in this study was 9.23 ± 3.24 years, with the largest proportion of eyes belonging to the 6-8 year age group. There was significant postoperative visual improvement across all three groups, with comparatively better outcomes in younger children, likely due to greater neuroplasticity and responsiveness to amblyopia therapy. In the 3-5 -year group, mean VA improved from 0.91 ± 0.10 preoperatively to 0.44 ± 0.30 at 6 months, representing a 51.6% improvement. In the 6-8 year group, VA improved from 1.16 ± 0.40 to 0.36 ± 0.29 , showing the greatest relative improvement of 69.0%. Similarly, the 9-15 year group demonstrated an improvement from

1.32 ± 0.42 preoperatively to 0.47 ± 0.41 at 6 months, corresponding to a 64.4% improvement. These findings are in agreement with Hu et al.¹⁴, who reported favorable long-term visual outcomes in children undergoing surgical management for pediatric aphakia and emphasized that earlier visual rehabilitation contributes to improved functional outcomes. Similarly, Repka et al.¹⁵ reported sustained visual improvement after pediatric cataract surgery, emphasizing early intervention and postoperative visual management. Their study focused on cataract-related aphakia, whereas the present study evaluated non-traumatic ectopia lentis managed with lensectomy without IOL implantation and spectacle correction. Despite these differences, the findings are broadly consistent with the potential benefits of early intervention and structured postoperative visual rehabilitation in pediatric patients.

Lensectomy produced a significant hyperopic shift in SE, from -1.38 ± 13.56 D preoperatively to $+12.18 \pm 3.41$ D at 6 months ($p < 0.001$). This predictable change follows crystalline lens removal and aligns with Navarrete et al.¹⁶, who reported substantial postoperative refractive shifts followed by stabilization in pediatric eyes after cataract extraction. Although their study involved infants with cataract and persistent fetal vasculature, both studies demonstrated relative refractive stability after the initial postoperative period. The lack of a significant difference between 3 and 6 month measurements supports early refractive stabilization and timely spectacle prescription.

Mean IOP decreased significantly from 16.57 ± 1.5 to 14.82 ± 1.4 mmHg at 6 months ($p = 0.0012$). The postoperative reduction, also reported by Venkataraman et al., may reflect improved aqueous dynamics after lens removal.¹⁷

Systemic associations were present in 36.4% of patients, most commonly Marfan syndrome (25%), consistent with previous reports.¹⁸⁻²⁰ These findings highlight the need for multidisciplinary care and long-term follow-up. Axial myopia occurred in 52.3% of eyes, consistent with Maharana et al.²¹, who reported increased axial length and progressive myopia in ectopia lentis. These changes may contribute to refractive instability, emphasizing the need for long-term follow-up.

All patients were rehabilitated with spectacles. Scleral-fixated IOLs in growing pediatric eyes carry risks including endophthalmitis, glaucoma, IOL dislocation, and induced astigmatism. Therefore, secondary IOL implantation may be considered later after individual risk

assessment.²² Recent studies have reported satisfactory visual outcomes with spectacle correction while avoiding these potential complications, supporting this approach, particularly in resource-limited settings.²³

The strengths of this study include the prospective design, standardized surgical technique, and systematic assessment of visual and refractive outcomes at predefined follow-up intervals. Repeated-measures analysis allowed evaluation of changes over time.

Limitations include the small sample size, six-month follow-up, non-random sampling, and single-center setting, which may limit statistical power and generalizability and preclude assessment of long-term refractive stability and late complications. The absence of a comparator group limits causal interpretation of postoperative changes.

Conclusion

In the bag lensectomy without IOL implantation safely improved visual acuity, reduced intraocular pressure, and produced a stable refractive outcome by 6 months. Aphakic spectacles provided satisfactory visual rehabilitation. Larger, long-term multicenter studies are needed to evaluate refractive stability, amblyopia, and late complications.

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Availability of Data: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval: The Ethical Review Committee of Al-Shifa Trust Eye Hospital, Rawalpindi approved the study via letter no. ERC-03/AST-25 dated 12/03/2025.

Conflict of Interest: None declared.

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