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CLINICAL STUDY

Strabismus developing after unilateral and bilateral cataract surgery in children

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Abstract

Purpose To evaluate the prevalence and risk factors of strabismus in children undergoing surgery for unilateral or bilateral cataract with or without intraocular lens implantation.

Methods Medical records of pediatric patients were evaluated from 2000 to 2011. Children undergoing surgery for unilateral or bilateral cataract with at least 1 year of follow-up were included. Children with ocular trauma, prematurity, or co-existing systemic disorders were excluded. The following data were evaluated: strabismus pre- and post-operation; age at surgery; post-operative aphakia or pseudophakia; and visual acuity.

Results Ninety patients were included, 40% had unilateral and 60% had bilateral cataracts. Follow-up was on average 51 months (range: 12–130 months). Strabismus was found preoperatively in 34.4% children, and in 43.3% children at last follow-up. Strabismus developed in 46.2% of children who were orthotropic preoperatively, whereas 32.3% of children who had strabismus before surgery became orthotropic. Strabismus occurred after unilateral or bilateral cataract surgery in 63.9% and 29.6% children, respectively. At the last follow-up, strabismus was found in 46.7% of aphakic and 58.7% of pseudophakic children ($P = 0.283$). Children who developed strabismus were generally operated at a younger age as compared with those without strabismus (mean of 25.9 _vs_ 52.7 months, $P < 0.001$). Final visual acuity was inversely correlated with prevalence of strabismus.

Conclusion Strabismus is a frequent complication after cataract surgery in children. Risk factors include unilateral cases and young age at surgery. No correlation was found between prevalence of strabismus and use of intraocular lens. Strabismus was more common in children with poor final visual acuity.

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Introduction

The rate of strabismus associated with cataract in children has been reported to range from 20.5 to 86%.[1] Strabismus is more prevalent in children who have been operated for cataract than in the general pediatric population.[2–8] Moreover, it occurs more frequently in patients with unilateral than bilateral cataract.[1] The association between timing of surgery or the use of intra ocular lens (IOL) with development of strabismus is still not fully understood.

The main purpose of this study is to evaluate the prevalence and risk factors of strabismus developing in children undergoing surgery for unilateral or bilateral cataract as well as comparing between eyes with pseudophakia or aphakia. In addition, we aimed to evaluate the frequency of strabismus according to age at surgery, cataract type, and visual outcome.

Materials and methods

Medical records of pediatric patients, who underwent cataract surgery in one or both eyes, were retrospectively reviewed, at the Pediatric Ophthalmology unit, Hadassah—Hebrew University Medical Center in Jerusalem, Israel, from 2000 to 2011. The study was approved by the local Helsinki Committee.

Children undergoing surgery for unilateral or bilateral cataract with at least one year of follow-up were included. Ocular trauma, prematurity (<36 gestational weeks), and co-existent metabolic, genetic, or other systemic disorders were excluded. However, isolated ocular pathologies and cataract due to persistent fetal vasculature (PFV) were included in the study.

The frequency of strabismus, before and after surgery, according to age at surgery, with or without the use of IOL and visual acuity (VA) outcome were evaluated. Data from the first and last follow-up visit were collected. One patient with missing data was excluded.

In cases where strabismus surgery was performed prior to the last follow-up visit, the data from the examination before strabismus repair were considered as the last follow-up. Data included: gender; pregnancy and general health background; age in months at first exam, at cataract diagnosis, at cataract surgery, and at the last follow-up; cataract morphology; ocular alignment at near and distance, strabismus measurements using prism and cover test, Hirschberg or Krimsky tests; binocular and monocular VA (measured by perception of light, fixation behavior, picture cube, LEA symbols chart, or Snellen chart according to age and cooperation of patient) and additional strabismus surgery.

All children were examined by a team consisting of any of four certified optometrists, one orthoptist and four senior pediatric ophthalmologists. All surgeries were performed by any of the four senior pediatric ophthalmologists using similar techniques.

All children who met the inclusion criteria were classified into four groups according to laterality and surgical procedure: unilateral cataract extraction with IOL implantation; unilateral cataract extraction with aphakia; bilateral cataract extraction with IOL implantation (in both eyes); and bilateral cataract extraction with aphakia.

VA was reversed to decimal scale and divided to three categories: 'poor VA'—$\leq$0.1, or no fixation, light perception or no light perception; 'functional VA'—0.1 to 0.4 or fix and follow, though not stable or maintained; and 'good VA'—$\geq$0.5 or normal fixation behavior.

Statistical analysis

P-value <0.05 was decided statistically significant.

Statistical analysis performed using Fisher's exact test, Pearson χ^2-test, Shapiro Wilk Test, Paired Samples test, Kolmogorov–Smirnov test, and univariate and multivariate binary logistic regression analysis.

Results

All demographic data, including eye laterality, gender, ocular pathologies, cataract type, age and mean period of follow-up are summarized in Table 1.

Ninety children, a total of 144 eyes, met the inclusion criteria. Thirty-six (40%) children had unilateral and 54 (60%) had bilateral cataracts. Seventy five (83.3%) underwent IOL implantation (28 and 47 patients in the unilateral and bilateral group, respectively) were the others remain aphakic.

Out of a total of 90 children, eye alignment assessment during the first visit, before surgery, showed 59 children (65.6%) who were orthotropic, and 31 (34.4%) with strabismus, when 17 children out of them had esotropia (18.9%, 1 with vertical component) and 14 had exotropia (15.6%, 1 with vertical component).

At the last follow-up, 51 children (56.7%) were orthotropic where the other 39 children (43.3%) presented with strabismus. Twenty-one children had esotropia (23.3%, 3 with vertical component) and 18 had exotropia (20.0%, 1 with vertical component). It should be noted that we related only to the horizontal strabismus as there were no cases of isolated vertical strabismus in our cohort.

In the last follow-up exam, 46.2% of children who were orthotropic preoperatively had developed strabismus, and 32.3% of children who had strabismus before surgery

Table 1 Demographic data

	Unilateral with pseudophakia no. (%)	*Unilateral with aphakia no. (%)*	*Bilateral with pseudophakia no. (%)*	*Bilateral with aphakia no. (%)*	*Total no. (%)*
No.	28 (37.3)	8 (53.3)	47 (62.7)	7 (46.7)	90 (100)
Eye—right/ left	16 (57.1)/12 (42.8)	4 (50)/4 (50)	47 (100)/47(100)	7 (100)/7(100)	74 (51.4)/70 (48.6)
Gender—females/males	18 (64.3)/10 (35.7)	3 (37.5)/5 (62.5)	20 (42.5)/27 (57.5)	4 (57.1)/3 (42.9)	45 (50)/45 (50)
Ocular pathologies					
Microphthalmia	6 (21.4)	5 (62.5)	0 (0)	2 (28.5)	13 (14.4)
Ptosis	1 (3.6)	0 (0)	0 (0)	0 (0)	1 (1.1)
Optic nerve coloboma	1 (3.6)	0 (0)	0 (0)	0 (0)	1 (1.1)
Cataract type					
Nuclear	8 (28.5)	0 (0)	38 (80.8)	7 (100)	55 (61.1)
PFV	6 (21.4)	6 (75)	0 (0)	0 (0)	12 (13.3)
PSC	2 (7.1)	0 (0)	7 (14.9)	0 (0)	9 (10)
PLC	8 (28.5)	2 (25)	0 (0)	0 (0)	8 (8.8)
AP	3 (10.7)	0 (0)	2 (4.2)	0 (0)	5 (5.5)
Cortical	1 (3.6)	0 (0)	0 (0)	0 (0)	1 (1.1)
Age at diagnosis (months) average, range, median	30.77, 0–99, 24	1.13, 0–6, 0.25	35.17, 1–131, 30	0.88, 0.13–2, 1	28.10, 0–131, 22.5
Age at first exam (months) average, range, median	25.17, 0.5–99, 16	1.84, 0–6, 0.5	30.46, 0–131, 24	0.73, 0–2, 0.5	23.94, 0–131, 15
Age at cataract surgery (months) average, range, median	40.99, 1–100, 34	2.75, 0–8, 1	53.23, 2–148, 59	1.91, 1–3, 2	42.95, 0–148, 40.77
Mean follow-up(months) average, range	56.09, 13–130	40.31, 12–128	50.91, 15–124	39.79, 14–93	50.71, 12–130

Abbreviations: AP, anterior polar cataract; PFV, persistent fetal vasculature; PLC, posterior lenticonus; PSC, posterior subcapsular cataract.

became orthotropic. Thirteen out of 90 children (14.4%) were finally operated for strabismus afterwards.

At final exam, the prevalence of strabismus was found to be higher in children with poor final VA ($P<0.001$). Seventeen children (18.9%) had poor VA when 13 out of them (76.5%) presented with strabismus. Functional VA was found in 33 children (36.75%) when 15 out of them (45.5%) had strabismus. Finally, 40 children showed good VA while only 11 out of them (27.5%) presented with strabismus (Table 2).

Furthermore, at last examination, 7 children out of 15 (46.7%) who were aphakic, compared to 44 out of 75 (58.7%) children who were pseudophakic manifested strabismus, with no significant difference ($P=0.283$). However, strabismus was found to be more common in unilateral than bilateral cataract (63.9% *vs* 29.6% respectively, $P<0.001$).

When stratifying strabismus into the different subtypes, we found overall a slight tendency for higher prevalence of esotropia, with no significant difference, in both unilateral and bilateral groups. In children with unilateral cataract and strabismus, there was no difference in prevalence of subtypes of strabismus whether the child was aphakic or pseudophakic. On the other hand, in bilateral cataract with strabismus, esotropia was more prevalent in the aphakic group, but it included only one case (Table 3).

Strabismus prevalence was correlated with age at cataract surgery. Children who developed strabismus were operated at a younger age (mean 25.9 ± 25.9, median 16.6, range 0.4–78.2 months) as compared with those who were orthotropic (mean 52.7 ± 36.8, median 51.6, range 1.1–146.8 months), $P<0.001$. To determine whether age is a risk factor for the development of strabismus, we compared the outcomes of younger (0–36 months) *vs* older (>36 months) children at cataract surgery. In children with unilateral cataract and pseudophakia, 80.00% of younger children compared with 30.77% of older children developed strabismus, respectively ($P<0.012$). In the bilateral cataract and pseudophakia group, 64.29% of the younger, as opposed to 18.8% of the older children, developed strabismus ($P=0.003$; Table 4).

As expected, strabismus was very prevalent in children with PFV (83.3%). Strabismus was found in 71.4% of children with posterior lenticonus and only in 32.1% of children with nuclear cataract. No significant correlation was found between the prevalence of strabismus and the existence of other ocular pathology.

Finally, univariate and multivariate logistic regressions were run in order to evaluate the impact of each individual factor and all factors together at the final examination, on the strabismus prevalence.

Logistic regression analysis was conducted to predict strabismus prevalence for all 90 children using cataract type, VA, cataract laterality, age, ocular pathology, and use of IOL as predictors. In the univariate analyses, cataract laterality, age at cataract surgery, and final VA had significantly impact on strabismus prevalence. As for the multivariate regression, the only strabismus prevalence predictor was final VA in the last follow-up. A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set, reliably distinguished between children with and without strabismus after cataract surgery ($\chi^2=33.660$, $P<0.010$ with df$=11$). The Wald criterion demonstrated that only final VA result had a significant contribution to prediction ($P=0.010$). Exp(B) value indicated that when the final VA is raised by one unit the odds ratio is nine

Table 2 Prevalence of strabismus according to final VA

	Total no. (%)	*Strabismus no. (%)*	*Orthotropia no. (%)*
Poor VA	17 (18.9)	13 (76.5)	4 (23.5)
Functional VA	33 (36.7)	15 (45.5)	18 (54.4)
Good VA	40 (44.4)	11 (27.5)	29 (72.5)

Table 3 Prevalence of strabismus subtypes according to the different groups

	Esotropia no. (%)	*Exotropia no. (%)*
Pseudophakia		
Unilateral	8 (50)	8 (50)
Bilateral	8 (53.3)	7 (46.7)
Aphakia		
Unilateral	4 (57.1)	3 (42.9)
Bilateral	1 (100)	0 (0)
Total		
Unilateral	12 (52.2)	11 (47.8)
Bilateral	9 (56.2)	7 (43.8)

Table 4 Strabismus prevalence in accordance to age at surgery

	Strabismus prevalence		*Fisher test P-value*	*Odds ratio*	*95% CI*
Age at surgery (months)	0–36	36<			
Unilateral with pseudophakia	80.00%	30.77%	0.012	9	1.60–50.69
Bilateral with pseudophakia	64.29%	18.18%	0.003	8.1	1.98–33.05

times as large. Therefore, child with poor VA in the final follow-up is nine times more likely to have strabismus. All of the logistic models were significant ($P<0.05$).

Discussion

Strabismus is known to be strongly associated with cataract in children. It is also found to be more prevalent after cataract surgery. Therefore, it is one of the major causes for difficulty in achieving favorable binocular vision, even after a successful surgery.[1]

The main purpose of this study is to evaluate the prevalence and risk factors of strabismus developing in children undergoing cataract surgery.

Final visual outcome in our study was reassuring and in agreement with similar studies.[1] The prevalence of strabismus was found to be higher in children with poor final VA ($P<0.001$), suggesting presence of strabismus to be a bad prognostic factor for VA.

We found a strong correlation between prevalence of strabismus and laterality of cataract. In the unilateral group, strabismus prevalence was significantly higher than in the bilateral group (63.9 *vs* 29.6%, $P<0.001$). Similarly, the IATS showed 51.4% of strabismus 1 year after surgery in children with unilateral congenital cataract.[9] Lee *et al*[1] also found that the frequency of strabismus was higher in children with unilateral (29.5%) *vs* bilateral (17.2%) congenital cataracts. The lower rate of strabismus in the study by Lee, as compared with ours, can be explained by his exclusion of children with strabismus presenting before cataract surgery and accompanying eye abnormalities. Conversely, Park *et al* found strabismus as a major complication of bilateral cataract surgery. They showed that strabismus developed in 55.4% of pediatric patients after bilateral cataract extraction.[8] Another recent study failed to show any significant difference in prevalence of strabismus in unilateral or bilateral cataract.[10] However, this study included older patients (<18 years of age) and did not differentiate between congenital and acquired cataract.

We found age at surgery to be a major risk factor for strabismus. Our study indicated that children operated at younger age had higher rate of strabismus than children who were operated at older age (median age at surgery, 25.9 months *vs* 52.7 months, respectively, $P<0.005$). This tendency was supported by other studies. Park *et al*[8] showed that 51.6% of children who underwent bilateral cataract surgery within the first year of life developed strabismus. Lee *et al*[1] found that age of less than a year at the time of surgery was related to onset of strabismus in bilateral cataracts, but not in unilateral cases. Interestingly, the 1-year outcomes of IATS showed that very young children (<49 days) at the time of surgery demonstrate significantly less strabismus as compared with children operated at an older age (≥49 days; 58.0% *vs* 80.0%, respectively).[9] Finally, another study by Weisberg *et al*[5] did not find any correlation between strabismus and age at cataract extraction. The differences in conclusions between these studies may stem from the diverse definitions of 'young' and 'old' age at cataract surgery.

Comparing the subtypes of strabismus, we found a slight tendency for higher prevalence of esotropia. Park *et al* found exotropia to be the most prevalent type of strabismus (45.2%) in both bilateral pseudophakic and aphakic groups in Korean children. Park *et al*[8] suggested that this higher prevalence of exotropia most likely was influenced by race. Weisberg *et al*[5] found exotropia to be only slightly more common than esotropia in his study of pediatric cataract. Similarly to our findings, France and Frank's found nearly equal number of esotropia and exotropia in their study of aphakic children.[2]

Despite the controversy, the frequency of IOL implantation is increasing in infants,[11] partly due to the clinical impression that it results in better visual outcome as compared with aphakia. However, the recent outcomes of the IATS showed that in unilateral cataract, aphakia is more recommended than primary IOL implantation when operating on an infant <7 months of age, due to less adverse events. In addition, IATS showed no significant difference in median VA at age 4.5 years in aphakic or pseudophakic eyes.[9]

Our study found that prevalence of strabismus was similar in children whether IOL was implanted or not, both in unilateral and bilateral cases. Other studies found a tendency of lower prevalence of strabismus in pseudophakic *vs* aphakic patients. The incidence of strabismus was 75% in pseudophakic compared with 92% in aphakic children in Lambert *et al*[3] study, though not proven statistically significant. Lim *et al*[12] also found lower prevalence of strabismus in pseudophakic (13%) compared with aphakic patients (36%), $P<0.001$. The dissimilar results between the studies may be explained partly by their smaller study group and shorter follow-up. We included 90 children with cataract and the follow-up was on average 4 years (average: 51, range: 12–130 months). Moreover, we avoided bias by populations with high prevalence of strabismus, such as in neurologically impaired or premature children.

In our study, cataract morphology was suggested as an additional risk factor in developing strabismus. Strabismus was particularly common in children with PFV type of cataract. The prevalence was significantly higher (83.3%) than in other types of cataract. Parks and Hiles' showed a 100% prevalence of strabismus in PFV type of cataracts.[13] This high rate of strabismus may be attributed to the less developed microsurgical technique used at the time of their study.

There are several limitations to our study, first by its retrospective design. A second limitation is the variability in follow-up time (1 to over 10 years). However, the mean follow-up was similar between the four treatment groups. Another possible limitation is the inclusion of cataract with PVF. All such cases were unilateral. Visual potential in PFV depends on the extent of the malformation, whether the posterior segment is affected or not, and therefore final vision is poorer than in simple congenital cataract.[14] We suggest that the low vision associated with PFV cataract is the main cause for the high prevalence of strabismus found in this subgroup. It should be noted that in our study children with PFV who underwent cataract surgery were mainly with anterior type, without significant posterior involvement.

In conclusion, there exists a strong correlation between cataract and strabismus in children. The main risk factors affecting the development of strabismus following cataract surgery are laterality of the cataract, PFV type, poor final VA, and young age at surgery. We found no correlation between prevalence of strabismus and the use of IOL. Pediatric ophthalmologist should carefully monitor for the possibility of strabismus development in children who undergo cataract surgery, especially when with aforementioned risk factors.

Summary

What was known before

- There exists a strong correlation between congenital cataract and strabismus.

What this study adds

- The main risk factors affecting the development of strabismus following cataract surgery are laterality of the cataract, PFV type, poor final VA, and young age at surgery. We found no correlation between prevalence of strabismus and the use of IOL.

Conflict of interest

The authors declare no conflict of interest.

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