

ORIGINAL ARTICLE

Pediatric Cataract Surgery: Comparison between Ages at Surgery and Contrast Sensitivity Outcomes

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ABSTRACT

Background: Pediatric cataracts are major causes of children's blindness. Surgery has proven to be beneficial in terms of visual function prognosis. Contrast sensitivity evaluation after surgery is as important as visual acuity considering that natural world consists of various objects in low-to-medium contrasts. The purpose of this study is to analyze the difference of contrast sensitivity outcomes based on ages at surgery.

Method: Retrospective data of children with pediatric developmental cataract from July 2013 to November 2015 were collected. All children who underwent cataract surgery at 60-months-old or less were randomized into two groups, ≤ 24 months and >24 -to-60 months. Contrast sensitivity was then examined with preferential-looking method using Hiding Heidi low-contrast test face chart. The main outcome measures were contrast sensitivity of both groups. Age-at-evaluation, cataract onset, duration of follow-up, duration of deprivation and visual acuity were also noted.

Result: Of 14 children (23 eyes), 11 eyes (47,8%) were in ≤ 24 months group, 12 eyes (52,2%) were in >24 -to-60 months group. All eyes underwent cataract extraction and similar type of intraocular lens implantation. Mean age-at-surgery was $28,2 \text{ months} \pm 16,8 \text{ (SD)}$. Mean contrast sensitivity for each group was $47,50 \% \pm 42,29$ and $18,33 \% \pm 27,38$, respectively, with p-value 0,031. Further analysis of Spearman's correlation test demonstrated significant negative correlation ($r_s = -0,559$; $p = 0,006$) between the two groups.

Conclusion: There was statistically significant difference in contrast sensitivity between those who underwent surgery at ≤ 24 months and >24 -to-60 months. Children who underwent surgery at older ages tend to have better contrast sensitivity afterwards.

Keywords: Pediatric Cataract, Contrast Sensitivity, Hiding Heidi

Management and prevention of blindness in children is one of the main priorities of WHO program, VISION 2020 – The Right to Sight. Childhood blindness is an important issue since most cases, approximately 50 to 70%,

is either preventable or treatable. One of the major cause is pediatric cataract.^{1,2,3} Globally, an estimated 200,000 children are bilaterally blind from cataract.^{2,4} Visual function assessment, therefore, has become a significant parameter after surgery. Spatial vision, including visual

acuity and contrast sensitivity, has proven to be deficient due to visual deprivation.⁵ In infants with cataract detected during the first month and extracted at about four months of age, contrast sensitivity values have consistently known to be decreased, both before and after surgery, no longer comparable to normal children with the same age even when they have reached 4 years of age.^{5,11} Pediatric cataracts will interfere with normal visual development process. When visual deprivation occurs earlier, it is estimated that anatomical and physiological changes of visual system will experience greater influence.¹¹

In the future, failure to recognize this deficit can lead to poor performance in daily activities, psychological and social stress to both the affected children and the parents.⁶ Therefore, contrast sensitivity is recommended as a part of visual function assessment.^{7,8}

Previous studies have proven that visual function at low contrast is an independent function, as differs from visual function at high contrast. Therefore, visual assessment at high contrast level alone is not deemed sufficient to predict visual capability of a person, especially since daily basis tasks occur naturally in medium to low contrast level.^{7,8,9} In adults with visual handicap, contrast sensitivity has proven to function as a predictive factor for reading ability, executing daily routine and recognizing facial expression. Therefore as expected, this could be extrapolated in children to predict as well as to illustrate both their current and upcoming visual performance, particularly in children who undergo visual rehabilitation.^{7,8,10}

The purpose of our study is to identify contrast sensitivity outcomes after developmental pediatric cataract surgery and compare them based on their ages at surgery. Therefore, we expect the results to demonstrate prediction of contrast sensitivity ability in children with pediatric cataract cases based on their age at surgery.

METHODS

This is a retrospective cohort study. Retrospective data of children underwent developmental

cataract surgery and intraocular lens implantation in our centre were reviewed since July 2013 through November 2015. Date of birth and date of surgery were recorded. We, then, counted the age at surgery and divided it into 2 groups, those who underwent surgery at ≤ 24 months and those who underwent surgery at >24 -to-60 months. From medical record, we obtained data such as gender, laterality, surgeon, examination under anesthesia result and best corrected visual acuity at last follow-up. In each group, simple random sampling was conducted as sampling method.

Inclusion criteria was pediatric eyes after cataract surgery with intraocular lens implantation (IOL); minimum visual acuity was one-meter finger counting or 0.50 cycles per degree (cpd); no signs of anterior segment inflammation (no conjunctival hyperemia, cornea is clear); patient no longer required any medication after surgery (at least 3 days since last administration); and parents/legal guardians have agreed to be included in this study which is shown by their willingness to sign the informed consent form. Children with traumatic pediatric cataract; proof of any posterior segment disorder; and presence of global developmental delay are excluded. During this study, any occasions such as post-surgical complications (IOL decentration or dislocation, posterior capsular opacification of visual axis, uveitis, and glaucoma); subjects who have not yet completed medication; and chosen subjects who deferred from any research protocol, are considered as drop out samples that will not be included in analysis.

To ensure optimal visual rehabilitation, IOL implantation was a requirement. All subjects received similar type and quality of IOL. There were two surgeons performed lens aspiration followed by IOL implantation. Both of them has equal capability.

After being selected through simple random sampling, samples were then contacted and asked to visit our ophthalmology outpatient clinic where contrast sensitivity testing will be performed. This study itself was conducted from December 2015 to February 2016. All subjects were tested in the same examination room with similar luminance rate. Beforehand, basic data

were collected, such as date of examination, segment anterior condition, presence of nystagmus or strabismus and other anomaly detected. Cataract onset was carefully traced through interview with the parents or legal guardian.

Contrast sensitivity examination was performed with preferential-looking technique by observing children's response toward presented target. *Hiding Heidi* low-contrast test face chart was used as targets. This chart is 23 cm x 23 cm in dimension, with diagram of a face on each side (identified as *Heidi's* face), as targets. There are 6 different levels of contrast presented, starting from the highest 100%, 25%, 10%, 5%, 2.5%, and the lowest 1.25%. Face pictorial diagram was presented in horizontal movement along with a blank card in front, 4 times for each level. All subjects were examined and observed by the same person and thus detection of each subject capability of recognizing level of contrasts was done at once. Subjects were deemed to fail whenever false detection of face-pictorial diagram occurred 3 out of 4 times. All subjects tested on each eye at a time and were using their optical corrections obtained at previous procedural follow-up.

Age at surgery was defined as age at cataract extraction with IOL implantation was performed on subjects and counted between date of birth to date of surgery. Contrast sensitivity was defined as child's ability to detect *Hiding Heidi* chart.

Other variables suspected as confounding factor were also recorded. Recovery time was measured in months and defined as duration after surgery up until post-operative follow-up

and medication was completed. Onset of cataract was obtained through family interview and defined as the age (in months) when lens opacity was first noticed on subjects. Re-evaluation of visual acuity using grating paddles was done and measured in cycles per degree (cpd). Age at examination was defined as subject's age in months at time of contrast sensitivity examination. All four parameters above are depicted in ratio data scale. Surgeon on all cases were recorded, however further analysis was not performed due to similar competence between them. Duration of deprivation was defined as time spare between onset of cataract to age at surgery performed.

Research data was tabulated and analyzed both descriptively and inferentially. Mann-Whitney comparative test was performed for comparison between age at surgery. If significant value was noted, further analysis was done to measure the correlation's strength (correlation coefficient, r). Correlation test was performed using Spearman correlation. All measurement and calculation were done in SPSS program.

RESULTS

A total of 23 eyes (14 subjects) were divided into two groups. 11 eyes (47,8%) belongs to ≤ 24 months of age at surgery and 12 eyes (52,2%) to > 24 months of age at surgery. From 14 subjects, 9 (64,3%) of them are boys and the rest (35,7%) are girls.

Table 1. Clinical Characteristics of Subjects based on Age Groups

Evaluation Parameter	Mean \pm SD		p*
	Age ≤ 24 months (n=11)	Age $> 24-60$ months (n=12)	
Age at Surgery (months)	12,73 \pm 6,23	42, 42 \pm 8,47	0,000*
Age at Examination (months)	24,00 \pm 12, 04	55,08 \pm 15, 42	0,000*
Onset of Cataract (months)	2, 55 \pm 3,53	5,50 \pm 8,90	0,513
Recovery Time (months)	11, 27 \pm 8,68	12,67 \pm 11,57	0,781
Duration of deprivation (months)	10, 18 \pm 5,81	36,00 \pm 16,20	0,000*
Visual Acuity(cpd)	4, 27 \pm 3,55	7,75 \pm 4,35	0,080

*significant value $p < 0.05$

Mean age at surgery was $28,2 \pm 16,8$ months. Mean age at examination was $40,2 \pm 20,9$ months. The majority of cases were bilateral cataract (78,6%). Distribution of eye affected were almost equal (52,2% right eye; 47,8% left eye). Onset of cataract started at approximately <1-month-old until 24-months-old with mean value $4,01 \pm 6,89$ months.

Recovery time mean value was $12,00 \pm 10,09$ months. Duration of deprivation mean value $23,65 \pm 17,90$ months ($p=0,000$). Mean visual acuity was $6,1 \pm 4,3$ cpd ($p=0,080$). Contrast sensitivity value overall mean value $32,3 \pm 37,5\%$, with $p\text{-value}=0,031$ meaning there was a significant difference between the two groups of age at surgery. Mean data of

clinical characteristics measured in this study are depicted in table 1.

At the same time, the presence of nystagmus and strabismus condition were also checked. There were no significant difference between the two groups with the occurrence of both nystagmus ($p=0,640$) and strabismus ($p=1,000$). Correlation analysis results are shown in table 2. There are no significant difference between contrast sensitivity with onset of cataract ($p=0,425$), recovery time ($p=0,202$), and duration of deprivation ($p=0,222$). While a negative correlation was obtained between contrast sensitivity and age at surgery ($r_s=-0,559$; $p=0,006$), age at examination ($r_s=-0,647$; $p=0,0001$) and visual acuity ($r_s=-0,476$; $p=0,022$).

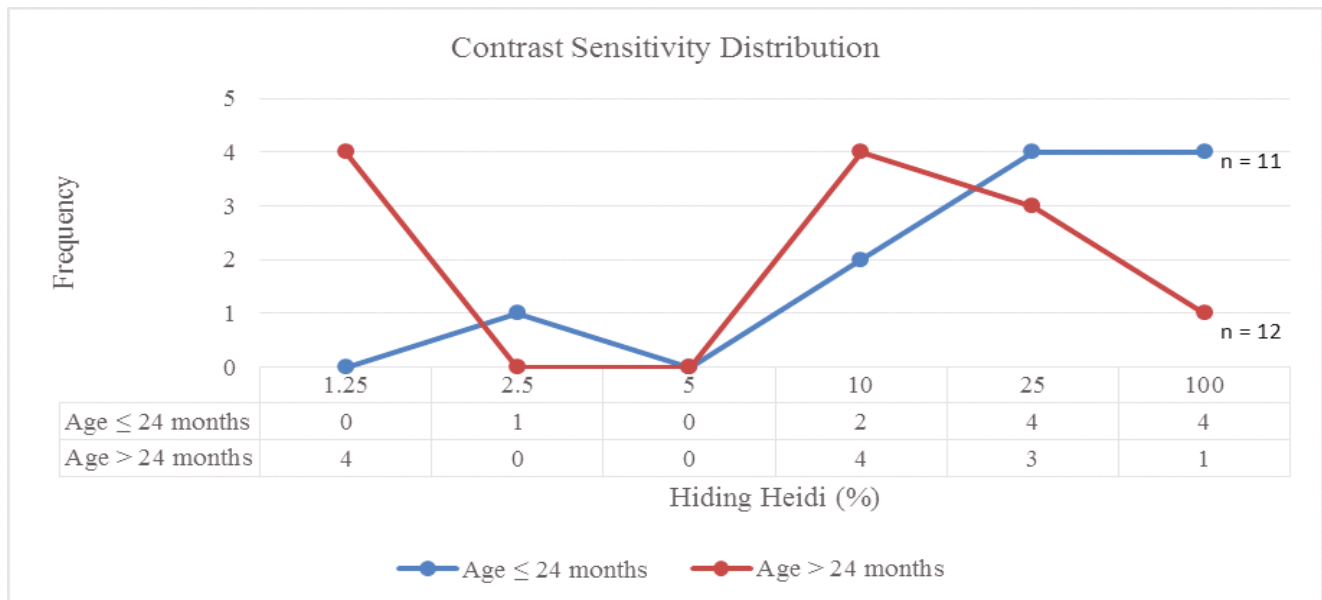


Fig 1. Frequency Distribution of Contrast Sensitivity using Hiding Heidi chart

Table 2. Correlation Analysis Between Age at Surgery, Age at Examination, Visual Acuity and Contrast Sensitivity

Evaluation Parameter		Contrast Sensitivity (%)
Age at Surgery (Months)	Correlation Coefficient (r)	-.559**
	Sig. (2-tailed)	0.006
	N	23
<i>Spearman's rho</i> Age at Examination (Months)	Correlation Coefficient (r)	-.647**
	Sig. (2-tailed)	0.001
	N	23
Visual Acuity (cpd)	Correlation Coefficient (r)	-.476*
	Sig. (2-tailed)	0.022
	N	23

**Significant correlation at level 0.01 (2-tailed test)

*Significant correlation at level 0.05 (2-tailed test)

DISCUSSION

Critical periods start early in life. These periods are marked based on investigation by Hubel & Wiesel in 1960.¹⁵ Normal visual experience after birth was deemed necessary and any visual deprivation would cause anatomical structure shrinkage. However, there are still periods of time to pursue and resolve the system function, once deprivation is halt.

There are three critical periods, developmental periods (occur until 3 to 5 years), period in which deprivation will cause amblyopia (few months old to 7 years), and recovery periods (from occurrence of deprivation until young adult) to resolve the visual system to normal or near normal.^{15,16,17} Visual development of a newborn grow most rapidly during the first six months. Visual acuity level is estimated at 20/400 (~3/60). At 24 months it is presumed anatomic differentiation of photoreceptor cells has occurred and axial length has reached stability. And physiologically, plasticity of optic nerve is still experiencing major progression thus any disruption took place in before that had a great chance of being fully recovered.

At 48 to 60 months of age, fovea maturation is nearly complete and visual acuity is on 20/20 level (~6/6). However, with the existence of critical periods, recovery time of visual system is expected to expand longer even when deprivation occurred at older age.^{12,13,14} Based on that knowledge, this research was divided into two groups of age based on age at surgery, ≤ 24 months and >24 -to-60 months.

Majority of subjects in this research are boys (64,3% to 35,7% girls). In developing countries, most pediatric cataract cases are dominated by boys, even though there are no scientific approval that gender related to incidence. It is considered that parents or legal guardian choose to seek for medical attention and use their family resource for their sons rather than their daughters.^{3,4,12}

Based on laterality, 11 subjects (78,6%) had cataract on both eyes. Bilateral cataract cases are commonly associated with multiple or systemic condition, or certain syndrome, while unilateral cataracts are more associated as a single disease.⁴

In this study, there are 3 unilateral cases, in which 2 of them had an extraocular malformation.

Nystagmus is found in 18 eyes (78,3%) and all of them occurred in bilateral cataract cases. There are no difference of nystagmus occurrence between the two groups. Nystagmus has a tendency to occur to those whose onset of cataract started at <6 months of age with deprivation period >6 months.^{3,19} Children who did not experience nystagmus in our study are those who had unilateral cataract or those whose cataract started at >6 months of age. However, in this study, we did not separate between nystagmus that occur before surgery or afterwards. Meanwhile, in general strabismus statistically manifested in 85% of congenital cataract cases. In our study, however, only 17,4% of the children experienced strabismus, predominantly nasal deviation. It is generally accepted that children with history of congenital cataract failed to have normal stereoacuity. This would mean problem for one's quality of life as this individu grows up.³

Onset of cataract found in this study is between less than 1-month-old to 24-months-old. Statistical analysis concluded there were no difference of onset between the two groups.

Duration of deprivation demonstrated significant difference between two groups ($p=0,00$). Mean deprivation lasted 23,65 ($\pm 17,9$) months. However, there were no correlation between duration of deprivation with contrast sensitivity.

Recovery time illustrated the length of healing time after cataract surgery. The mean time for healing after pediatric cataract surgery is told between 3 to 4 weeks, but medication occasionally lasts up to 6 weeks. In our study, we use the minimum recovery time of 1 month as inclusion, with the mean time is $12,00 \pm 10,09$ months.

From visual acuity examination we performed, there were no difference between the two groups. We used LEA Grating Acuity paddles.²⁰ Visual acuity is just one aspect of visual measurement, and it is highly correlated with how good an individual can cooperate to detect and process information within certain spatial frequency at maximum contrast.^{7,8,9,11} Normal

infants at 24 months of age, would reach the milestones of 15 cpd (~20/40) using the grating paddles, and by 4 or 5 years old, they would reach 30 cpd (~20/20).¹⁵ After surgery, children with bilateral cataract tends to have better acuity than those with unilateral cataract.^{18,22}

Significant difference between some clinical characteristics including age at examination and duration of deprivation might influence the final result. However, we found that duration of deprivation did not correlate to contrast sensitivity.

Contrast sensitivity, as our main objective in this study, showed significant difference between the two groups, where older age at surgery was correlated with better contrast sensitivity. Older group has longer mean duration of deprivation time ($p < 0.00$). Therefore, this result was contradictory to the theory in which the severity of visual impairment depends on age at the onset of visual deprivation and its duration; early (infantile) onset and prolonged deprivation are associated with profound and irreversible visual impairment. Nevertheless, as has been stated above, there are critical periods which enable the visual system to recover in a certain amount of time, whether anatomically, physiologically, or both.^{5,13,15} This period is a great news that indicate there are plenty hopes and chances for these children to pursue their lag in contrast sensitivity ability especially for doing everyday tasks.

There is a few limitations to our research. This could probably be some of the factors that yielded our result. All examinations were performed at one time for all individuals. In the study by Vasavada et al (2014),⁹ contrast sensitivity measured under photopic condition showed variations when measured at different time points for the same individual. Measurement time including pre-surgery, a month after and 3 months after. Contrast at first month post surgery was different from pre-surgery. When re-measurement took place at month-3 after surgery, different results were obtained ($p < 0.001$).⁹ As has been explained before, our study was taken only once after the surgery regardless of different recovery time period.

Absence of pre-surgery evaluation was another factor that might contribute to this result. It is widely known that cataract density and point of time when cataract become visually significant played important roles and could be very different in each cases.² Morphology of cataract also may affect prognosis.¹⁵ Presence of any pre-operative issues we might not knew could also be a probable factor that we failed to recognize. Through verbal interview with parents or legal guardian we were able to ascertained the onset of cataract. Unfortunately, this was the only pre-surgery information we obtained.

Pediatric cataract cases often associated with other condition, or sometimes, malformations. This dissimilarity played a probable significant role to their cognitive ability. Children approaching maturity age of contrast sensitivity function could very well did better at examination than they who were younger. Older children also known to have better attention span. As a consequent their mean value results for contrast sensitivity examination would excel. However, our study dealt with pediatric cataract cases, in which, each cases were different and they definitely did not experience the same visual experience as children with no cataract.

Hiding Heidi low contrast test face is capable of measuring a pseudophakic child's ability to recognize pictures in various contrasts. By utilizing facial expression, objects have a more natural feel and are able to capture child's attention. However, observing clinician should have patience and be meticulous when making interpretation of the results.^{7,8}

Our main conclusion from this study is that there is a difference in contrast sensitivity between children who underwent cataract extraction before 24-months-old and >24-to-60 months old, being those who underwent cataract surgery at the older age group tend to have better contrast sensitivity. Through this research, we would like to emphasize the importance of contrast sensitivity examination. For visual rehabilitation purposes, this procedure would serve as predictor to how well had the surgery result been. Furthermore, it could be included as a part of pre-operative evaluation routine

for pediatric cataract cases. Along with another procedure and pre-operative examinations, contrast sensitivity could be an important factor to obtain optimal timing of surgery.^{2,3,11}

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