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CLINICAL STUDY

Visual acuity and its predictors after surgery for bilateral cataracts in children

LA Bonaparte[1,2], RH Trivedi[1], V Ramakrishnan[3] and ME Wilson[1]

Abstract

Purpose **The objective of this study was to investigate preoperative factors associated with postoperative visual acuity outcomes and to develop a model to predict visual acuity prognosis.**

Methods **A retrospective study was conducted by reviewing clinical charts of pediatric patients who underwent bilateral cataract surgery by a single surgeon (MEW) at the Storm Eye Institute. A multiple logistic regression model was constructed to predict the odds of poor postoperative visual acuity, that is, worse than 20/40, based on age at surgery, gender, primary intraocular lens (IOL) placement, ethnicity, and preoperative nystagmus.**

Results **A sample size of 157 children (314 eyes) was investigated with median duration of follow-up of 6.4 years. A total of 78% of children with bilateral cataract had postoperative visual acuity of 20/40 or better. The presence of preoperative nystagmus was highly correlated with poor postoperative visual acuity (OR = 6.0; 95% CLs, 2.5–14.1; *P*-value < 0.0001). Children of age <1 year at time of cataract extraction (OR = 3.2; 95% CLs, 1.4–7.6; *P*-value = 0.0073), male gender (OR = 2.3; 95% CLs, 1.1–4.5; *P*-value = 0.02), the absence of primary IOL placement (OR = 3.0; 95% CLs, 1.05–8.4; *P*-value = 0.04), and non-Caucasian ethnicity (OR = 2.0; 95% CLs, 1.02–4.03; *P*-value 0.0447) were associated with poor visual acuity postoperatively.**

Conclusions **Satisfactory visual outcomes occurred in 78% of children operated on for bilateral cataracts. Preoperative nystagmus, age <1 year at time of cataract extraction, absence of primary IOL placement, male gender, and non-Caucasian ethnicity, were all factors associated with poor postoperative visual acuity.**

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Introduction

Early treatment of cataract can be beneficial as it is a treatable cause of visual handicap in children.[1] Visually significant cataracts, if left untreated, can lead to poor vision, which can adversely affect a child's education, occupation, and socio-economic status for life.[2] Early detection through screening mechanisms and prompt treatment are imperative to prevent poor vision and blindness.[3,4] Understanding certain clinical factors and their roles in affecting visual acuity after cataract surgery helps determine visual outcomes.

Many clinical factors have been suggested in previous studies to be important influences of visual outcomes for pediatric patients with unilateral and bilateral cataracts.[4–7] Previous studies have determined that age at time of cataract extraction, method of postoperative optical correction, and presence of nystagmus are all factors that may help predict postoperative visual outcomes. Preoperative nystagmus has been associated with poor postoperative visual acuity in bilateral cataract cases.[5,6] Postoperative glaucoma patients also have lower rates of good visual acuity results.[7,8] The presence of systemic disorders have been associated with poor visual acuity in bilateral cases, reflecting additional causes of poor vision.[4] Many previous studies have included both unilateral and bilateral cataracts within the same study. However, there have been limited studies based solely on bilateral cataracts in children,[9] and to our knowledge, a model to predict visual acuity before surgery has yet to be developed.

There is a paucity of data regarding preoperative factors that predict postoperative visual outcomes in the pediatric bilateral cataract population. In this study, we report visual acuity outcomes when childhood cataracts present bilaterally. The objective of this study was to acquire a better understanding of the factors that

[1]Department of Ophthalmology, Storm Eye Institute, Medical University of South Carolina, Charleston, SC, USA

[2]Department of Ophthalmology, Nassau University Medical Center, East Meadow, NY, USA

[3]Public Health Sciences, Medical University of South Carolina, Charleston, SC, USA

Correspondence: ME Wilson, Department of Ophthalmology, Storm Eye Institute, Medical University of South Carolina, Rm 218, 167 Ashley Avenue, MSC 676, Charleston, SC 29425-6760, USA
Tel: +1 84 3792 7622; Fax: +1 84 3792 8289.
E-mail: wilsonme@musc.edu

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are associated with postoperative visual acuity outcomes and to develop a model to predict visual acuity prognosis preoperatively. Specifically, the relationship between preoperative variables and visual outcomes after bilateral pediatric cataract extraction was investigated.

Materials and methods

A retrospective study was conducted by reviewing clinical charts of pediatric patients who underwent bilateral cataract surgery by a single surgeon (MEW) at the Storm Eye Institute from January 1991 to October 2012. The institutional review board at the Medical University of South Carolina approved the study protocol according to the tenets of the Declaration of Helsinki. Patients from birth to 18 years of age with visually significant bilateral cataracts who had bilateral cataract extraction with or without intraocular lens (IOL) implantation were included in this study. Children in whom cataracts were acquired as a result of trauma, patients with additional ocular pathology, such as lens subluxation or congenital glaucoma, and children <5 years of age at last follow-up were excluded from this study. In addition, patients with postoperative follow-up period of <6 months were excluded.

The following preoperative data were reviewed: cause and type of cataract, age at surgery, duration between first eye cataract surgery to second eye cataract surgery, associated ocular conditions, associated systemic conditions, past medical history, including developmental delay, nystagmus (if present, yes or no), strabismus (if present, yes or no), and best-corrected distance visual acuity (BCDVA). The initial surgical technique was reviewed and whether the patient was treated with IOLs or contact lenses was determined. If IOLs were implanted, power of the IOLs and the targeted refractions were noted. The following data were collected from postoperative follow-up notes and dictations: age at last follow-up, postoperative complications, such as glaucoma, and BCDVA at 1 month and last follow-up. If BCDVA was $<20/100$ at the last follow-up exam, causes for poor visual outcome were determined. Data collected also included demographic information, consisting of gender and ethnicity.

The primary outcome measure was postoperative BCDVA using Snellen linear optotypes. The geometric visual acuity was then converted to a logarithm of the minimal angle of resolution units for statistical analysis. Visual acuity was also categorized as better than or equal to 20/40 and worse than 20/40, creating a dichotomous outcome for visual acuity.

Statistical analyses were performed on eyes that met the inclusion criteria. Descriptive statistics were calculated for case characteristics. A multivariate analysis was performed using SAS software, version 9.3 (SAS Institute Inc., Cary, NC, USA). Logistic regression analysis was performed to investigate the influence of age at time of cataract surgery, gender, ethnicity, preoperative nystagmus, and primary *vs* secondary/no IOL implantation on postoperative visual function. A multivariate model was constructed to predict the odds of worse visual acuity based on the preoperative variables. *P*-values of <0.05 were considered to be of statistical significance.

In addition, we compared our postoperative visual outcomes with the required visual acuity to qualify for a driving license in the US; conventionally, best-corrected visual acuity must be 20/40 in at least one eye for the majority of states in the US.

Results

In all, 314 eyes of 157 children fitted inclusion criteria. Approximately 61% of children were Caucasian ($n=96$), 34% African-American ($n=53$), 3% Hispanic ($n=5$), and 2% other ($n=3$). Race was classified as 'Caucasian' and 'non-Caucasian' during regression analysis (61% Caucasian *vs* 39% non-Caucasian). In all, 53% of our patient database was male ($n=83$) and 47% was female ($n=74$). Median age at surgery was 3.91 years, with a range of 0.01–17.5. Median follow-up was 6.4 years.

The distributions of the variables, nystagmus, preoperative strabismus, and IOL placement were as follows: 23% of eyes were noted to have nystagmus and 19% had strabismus preoperatively. A total of 80% of eyes had primary IOL placed at time of surgery, 9% had a secondary IOL placed, and 11% remained aphakic.

Median visual acuity of the eye with better vision was best in children older than 4 years of age with a Snellen visual acuity of 20/25. Median visual acuity of the eye with poor vision was worse for children younger than 1 year of age with a Snellen visual acuity of 20/60 (Table 1). Furthermore, median visual acuity in the eye with better vision was 20/40 for children in the amblyogenic age group, that is, ≤ 5 years of age ($n=94$), and 20/25 for

Table 1 Median VA and range for age at surgery

Age at surgery (years)	N	*Median VA of eye with better vision*	*Median VA of eye with worse vision*	*Driving license in the US (%)*
<1	51	20/40	20/60	61
1–4	28	20/30	20/40	93
4–8	40	20/25	20/30	80
>8	38	20/25	20/25	90
Total	157	20/30	20/40	78

Abbreviations: N, number of patients; VA, visual acuity.

those above 5 years of age ($n=63$). Median visual acuity in the eye with worse vision was 20/50 for children in the amblyogenic age group, that is, ≤5 years of age and 20/30 for children above 5 years of age.

A multiple logistic regression model was constructed to predict the odds of poor postoperative visual acuity, that is, worse than 20/40, based on age at surgery, gender, primary IOL placement, ethnicity, and preoperative nystagmus (Table 2). Visual acuity of 20/40 or better occurred in 78% of children operated on for bilateral cataracts. The presence of preoperative nystagmus was associated with increased odds of poor postoperative visual acuity (OR = 6.0; 95% CLs, 2.5–14.1; *P*-value < 0.0001). Children of age <1 year at time of cataract extraction were three times more likely to have poor visual acuity when compared with children older than 1 year of age (OR = 3.2; 95% CLs, 1.4–7.6; *P*-value = 0.0073). There was also an increase in the odds of poor postoperative visual acuity without primary IOL placement, that is, with secondary IOL placement or when the patient was left aphakic (OR = 3.0; 95% CLs, 1.05–8.4; *P*-value = 0.04). Male gender was associated with poor visual acuity postoperatively (OR = 2.3; 95% CLs, 1.1–4.5; *P*-value = 0.02). Ethnicity, that is, non-Caucasian race, was also associated with increased odds of poor visual acuity (OR = 2.0; 95% CLs, 1.02–4.03; *P*-value = 0.0447).

Table 2 Multivariate (joint effects) analysis of factors associated with poor acuity as dichotomous outcome

Preoperative variable (reference category)	*Relative odds of having poor visual acuity*[a]	*P-value*
Nystagmus (yes)	6.0 (2.5–14.1)	<0.0001
Age at operation (<1 year)	3.2 (1.4–7.6)	0.0073
Primary IOL (no)	3.0 (1.05–8.4)	0.04
Gender (male)	2.3 (1.1–4.5)	0.02
Ethnicity (non-Caucasian)	2.0 (1.02–4.03)	0.0447

[a]Visual acuity worse than 20/40.

Discussion

We identified preoperative predictors for poor visual outcome in children operated for bilateral cataract using a multivariate analysis. A large sample size of 157 children (314 eyes) was investigated with long duration of follow-up. It was determined in our study that children who were <1 year of age at time of cataract extraction had a higher risk of having worse visual acuity than children older than 1 year of age at time of surgery. There is a concurrent presence of amblyopia in the cohort of children that undergo congenital cataract extraction. Published literature has no documented evidence of delays longer than a few months between onset of visually significant cataract (or progression of a cataract to visual significance) and surgery for the cataract. In our cohort, the date of surgery is a reasonable surrogate for age of onset. The fact that surgery at <1 year of age yielded poorer visual outcome indicates that cataracts present during infancy disrupt visual development more than cataracts that first appear after the early sensitive years of visual maturation. Having a normal visual experience in the first year of life is very important. Removal of cataracts that develop after this early stage of visual development more often lead to normal or near normal visual outcomes. It is also known that children who undergo cataract surgery at an earlier age are at a high risk for the development of glaucoma leading to poor vision.[8] As purpose of our study was to evaluate preoperative factors influencing visual outcome, we did not include postoperative glaucoma as one of the variable in the model. The effects of amblyopia and glaucoma make a huge impact on visual development, and unfortunately their effects are often detrimental; this is reflected in our study.

In our study, eyes with nystagmus were six times more likely to achieve vision worse than 20/40. This finding is congruent with previous studies. Yamamato *et al*[10] found that nystagmus is a significant factor that influences final visual acuity for bilateral congenital cataract cases. In the study by Lambert *et al*,[5] the presence of nystagmus was more strongly correlated with poor visual outcome than late surgery in 43 children with bilateral congenital cataracts. In the study by Robb *et al*,[11] average postoperative visual acuity of children without nystagmus and with bilateral cataract was 20/45 and that of individuals with nystagmus was 20/80. In addition, Bowman *et al*[6] found that in a population of Tanzanian children, preoperative nystagmus predicted poor postoperative visual outcomes. These findings may suggest that nystagmus detrimentally affects the critical period of vision development, leading to poor visual outcomes long-term. For some patients, congenital nystagmus was present before the cataracts became visually significant, whereas others developed nystagmus as a result of early sensory deprivation.

Our study demonstrated an increase in the odds of poor postoperative visual acuity without primary IOL placement, which occurred with secondary IOL placement or when a patient was left aphakic. Advancements in surgical technique and new developments in both contact lens and IOL technologies have also led to better visual outcomes for children who undergo cataract extraction.[12] Primary IOL implantation appears advantageous over secondary implantation or aphakia regarding postoperative visual outcomes in our study, which has also been demonstrated in previous studies. Lesueur *et al*[4] demonstrated that good prognosis

depends on early diagnosis, timely surgery, and IOL implantation for both unilateral and bilateral cataract cases. Several previous studies found that the majority of children with bilateral cataracts had a final BCDVA of 20/60 or better after primary IOL implantation, which is similar to our results.[13–18] However, Magli *et al*[15] determined that there were no significant differences of visual outcome between eyes that underwent primary IOL implantation and those that underwent secondary IOL implantation after simultaneous extraction of bilateral congenital cataracts, which differs from the results of our study. Furthermore, Kim *et al*[19] demonstrated that secondary IOL at 2 years of age showed better visual outcomes for bilateral congenital cataracts than primary implantation, given postoperative complications, such as secondary glaucoma and strabismus, and required additional surgeries. Our study design was different from these two studies in that a larger sample size was used, and both congenital and developmental cataracts were included. As our study was retrospective and non-randomized, the absence of a primary IOL implantation at the initial surgery may be a marker for microphthalmia or an overall less developed eye. Thus, the poorer visual outcome may not be related to the aphakia itself, but to the type of eyes left aphakic.

Furthermore, our study showed increased odds of poor visual outcomes in male individuals. There has been limited previous research on association between gender and visual outcomes for bilateral cataract. One previous study found that female sex was a factor associated with worse visual outcomes in a cohort of 415 children in Mexico, which was thought to be potentially because of noncompliance with postoperative care.[20] In our current study, it is unclear why male gender was associated with poorer visual outcomes. Further studies are needed to investigate this relationship.

In addition, our study demonstrated that children of non-Caucasian decent were twice as likely to have poor visual acuity outcomes than their Caucasian counterparts. There is a complex relationship between race and socio-economic status in the US. The effects of social disadvantage lead to worse health outcomes. Our study has highlighted this inequality, and perhaps will one day serve as an aid to bridge this gap in health disparities in the pediatric cataract cohort.

Although this study has the limitation of retrospective design, there were several strengths to this study. A large sample size of 157 children (314 eyes) was investigated. Patients were unselected, allowing for 'real word,' unbiased conclusions on visual outcomes. In addition, there was a longer duration of follow-up with a median of 6.4 years, adding to the strength of this study. Finally, there was reduced bias in surgical technique as data were collected from a sole operator.

In summary, satisfactory visual outcomes occurred in 78% of children operated on for bilateral cataracts in this study. Thus, the majority of this population with bilateral cataract would be eligible to obtain a driving license, allowing for a child to become independent and lead a 'normal' life. Our model will be utilized to guide preoperative counseling of parents with children with bilateral cataracts and aid in determining prognosis. Future advancements will be tailored to investigating other preoperative variables to include in our original model to predict visual outcomes.

Summary

What was known before

- Many clinical factors have been suggested in previous studies to be important influences of visual outcomes for pediatric patients with unilateral and bilateral cataracts. However, there have been limited studies based solely on the bilateral cataracts in children, and there is a paucity of data regarding the factors that predict postoperative visual outcomes in the pediatric bilateral cataract population.

What this study adds

- In this study, we report visual acuity outcomes when childhood cataracts present bilaterally. The objective of this study was to acquire a better understanding of the factors that are associated with postoperative visual acuity outcomes and to develop a model to predict visual acuity prognosis preoperatively.

Conflict of interest

The authors declare no conflict of interest.

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