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Original Article

Frequency, Patterns, and Associated Factors of Postoperative Complications After Pediatric Strabismus Surgery: A Prospective Observational Study

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ABSTRACT

Strabismus surgery is a common intervention in pediatric ophthalmology aimed at restoring ocular alignment and improving binocular vision. While effective, the procedure carries a risk of postoperative complications that may affect long-term outcomes. **Objectives:** To determine the frequency, pattern, and associated factors of postoperative complications in children undergoing strabismus surgery during follow-up assessments. **Methods:** This prospective, observational cohort study was conducted from Jan 2023 to May 2025 at the Department of Ophthalmology, Hayatabad Medical Complex (HMC), Peshawar, Pakistan. Institutional ethical approval was obtained before commencement of the study. Written consent from the legal guardian (s) was also obtained for all children included in the study before their inclusion. **Results:** A total of 34 (28.3%) children developed postoperative complications. Amongst which the most common complications were under correction (5.8%), overcorrection (4.2%), diplopia/loss of binocular fusion (2.5%), postoperative inflammation (2.5%), and granuloma formation (2.5%). 9 children (7.5%) required reoperation because of recurrence or severe residual deviation. Each patient had an average of 2.1 ± 0.6 extraocular muscle procedures. Intraoperative complications were uncommon and occurred in 4 children (3.3%), including scleral thinning without perforation and minor muscle hemorrhage. **Conclusions:** Postoperative complications were observed in a considerable proportion of children undergoing strabismus surgery in this cohort. There were several clinical and operative variables, such as older age, complex strabismus, surgery, intraoperative complications, and amblyopia, which were linked to higher postoperative risk.

INTRODUCTION

Strabismus, commonly referred to as squint, occurs in around 2–5% of children across the world and is a major cause of visual impairment and psychosocial problems in the pediatric age group [1]. Surgical treatment is still an effective treatment modality when conservative methods, including optical correction and orthoptic exercises, are inappropriate [2]. Although pediatric strabismus surgery is safe and effective, postoperative complications are observed frequently and can include overcorrection, under correction, infection, adherence syndrome, and sensory disturbances [3, 4]. Children present unique challenges for strabismus surgery due to their developing visual system, inability to provide reliable feedback, and high neuroplasticity, which can both facilitate and complicate visual recovery [5]. Besides, the age at surgery, the nature of strabismus, the preoperative angle, as well as the presence of both systemic and ocular diseases, constitute very important variables that can affect postoperative results [6]. Despite the improvement in surgical techniques, postoperative complications still affect the long-term alignment, binocularity, and quality of life of these younger children [7]. The stability of ocular alignment and sensory results may be impacted by the clinical spectrum and determinants of postoperative

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events in children; thus, a specific evaluation of these factors is required. Improved knowledge of these variables can improve perioperative risk assessment and support evidence-based surgical care decision-making. Even though surgical success rates have been reported in many studies, it is still difficult to find evidence specifically covering the spectrum, predictors, and longer-term outcomes of postoperative complications in pediatric strabismus surgery [8]. The available literature has primarily focused on children's variables like the age at the time of surgery, the deviation angle during preoperative, and the related neurological or syndromic conditions [9]. Additionally, several of the published studies are of a retrospective nature or lack sufficient follow-up to adequately determine delayed or persistent postoperative outcomes, such as consecutive deviation, inability to enhance alignment, and delayed recurrence [10, 11].

Referral patterns, access to orthoptic care, the timing of surgery, and adherence to follow-ups may differ in Pakistan because most of the evidence that is now available was generated in high-income settings. Children in Pakistan may present later, amblyopia may appear more frequently, and the diagnosis and pattern of surgical complications may be impacted by inadequate follow-up. Therefore, in order to have a more accurate understanding of the complication profile and associated risk factors in the current setting, local prospective data are needed. This study aimed to determine the frequency, pattern, and predictors of postoperative complications in children undergoing strabismus surgery and to provide evidence to inform surgical planning, perioperative counseling, and postoperative care in pediatric ophthalmology.

METHODS

This prospective, observational cohort study was carried out from Jan 2023 to May 2025, at the Department of Ophthalmology, Hayatabad Medical Complex (HMC), Peshawar, Pakistan. Institutional review board approval was obtained before commencement of the study (approval no 1194; dated 24th December 2022). Written consent from the legal guardian(s) was also obtained for all children included in the study before their inclusion. During the study period, children aged 6 months to 15 years who had received general anesthesia and had undergone strabismus surgery met the inclusion criteria. A consecutive sampling technique was used, whereby all eligible children presenting during the study period were enrolled consecutively. Children within the specified age range who were scheduled for surgery and had a clinical diagnosis of visible strabismus, including esotropia (ET), exotropia (XT), and vertical abnormalities, were considered eligible. Only children who had undergone extra-ocular muscle surgery in the eye muscles, such as resection, recession, or transposition, were included. Children with a history of previous intraocular surgery, trauma-related strabismus, restricted thyroid ophthalmopathy, and systemic neurologic disorders involving ocular fixation were excluded. Children who already had a coagulation disorder, were in poor general health for surgery, or for whom follow-up would not be possible were also excluded. All surgeries were conducted under general anesthesia by a single consultant ophthalmic surgeon with extensive experience in pediatric strabismus surgery. This approach ensured surgical technique consistency. Standard surgical procedures were used with muscle recession or resection, or muscle plication unilaterally or bilaterally, according to the type and degree of deformity. In the operating room, we conducted forced duction tests in difficult cases to exclude the presence of any restrictive elements. The conjunctiva was closed with 6-0 absorbable Vicryl sutures. A predesigned and structured proforma was used for data collection in the current study. Demographic data, including the age and sex of the children, preoperative clinical characteristics (type of and duration of strabismus, best-corrected visual acuity (BCVA), cycloplegic refraction, retinoscopy, amblyopia types & density of amblyopia and ocular motility) were obtained. The angle of deviation preoperatively was assessed by the prism and alternate cover test for near and distance fixation. Worth 4-dot and Titmus fly tests, as appropriate, were used to assess binocular function and sensory status in older children. The following intraoperative variables were recorded: Number and type of operated muscles, duration of surgery, surgical procedure, and intraoperative complications like haemorrhage or sclera perforation. Postoperative evaluations were carried out on the first day, 1 week, and then at 1, 3, 6, and 12 months. The final 12-month follow-up was completed by May 2025 for the last enrolled patient. All data were collected prospectively during the study period. No retrospective data extraction or post-hoc adjustments were made after the completion of follow-up. Postoperative complications evaluated were residual or under correction, overcorrection causing consecutive strabismus, slippage or loss of muscles, adherence syndrome, conjunctival dehiscence, granuloma formation, localized infection or inflammation, and loss of binocularity or persistence of double vision in older children. Furthermore, any patient who required surgical reintervention during the follow-up was also noted. Under correction was considered as remaining postoperative deviation of >10 prism diopters in the primary position at distance fixation 3 months or above. Overcorrection was considered a subsequent opposite deviation of >10 prism diopters in follow-up. Muscle slip was described as a clinically suspicious or surgically determined loss of the

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operated extraocular muscle insertion relating to deviation recurrence or novelty. Adherence syndrome was described as a limitation of ocular motility constrained by conjunctival or scleral scarring, which was proven by clinical examination and forced duction test. To minimize inter-observer variability, all postoperative follow-up evaluations were performed by the same ophthalmologist, who was not involved in the surgery.

Statistical analyses were performed using SPSS version 25.0. Quantitative variables were summarized as mean ± standard deviation or median (interquartile range), depending on data distribution, whereas categorical variables were presented as frequencies and percentages. For bivariate comparisons, an independent samples t-test was used for normally distributed continuous variables, and the Mann-Whitney U test was used for non-normally distributed continuous variables. For categorical variables, the Chi-square test or Fisher's exact test was used as appropriate. For non-parametric continuous variables, medians and interquartile ranges are reported in the results, and the Mann-Whitney U test was used for group comparisons. No separate reporting of non-parametric comparison methods was required in the final results. The primary outcome variable for regression analysis was the occurrence of any postoperative complication during follow-up (yes/no). Children with documented postoperative outcome status at follow-up were included in the final analysis. Those requiring re-intervention were retained in the postoperative complication group. No formal imputation was performed because missing follow-up data for the primary outcome were minimal. Therefore, binary logistic regression was performed to identify factors independently associated with postoperative complications. Variables considered clinically relevant and/or significant in bivariate analysis were entered into the multivariable model, including age group, sex, type of strabismus, number of muscles operated, secondary surgery, intraoperative complications, and amblyopia. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported. A p-value of ≤ 0.05 was considered statistically significant. Age >8 years, complex strabismus, previous surgery, intraoperative complications, and amblyopia were significantly associated ($p < 0.05$) with postoperative complications. However, these exploratory findings require confirmation in larger prospective studies.

RESULTS

At the time of surgery, the average age was 6.7 ± 3.4 years, and there were slightly more boys than girls (68 males and 52 females). Esotropia was the most prevalent form of strabismus, occurring in 55 children (45.8%), followed by exotropia in 45 children (37.5%), vertical deviations in 10 children (8.3%), and complex patterns (horizontal and vertical combined) in 10 children (8.3%). 104 cases (86.7%) involved primary strabismus surgeries, and 16 children (13.3%) had prior strabismus procedures. Presence of amblyopia was observed in 38 (31.7%) cases (Table 1).

Table 1: Summary of Patient Demographics and Surgical Characteristics

Variables	n (%) / Mean ± SD
Mean age (years)	6.7 ± 3.4
Gender	
Male	68 (56.7%)
Female	52 (43.3%)
Type of Strabismus	
Esotropia	55 (45.8%)
Exotropia	45 (37.5%)
Vertical	10 (8.3%)
Complex	10 (8.3%)
Surgery Type	
Primary Surgeries	104 (86.7%)
Secondary Surgeries	16 (13.3%)
Type of Amblyopia	
Strabismic	20 (52.6%)
Anisometropic	10 (26.3%)
Mixed (Strabismic + Aniso)	8 (21.1%)
Density of Amblyopia	
Mild (20/30 to 20/40)	12 (31.6%)
Moderate (20/50 to 20/100)	16 (42.1%)
Severe (<20/100)	10 (26.3%)

Note: Percentages for type and severity of amblyopia were calculated using children with amblyopia (n=38) as the denominator

A total of 34 (28.3%) children experienced postoperative complications. The most common reported complication was under correction 7 (5.8%), while 5 (4.2%) experienced overcorrection or consecutive deviation. 3 (2.5%) had diplopia, or loss of binocular fusion, and slipped muscle (2.5%). Postoperative inflammation was noted in 3 (2.5%). Granuloma occurred in 3 (2.5%). Conjunctival edema & foreign body sensation occurred in 2 (1.7%) cases each, while redness, lid edema, and watering eye were recorded in 1 (0.8%) of cases, respectively. During the follow-up period, nine children (7.5%) needed re-operation because of severe misalignment or recurrence. Topical antibiotics and corticosteroids were effective in managing all of these cases. Each patient had an average of 2.1 ± 0.6 extraocular muscle operations. Only 4 children (3.3%) experienced intraoperative complications, which included scleral thinning without perforation and minor muscle hemorrhage (Figure 1).

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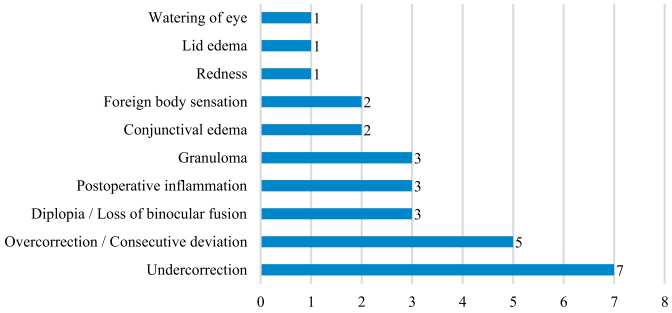


Figure 1: Postoperative Complications in Pediatric Strabismus Surgery

The relationship between demographic, clinical, and operative factors and the postoperative complications was analyzed using bivariate analysis. The binary logistic regression model included clinically relevant variables and those that were significantly associated during bivariate analysis. The last multivariate model found the independent variables to be age >8 years, complex strabismus, secondary surgery, intraoperative complications, and amblyopia as the independent variables (Table 2).

Table 2: Multivariate Logistic Regression Analysis for Predictors of Postoperative Complications

Variables	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-value
Age (>8 Years)	2.12	1.01 – 4.46	0.047*
Male Gender	1.15	0.54 – 2.43	0.710
Type of Strabismus (Complex vs Others)	2.76	1.03 – 7.40	0.043*
Number of Muscles Operated (>2)	1.89	0.85 – 4.20	0.118
Secondary Surgery	3.58	1.29 – 9.94	0.014*
Intraoperative Complications	4.92	1.01 – 23.92	0.049*
Amblyopia (Yes vs No)	2.14	1.01-4.52	0.046*

DISCUSSION

The current research covered 120 children (mean age of 6.7 ±3.4 years) with a slightly higher number of boys as compared to girls (68 vs. 52). The most prevalent was esotropia, then exotropia, and less frequent were vertical and complex deviations. This distribution is widely comparable with past pediatric strabismus series [12-15]. The predominance of esotropia in our cohort (45.8%) is consistent with findings from other series from South Asia [12]. This may reflect referral patterns in our setting, where convergent deviations are more readily recognized by parents, although this hypothesis requires formal investigation. Intraoperative complications were rare (3.3%) and were limited to minor hemorrhage and scleral thinning without perforation. This rate is a little higher than other large published series [16], possibly due to the greater complexities of cases, secondary surgeries, and more comprehensive prospective reporting of minor intraoperative occurrences in the current cohort. However, the fact that serious intraoperative complications are rather rare adds to the procedure's safety when it comes to juvenile strabismus surgery performed in specialized facilities. The incidence of postoperative complications in the current study was found to be 28.3%, with under correction (5.8%) and overcorrection (4.2%) being the most common. These rates are similar to those in previous literature and could possibly be associated with similar distributions of large-angle deviations, amblyopia load, and secondary surgeries [17]. Conversely, those studies with lesser residual deviation rates tend to have more selective populations, less time-span strabismus, or less complicated referral patterns. Delays in presentation and increased preoperative angles can be a cause of residual deviation postoperatively, especially under correction, even with proper surgical dosing in our setup. The 7.5% reoperation rate observed in this cohort is comparable to previously published pediatric studies [18]. This is likely a sign of the dynamic nature of ocular alignment in developing children, where remnant deviation, recurring deviation, and sensory adaptation may vary over time, rather than a single surgical failure. Diplopia or loss of binocularity was noted in 2.5% of children, especially older children undergoing large-angle corrections. This result is in line with prior findings that age at surgery, amblyopia, and the magnitude of deviation pre-surgery could be related to postoperative sensory recovery [19]. Compared to the findings of larger international cohorts [20], the rate of postoperative inflammation was slightly higher in current study. The slightly higher rate of postoperative inflammation compared to some international cohorts [18] may reflect differences in surgical technique, postoperative care protocols, or patient populations. However, direct comparisons are limited by differences in study design and outcome definitions across studies. Complications of granuloma formation and conjunctival wounds were rare and readily managed by conservative means. The regression analysis was designated as exploratory due to the sample size being powered for the primary outcome proportion rather than for multivariable modeling. Therefore, the identified associations should be considered preliminary and require validation in larger, adequately powered studies. The low incidence of these tissue-related events is in agreement with previous reports of minor conjunctival cysts and corneal dellen after strabismus surgery [21].

There are some limitations that must be considered while interpreting these results. The study may not be very generalizable to other organizations and healthcare systems because it was conducted on a single tertiary care center. However, the consecutive enrolment approach

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minimized selection bias. Moreover, all the surgeries were carried out by one skilled surgeon and all the postoperative evaluations by one ophthalmologist, which enhanced the consistency of the procedures and assessments but could also lead to operator-related bias. Limitations of causal inference are also associated with the observational design, the lack of randomization, and the use of consecutive non-probability sampling. Moreover, the 12-month follow-up time might not adequately predict the delayed recurrence, late sensory changes, and long-term re-operative requirements. To confirm these results and additional characterize long-term predictors of postoperative complications in pediatric strabismus surgery, future multicenter prospective studies with bigger sample sizes and long-term follow-up are required.

CONCLUSIONS

In conclusion, the rate of postoperative complications in this study was significant among children who underwent strabismus surgery. The most common postoperative complications reported were under correction and overcorrection. Age, complex strabismus, previous strabismus surgery, intraoperative complications, and amblyopia were all significantly related to increased risk of postoperative complications.

Authors' Contribution

Conceptualization: AQ, N
Methodology: AQ, N, NUH
Formal analysis: AK, MA
Writing and Drafting: N, AK, NUH, MA
Review and Editing: AQ, N, AK, NUH, MA

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflict of Interest

All the authors declare no conflict of interest.

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