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Original Article

Effect of Strabismus Surgery on Binocular Vision in Children: A Prospective Pre-Post Hospital-Based Study

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ABSTRACT

Background: Strabismus in childhood disrupts normal binocular vision development, leading to impaired stereopsis and sensory fusion. Although surgical correction restores ocular alignment, its effect on functional binocular outcomes remains variably reported, particularly in low- and middle-income settings. Objective: To evaluate changes in binocular vision following strabismus surgery in children and to assess demographic and clinical factors associated with postoperative functional outcomes. Methods: This prospective pre-post observational study included 135 children aged 3-16 years undergoing primary strabismus surgery at several tertiary care hospitals in Pakistan. Comprehensive ophthalmic assessments were performed preoperatively and at 12 months postoperatively. Binocular vision was evaluated using quantitative stereopsis testing and sensory fusion assessment. Motor alignment, amblyopia status, and surgical variables were also recorded. Paired t-test was used to compare preoperative and postoperative stereoacuity, while independent t-tests, chi-square tests, Pearson correlation, and binary logistic regression were used to evaluate associations and predictors of outcomes. Results: Mean stereoacuity improved significantly from 475.24 ± 245.82 arc seconds preoperatively to 309.82 ± 161.31 arc seconds at 12 months postoperatively, with a mean improvement of 165.41 arc seconds ($p < 0.001$). Fusion was achieved in 69.6% of patients, and motor success was observed in 65.2%. No demographic, clinical, or surgical factor independently predicted fusion recovery (all $p > 0.05$), although duration of symptoms showed a weak positive correlation with stereoacuity improvement ($r = 0.178$, $p = 0.039$). Conclusion: Strabismus surgery leads to significant improvement in stereopsis and satisfactory binocular vision recovery in children, although postoperative functional outcomes appear to be multifactorial and not explained by any single baseline predictor. Keywords: Pediatric strabismus, binocular vision, stereopsis, fusion, strabismus surgery

INTRODUCTION

Strabismus is a common ocular condition characterized by misalignment of the visual axes, resulting in impaired binocular vision, reduced stereoacuity, and potential development of amblyopia.(1,2) Beyond its functional consequences, strabismus has been shown to negatively impact psychosocial well-being and quality of life.(3,4) Surgical correction remains the mainstay of management, with the primary goals of achieving ocular alignment (motor success) and restoring binocular visual function.

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Traditionally, surgical outcomes in strabismus have been evaluated based on motor alignment; however, increasing emphasis has been placed on sensory outcomes, particularly fusion and stereoacuity, as they reflect true functional recovery.(5-7) Several studies have reported that successful ocular alignment does not always translate into restoration of binocular vision, suggesting that motor and sensory outcomes may not be directly correlated.(8)

Various demographic and clinical factors have been investigated as potential predictors of postoperative sensory outcomes.(5,9-12) Age at surgery has been considered an important determinant, with earlier intervention generally associated with better binocular vision recovery due to greater neural plasticity.(13-16) Similarly, the duration of strabismus has been reported to influence sensory outcomes, with longer duration often linked to poorer prognosis.(5,17,18) However, some studies have shown inconsistent or weak associations, indicating that recovery of binocular function may still be possible even in long-standing cases.(19-21)

Preoperative clinical characteristics, including the type of deviation (esotropia vs exotropia), magnitude of deviation, and baseline stereoacuity, have also been explored. While some authors suggest that smaller preoperative angles and better baseline stereoacuity are associated with improved postoperative outcomes,(22-25) others have found no significant predictive value.(26) The presence and severity of amblyopia is another critical factor, as it may limit the potential for binocular integration despite successful alignment.(8,27,28)

Furthermore, the relationship between motor success and sensory recovery remains complex. Although motor alignment is a prerequisite for binocular vision, studies have demonstrated that not all patients achieving satisfactory alignment regain fusion or stereoacuity. This highlights the multifactorial nature of binocular vision recovery and the need for comprehensive evaluation beyond motor outcomes alone. Despite growing evidence on postoperative sensory outcomes, data from low- and middle-income settings remain limited, particularly regarding predictors of functional binocular recovery.

Given these inconsistencies in the literature, there is a need for further research to better understand the predictors of postoperative sensory outcomes. Therefore, the present study aims to evaluate motor success, fusion, and stereoacuity outcomes following strabismus surgery, and to investigate the association of demographic and clinical factors with binocular vision recovery, particularly fusion and stereoacuity improvement. It was hypothesized that strabismus surgery would significantly improve stereopsis, while demographic and clinical factors may influence postoperative functional outcomes.

MATERIAL AND METHODS

This prospective pre-post observational study was conducted at the Department of Ophthalmology of several tertiary care hospitals in Pakistan over a period of 18 months, including 6 months of patient recruitment and 12 months of follow-up. The study included children aged 3-16 years diagnosed with concomitant esotropia or exotropia who were scheduled for primary strabismus surgery. Patients with paralytic or restrictive strabismus, previous ocular surgery, neurological disorders affecting vision, or severe developmental delay were excluded. A total of 135 children were enrolled using a non-probability consecutive sampling technique.

All participants underwent a comprehensive preoperative ophthalmic evaluation. Visual acuity was assessed using age-appropriate charts (Lea symbols or HOTV for younger children and Snellen chart for older children), and best-corrected visual acuity was recorded in log MAR units. Cycloplegic refraction was performed using cyclopentolate 1%, and appropriate refractive correction was prescribed prior to surgery when indicated. Motor alignment was evaluated using the prism alternate cover test at distance (6 m) and near (33 cm), with deviations recorded in prism diopters. Sensory assessment included evaluation of fusion using Worth 4-Dot and Bagolini striated glasses, and stereopsis was measured using standardized tests such as the Titmus Fly Test and Randot Preschool Stereoacuity Test, recorded in

seconds of arc. Amblyopia was classified as mild, moderate, or severe and managed according to standard protocols using occlusion or penalization therapy.

All patients underwent strabismus surgery based on the type and magnitude of deviation, with standard recession, resection, or combined procedures performed. Surgical details, including muscles operated, amount of recession or resection, and whether surgery was unilateral or bilateral, were documented. Postoperatively, patients received topical antibiotics and steroids for two weeks, continued refractive correction, and resumed amblyopia therapy when indicated.

Patients were followed up at 12 months postoperatively, where motor alignment, stereopsis, and sensory fusion were reassessed using the same standardized methods as preoperatively. The primary outcome measure was improvement in stereoacuity, defined as a reduction in seconds of arc at 12 months compared to baseline. Secondary outcomes included restoration of sensory fusion and motor alignment success, defined as residual deviation of less than 10 prism diopters.

To improve consistency and reduce measurement variability, the same standardized clinical methods and instruments were used for preoperative and postoperative assessment. Potential confounding related to refractive error and amblyopia was addressed through preoperative refractive correction and standard amblyopia management before and after surgery where indicated. Data were analyzed using SPSS version 26. Descriptive statistics were reported as mean ± standard deviation for continuous variables and frequencies with percentages for categorical variables. Pre- and postoperative stereopsis were compared using paired t-test. Independent t-tests were applied to compare continuous variables between groups, while chi-square tests were used to assess associations between categorical variables and fusion outcomes. Binary logistic regression analysis was performed to identify predictors of 12-month fusion recovery, with all selected demographic, clinical, and surgical variables entered into the model simultaneously. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 135 children with strabismus were included in the study. The mean age was 9.90 ± 4.03 years, and the mean duration of strabismus was 46.94 ± 22.86 months. The mean preoperative deviation angle was 32.33 ± 12.45 prism diopters at distance and 30.05 ± 12.57 prism diopters at near. The mean preoperative stereoacuity was 475.24 ± 245.82 arc seconds. There were 76 (56.3%) males and 59 (43.7%) females. Esotropia was present in 73 (54.1%) patients, while 62 (45.9%) had exotropia. Most patients had constant deviation (58.5%), whereas 41.5% had intermittent deviation. Amblyopia was observed in 90 (66.7%) patients, including mild (35.6%), moderate (17.8%), and severe (13.3%) forms, while 45 (33.3%) had no amblyopia. Combined procedures were most commonly performed in 77 (57.0%) patients, followed by recession in 37 (27.4%) and resection in 21 (15.6%) (Table 1).

Table 1. Baseline Characteristics of Study Participants (n = 135)

Variable	Value
Continuous Variables	Mean ± SD
Age (years)	9.90 ± 4.03
Duration (months)	46.94 ± 22.86
Pre-Op angle (Distance, PD)	32.33 ± 12.45
Pre-Op angle (Near, PD)	30.05 ± 12.57
Pre-Op stereo (arc sec)	475.24 ± 245.82
Categorical Variables	n (%)
Gender: Male	76 (56.3%)
Gender: Female	59 (43.7%)
Strabismus Type: Esotropia	73 (54.1%)
Strabismus Type: Exotropia	62 (45.9%)
Pattern: Constant	79 (58.5%)
Pattern: Intermittent	56 (41.5%)
Amblyopia: None	45 (33.3%)
Amblyopia: Mild	48 (35.6%)

Variable	Value
Amblyopia: Moderate	24 (17.8%)
Amblyopia: Severe	18 (13.3%)
Surgery Type: Combined	77 (57.0%)
Surgery Type: Recession	37 (27.4%)
Surgery Type: Resection	21 (15.6%)

At 12 months postoperatively, motor success, defined as residual deviation of less than 10 prism diopters, was achieved in 88 (65.2%) patients, whereas 47 (34.8%) had residual deviation of 10 prism diopters or more. Sensory fusion was observed in 94 (69.6%) patients, while 41 (30.4%) did not demonstrate fusion (Table 2).

Table 2. Surgical and Functional Outcomes at 12 Months (n = 135)

Outcome	n (%)
Motor Outcome	
Success (<10 PD)	88 (65.2%)
Failure (≥10 PD)	47 (34.8%)
Sensory Outcome	
Fusion achieved	94 (69.6%)
No fusion	41 (30.4%)

There was a statistically significant improvement in stereopsis following surgery. Mean stereoacuity improved from 475.24 ± 245.82 arc seconds preoperatively to 309.82 ± 161.31 arc seconds at 12 months postoperatively, corresponding to a mean improvement of 165.41 arc seconds ($p < 0.001$) (Table 3). This indicates a substantial postoperative gain in binocular visual function.

Table 3. Change in Stereoacuity from Baseline to 12 Months (n = 135)

Measure	Mean ± SD (arc sec)	Mean Difference	p-value
Preoperative stereoacuity	475.24 ± 245.82	165.41	<0.001
Postoperative stereoacuity (12 months)	309.82 ± 161.31		

When demographic and preoperative clinical variables were compared between patients with and without motor success, no statistically significant differences were identified. Mean age was not different between groups ($p = 0.951$), nor were duration of symptoms ($p = 0.835$), preoperative deviation angle at distance ($p = 0.642$), or preoperative deviation angle at near ($p = 0.839$). All 95% confidence intervals crossed zero, supporting the absence of a meaningful group difference for these variables (Table 4).

Table 4. Comparison of Demographic and Preoperative Clinical Variables by Motor Outcome

Variable	Levene's Test (F, p)	t	df	p-value	Mean Difference (95% CI)
Age (years)	8.776, 0.004	-0.062	79.63	0.951	-0.05 (-1.59, 1.50)
Duration of Symptoms (months)	10.828, 0.001	0.208	123.69	0.835	0.78 (-6.60, 8.16)
Preop Angle (Distance)	0.452, 0.502	-0.466	98.94	0.642	-1.03 (-5.43, 3.36)
Preop Angle (Near)	1.667, 0.199	0.203	87.57	0.839	0.48 (-4.17, 5.12)

Similarly, categorical variables including gender, strabismus type, deviation pattern, amblyopia grade, surgery type, and fusion status were not significantly associated with motor success at follow-up (all $p > 0.05$). For example, motor success was observed in 63.2% of males and 67.8% of females ($p = 0.575$), and in 61.6% of esotropic versus 69.4% of exotropic patients ($p = 0.349$) (Table 5).

Table 5. Association of Demographic, Clinical, and Surgical Factors with Motor Success at Follow-Up

Variable	Categories	Motor Success No, n (%)	Motor Success Yes, n (%)	χ^2	df	p-value
Gender	Male	28 (36.8%)	48 (63.2%)	0.32	1	0.575
	Female	19 (32.2%)	40 (67.8%)			
Strabismus Type	Esotropia	28 (38.4%)	45 (61.6%)	0.88	1	0.349
	Exotropia	19 (30.6%)	43 (69.4%)			
Pattern	Constant	28 (35.4%)	51 (64.6%)	0.03	1	0.856
	Intermittent	19 (33.9%)	37 (66.1%)			
Amblyopia Grade	Mild	14 (29.8%)	34 (38.6%)	1.36	3	0.714
	Moderate	10 (21.3%)	14 (15.9%)			

Variable	Categories	Motor Success No, n (%)	Motor Success Yes, n (%)	χ^2	df	p-value
	Severe	6 (12.8%)	12 (13.6%)			
	None	17 (36.2%)	28 (31.8%)			
Surgery Type	Recession	10 (21.3%)	27 (30.7%)	3.65	2	0.161
	Resection	5 (10.6%)	16 (18.2%)			
	Combined	32 (68.1%)	45 (51.1%)			
Fusion (After 12 months)	No	13 (27.7%)	28 (31.8%)	0.25	1	0.617
	Yes	34 (72.3%)	60 (68.2%)			

When variables were compared according to fusion outcome, no statistically significant differences were found in age (p = 0.965), duration of strabismus (p = 0.198), preoperative angle at distance (p = 0.672), or baseline stereopsis (p = 0.988). Preoperative near deviation showed a borderline association with fusion recovery, with a mean difference of -4.42 prism diopters (95% CI: -9.03 to 0.19), but this did not reach statistical significance (p = 0.060) (Table 6).

Table 6. Comparison of Demographic and Preoperative Clinical Variables by Fusion Outcome

Variable	Levene's Test (F, p)	t	df	p-value	Mean Difference (95% CI)
Age (years)	0.035, 0.852	0.044	133	0.965	0.03 (-1.47, 1.53)
Duration (months)	2.310, 0.131	-1.293	133	0.198	-5.52 (-13.96, 2.92)
Pre-Op Angle (Distance)	0.019, 0.891	0.425	133	0.672	0.99 (-3.63, 5.62)
Pre-Op Angle (Near)	0.096, 0.758	-1.895	133	0.060	-4.42 (-9.03, 0.19)
Pre-Op Stereopsis (arc sec)	5.467, 0.021	0.015	65.07	0.988	0.75 (-98.51, 99.99)

Categorical variables also did not show significant associations with fusion recovery. Fusion was achieved in 68.4% of males and 71.2% of females (p = 0.729), in 68.5% of esotropic and 71.0% of exotropic patients (p = 0.755), and in 70.1% of those undergoing combined surgery compared with 70.3% after recession and 66.7% after resection (p = 0.950). Likewise, motor success was not significantly associated with fusion recovery (p = 0.617) (Table 7).

Table 7. Association of Demographic, Clinical, and Surgical Factors with Fusion Outcomes at Follow-Up

Variable	Categories	Fusion No, n (%)	Fusion Yes, n (%)	χ^2	df	p-value
Gender	Male	24 (31.6%)	52 (68.4%)	0.12	1	0.729
	Female	17 (28.8%)	42 (71.2%)			
Strabismus Type	Esotropia	23 (31.5%)	50 (68.5%)	0.10	1	0.755
	Exotropia	18 (29.0%)	44 (71.0%)			
Pattern	Constant	21 (26.6%)	58 (73.4%)	1.21	1	0.751
	Intermittent	20 (35.7%)	36 (64.3%)			
Amblyopia Grade	Mild	17 (35.4%)	31 (64.6%)	1.21	3	0.751
	Moderate	7 (29.2%)	17 (70.8%)			
	Severe	4 (22.2%)	14 (77.8%)			
	None	13 (28.9%)	32 (71.1%)			
Surgery Type	Combined	23 (29.9%)	54 (70.1%)	0.10	2	0.950
	Recession	11 (29.7%)	26 (70.3%)			
	Resection	7 (33.3%)	14 (66.7%)			
Motor Success	No	13 (27.7%)	34 (72.3%)	0.25	1	0.617
	Yes	28 (31.8%)	60 (68.2%)			

Binary logistic regression analysis likewise showed that none of the demographic, clinical, or surgical variables significantly predicted 12-month fusion recovery. Odds ratios ranged from 0.438 to 1.342, and all 95% confidence intervals included 1.00, indicating no statistically significant independent predictors in the model (Table 8).

Table 8. Binary Logistic Regression Analysis of Predictors for 12-Month Binocular Vision (Fusion) Recovery

Predictor	Odds Ratio (95% CI)	p-value
Age (years)	0.997 (0.899–1.105)	0.953
Gender (Male)*	1.323 (0.584–3.001)	0.502
Duration (months)	1.006 (0.988–1.025)	0.497
Strabismus Type (Esotropia)*	0.847 (0.369–1.944)	0.696
Pattern (Intermittent)*	1.342 (0.600–2.999)	0.474
PreOp Angle (Distance)	0.996 (0.964–1.029)	0.792
PreOp Angle (Near)	1.029 (0.994–1.065)	0.103

Predictor	Odds Ratio (95% CI)	p-value
Amblyopia Grade (Mild)*	0.438 (0.106–1.814)	0.255
Amblyopia Grade (Moderate)*	0.564 (0.119–2.682)	0.472
Amblyopia Grade (Severe)*	0.637 (0.162–2.511)	0.520
Pre-Op Stereopsis (arc sec)	1.000 (0.998–1.001)	0.725
Surgery Type (Recession)*	0.972 (0.314–3.012)	0.961
Surgery Type (Resection)*	1.181 (0.324–4.308)	0.801
Motor Success after 12 months (Yes)*	1.203 (0.524–2.762)	0.663

*Reference categories: Female, Exotropia, Constant deviation, No amblyopia, Combined surgery, and No motor success.

Pearson correlation analysis showed that duration of symptoms was weakly but significantly positively correlated with stereoacuity improvement (r = 0.178, p = 0.039). In contrast, age (r = -0.110, p = 0.205), preoperative distance angle (r = 0.072, p = 0.405), preoperative near angle (r = 0.046, p = 0.596), and baseline stereopsis (r = 0.066, p = 0.444) were not significantly correlated with postoperative improvement (Table 9).

Table 9. Pearson Correlation Analysis Between Demographic/Clinical Variables and Stereoacuity Improvement

Variable	r	p-value
Age (years)	-0.110	0.205
Duration (months)	0.178	0.039*
Pre-Op Angle (Distance)	0.072	0.405
Pre-Op Angle (Near)	0.046	0.596
Pre-Op Stereopsis (arc sec)	0.066	0.444

*Statistically significant at p < 0.05.

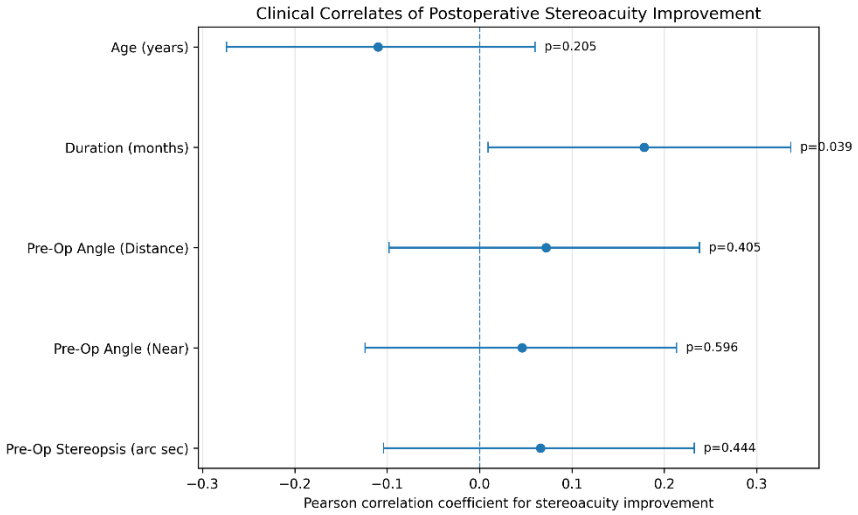

Figure 1 Clinical Correlates of Postoperative Stereoacuity Improvement

The correlation profile demonstrated that duration of symptoms had the only statistically significant association with postoperative stereoacuity improvement (r = 0.178, p = 0.039), whereas age (r = -0.110, p = 0.205), preoperative distance deviation (r = 0.072, p = 0.405), preoperative near deviation (r = 0.046, p = 0.596), and baseline stereopsis (r = 0.066, p = 0.444) showed weak, non-significant relationships. The confidence intervals for all non-significant variables crossed the null line, while the effect for duration remained modest in magnitude, indicating that greater symptom duration was associated with only a small increase in stereoacuity gain after surgery.

DISCUSSION

The present study evaluated motor and sensory outcomes following strabismus surgery in children and explored factors associated with binocular vision recovery. The findings demonstrated a significant improvement in stereoacuity at 12 months postoperatively, with a substantial proportion of patients

achieving motor success and sensory fusion. However, no significant association was identified between demographic or clinical variables and postoperative motor or sensory outcomes, and no independent predictor of fusion recovery was identified in regression analysis.

A key finding of this study was the significant improvement in stereoacuity following surgical correction. The mean stereoacuity improved markedly from the preoperative period to 12 months postoperatively, indicating enhanced binocular function after realignment. This is consistent with previous studies that have reported improvement in stereopsis following strabismus surgery, emphasizing that surgical alignment can facilitate sensory recovery in pediatric patients.(5,6,24) The observed improvement supports the concept that restoring ocular alignment provides the necessary conditions for re-establishing binocular interaction and cortical fusion. This sensory improvement may reflect postoperative restoration of binocular cortical input and gradual neural adaptation following correction of ocular misalignment.

In the present study, motor success was achieved in approximately two-thirds of patients, and sensory fusion was observed in nearly 70% of cases. These findings are comparable to previously reported outcomes, where satisfactory alignment and functional binocular recovery have been achieved in a significant proportion of patients following surgery.(9,10,12) However, similar to earlier reports, motor alignment did not necessarily guarantee restoration of binocular function in all patients, highlighting the complex and multifactorial nature of sensory recovery.(8) This suggests that although motor alignment is an essential prerequisite, postoperative binocular rehabilitation may also depend on sensory adaptation, baseline cortical plasticity, suppression status, amblyopia treatment response, and other unmeasured factors.

An important aspect of this study was the evaluation of factors influencing postoperative outcomes. Contrary to several previous studies, no significant association was found between age at surgery and binocular vision recovery. While earlier literature suggests that younger age is associated with better outcomes due to greater neural plasticity,(13-16) the lack of significant association in this study may indicate that meaningful sensory improvement can still occur beyond the early critical period. This finding aligns with studies demonstrating that recovery of binocular function is possible even in older children and in long-standing strabismus.(19-21)

Similarly, the duration of strabismus did not show a significant impact on motor or fusion outcomes in group-based analyses. Although prolonged duration has traditionally been associated with poorer prognosis,(5,17,18) the present findings suggest that surgical intervention may still yield functional benefits regardless of duration. At the same time, Pearson correlation analysis demonstrated a weak but statistically significant positive correlation between duration of symptoms and stereoacuity improvement. Although the strength of this association was small and should be interpreted cautiously, it suggests that postoperative sensory gain may still occur even in children with longer-standing deviation. This reinforces the importance of offering surgical correction even in delayed presentations rather than excluding patients on the basis of symptom duration alone.

Preoperative clinical characteristics, including type of strabismus, magnitude of deviation, and baseline stereoacuity, were also not significantly associated with postoperative outcomes. While some studies have reported that smaller angles of deviation and better preoperative stereopsis are predictive of improved postoperative results,(22-25) others have shown inconsistent findings,(26) which is in agreement with the results of the present study. A borderline association was observed between preoperative near deviation and fusion outcomes; however, this did not reach statistical significance, suggesting only a possible trend that requires further investigation in larger cohorts.

The role of amblyopia in influencing binocular outcomes has been widely discussed in the literature. Although amblyopia is considered a limiting factor for binocular integration,(8,27,28) the present study did not demonstrate a significant association between amblyopia severity and postoperative fusion or

motor success. This may reflect the effect of concurrent amblyopia management and suggests that functional recovery is still achievable in amblyopic patients with appropriate treatment.

Another important observation was the lack of a significant relationship between motor success and sensory outcomes. Although motor alignment is essential for binocular vision, not all patients with successful alignment achieved fusion. This finding is consistent with previous studies highlighting that motor and sensory outcomes are not always directly correlated.(8) It underscores the need for comprehensive postoperative assessment, including both motor and sensory evaluation, rather than relying on alignment outcomes alone.

The findings of this study have important clinical implications. The significant improvement in stereopsis and the relatively high rates of motor and sensory success emphasize the value of strabismus surgery in restoring functional vision. Moreover, the absence of strong predictors suggests that surgical intervention should not be restricted based on age, duration, or baseline clinical characteristics alone, as meaningful recovery can still be achieved. At the same time, the absence of statistically significant predictors should be interpreted with caution, as residual confounding, limited statistical power for subgroup effects, and unmeasured sensory or neurodevelopmental factors may have influenced the model.

This study has several strengths, including a well-defined pediatric population, standardized assessment of motor and sensory outcomes, and a relatively adequate sample size. However, certain limitations should be acknowledged. The study evaluated outcomes at a single postoperative time point of 12 months, limiting assessment of the temporal pattern of recovery. Additionally, the absence of long-term follow-up beyond one year and the use of hospital-based non-probability sampling may affect the generalizability of the findings. Although regression analysis was performed, the possibility of limited power to detect weaker independent associations cannot be excluded. Future multicenter studies with longer follow-up and broader sensory profiling may help clarify the determinants of binocular recovery after pediatric strabismus surgery.

CONCLUSION

Strabismus surgery results in significant improvement in stereopsis and favorable motor and sensory outcomes in children. Despite this, no specific demographic or clinical predictors of binocular vision recovery were identified in the present cohort. These findings emphasize the complex and multifactorial nature of sensory outcomes and suggest that meaningful functional improvement can be achieved irrespective of baseline characteristics, supporting the clinical value of surgical correction even in children without clearly favorable preoperative predictors.

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