ORIGINAL ARTICLE

REFRACTIVE AND VISUAL OUTCOMES OF PEDIATRIC CATARACT SURGERY IN INDONESIAN TERTIARY EYE CENTER

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ABSTRACT

Introduction: *Cataract remains as a leading cause of visual impairment in children. Surgical intervention and post-operative refractive correction remain fundamental. This study aims to describe the refractive and visual outcome of pediatric cataract surgery in a tertiary eye center in Indonesia.*

Methods: *This retrospective study was conducted utilizing medical records of all congenital and developmental cataracts patients undergoing cataract extraction procedures with or without primary IOL implantation between January and December 2022. Exclusion criteria included patients who did not undergo visual acuity and objective refraction examination 1-month post-cataract surgery and those with incomplete medical records data.*

Results: *A total of 118 eyes from 65 patients was included in this study. Most patients had bilateral cataracts (93.80%) and operated at the median age of 18 (0.96-212.64) months. Post-operatively, there were 71 (60.19%) aphakic and 47 (39.81%) pseudophakic eyes with a respective refractive status of +18.00 (12.00 – 21.13) D and +0.60 (±2.37) D. Prediction error (PE) and absolute prediction error (APE) were obtained within 1.00 D. Most aphakic eyes had unquantifiable visual acuity both before (91.50%) and after (83%) surgery. Among pseudophakic eyes, nine (19.16%) had visual acuity of ≥ 6/12 and seven (14.89%) had visual acuity of <6/12 - 6/18 post-operatively. No patients had visual acuity ≥ 6/12 and <6/12 - 6/18 before surgery.*

Conclusion: *Post-operative refractive status of both aphakic and pseudophakic patients were well within correctable range. There was an improvement of vision after surgery. Limited visual potential may be attributed to the presence of amblyopia.*

Keywords: *cataract extraction, congenital cataract, visual acuity*

INTRODUCTION

Cataract remains as a leading cause of visual impairment in children. It was estimated that the prevalence of congenital cataract is 0.6 to 9.3 per 10,000 live births. They account for 10% of pediatric visual impairment worldwide. Four percent of childhood blindness could be attributed to cataract due to inoperable bilateral condition, amblyopia, postoperative complications, and associated ocular conditions.[1–3]

Lens extraction procedure remains the mainstay of treatment for congenital cataract. Discussions regarding several aspects of congenital cataract surgery, such as the optimal age for primary intraocular lens (IOL) implantation and the target refraction for IOL implantation, were

still ongoing. However, timely surgery for clinically significant cataracts and postoperative refractive correction remains critical to prevent amblyopia.[1,3,4]

Pediatric cataract surgery is one of the initiatives to reduce the prevalence of childhood visual impairment and blindness. Post-operative evaluations are crucial to determine the quality of surgical service. In Indonesia, some of the barriers to cataract surgical services include cost, community awareness, and willingness to undergo surgery. Similar barriers are also faced in the implementation of cataract surgical services for children in developing countries. Performing pediatric cataract surgery in a timely manner in developing countries may still be challenging.[5,6] This study aims to describe the refractive and visual outcome of pediatric cataract surgery in a tertiary eye center in Indonesia.

METHODS

This study employed a single-center retrospective design, analyzing medical records of patients diagnosed with congenital or developmental cataracts who underwent surgery between January and December 2022. The study included children who underwent cataract extraction procedure with or without primary IOL implantation. Patients who loss to follow up and did not undergo objective refraction examination 1 month post operatively or lacked complete medical records were excluded.

Data collected from medical records included child's age at recognition (when signs of cataract were first noticed by the parents or caregiver), age at surgery (when the first surgery was done), gender, place of resident, cataract laterality, pre-operative biometry and keratometry, and associated ocular and systemic disorder. Pre-operative and post-operative presenting visual acuity (PVA), post-operative lens status, and post-operative objective refraction were also documented. In uncooperative patients, keratometry (Autokeratometer KM-500, Nidek Co. Ltd., Japan) and A-scan biometry (Biometer AL-100, Tomey, Japan) measurements were done in general anaesthesia before surgery. IOL Master® 700 (Carl Zeiss, Germany) were done in cooperative patient. To determine refractive target, Enyedi's Rule of Seven were used for children under 7 years. In cases of unilateral cataract or pseudophakic fellow eye, refractive target adjusted according to the objective refraction of the fellow eye.

All lens extraction procedures, with or without primary IOL implantation, were performed under general anaesthesia. Primary posterior capsulotomy with or without anterior vitrectomy were done in children under 5 years or deemed uncooperative for post-operative in-office Nd:Yag capsulotomy laser due to posterior capsule opacification (PCO) or visual axis opacification (VAO). Primary IOL implantation was done in children aged at least 2 years old

and sufficient corneal diameter. IOL may be implanted in-the-bag or in sulcus. At the end of the procedure, corneal incision was sutured using non-absorbable 10–0 nylon. Five experienced pediatric ophthalmology consultants performed all of the surgeries.

All participants were examined after surgery with follow-up appointments at 1 day, 1 week, and 1 month. Visual acuity and objective refraction measurement at the 1-month mark were used for the study's analysis. Visual acuity assessment methods were varied depending on the child's age, ability to communicate verbally, and overall cooperation, using Snellen chart, Cardiff cards, cake decoration, toys, or pen light. Patients aged 5 years old and/or able to communicate properly were assessed using Snellen Chart. Those aged below 5 years were assessed with Cardiff card or Cake Decoration if the patient is not cooperative enough. Infant patients were assessed with blink reflex or light/object fixation examination.

Objective refraction measurement is conducted using an autokeratorefractometer (TONOREFTM III; Nidek Co. Ltd., Japan) on cooperative patients and streak retinoscopy on uncooperative patients. Refractive status is then converted into spherical equivalent (SE). Subsequently, prediction error (PE) is calculated by subtracting the predicted refractive status from the actual postoperative refractive status and absolute prediction error (APE) is calculated by subtracting the predicted refractive status from the actual postoperative refractive status in absolute value.

Data processing and analysis were conducted using Microsoft® Excel (Microsoft, Washington, USA) and Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corporation, New York, USA). To determine the normality of distribution within variable, the Shapiro-Wilk tests and the Kolmogorov-Smirnov tests were used where the sample size was either smaller or larger than 50 in each group, respectively. Mean and standard deviation were used to describe normally distributed data, while median and range were used to describe non-normally distributed data. This study adhered to the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of our institution (No.:DP.04.03/D.XXIV.16/5400/2024; April 1,2024).

RESULTS

Congenital and developmental cataract surgery was performed on 71 pediatric patients at our institution during the period of January-December 2022. Six patients were excluded due to incomplete follow-up data, resulting in 118 eyes from 65 patients who were used as the sample for this study.

Demographic and clinical characteristics were presented in Table 1. The median age at where cataract signs were recognized was quite early at 1.92 months with several patients were recognized not long after birth. However, there was a delay before patients present to our institution and subsequently, surgery was performed at median age of 18.00 months. Males were slightly more prevalent, making up 56.9% of the patients. Bilateral cataracts were present in the vast majority (93.8%) of patients. Nystagmus (53.85%) and congenital heart disease (7.7%) was the most frequently found associated ocular and systemic disorder, respectively. In addition, 3 cases (4.6%) were linked to congenital rubella syndrome.

Table 1. Clinical And Demographic Profile

Profile	n=65 (patients)
Age, recognized (months)	1.92(0.00-123.00)*
Age, surgery (months)	18.00(0.96-212.64)*
Sex	
Male	37(56.90%)
Female	28(43.10%)
Laterality	
Bilateral	61(93.80%)
Unilateral	4(6.20%)
Associated Ocular Disorder	
Nystagmus	35(53.85%)
Strabismus	7(10.77%)
Microcornea	5(7.69%)
Persistent fetal vasculature	4(6.15%)
Microphtalmia	2(3.08%)
Anterior segment dysgenesis	1(1.54%)
Optic nerve hypoplasia	1(1.54%)
Microspherophakia	1(1.54%)
Retinopathy of prematurity	1(1.54%)
Associated Systemic Disorder	
Congenital heart disease	5(7.70%)
Down syndrome	4(6.20%)
Microcephaly	3(4.60%)
Congenital rubella syndrome	3(4.60%)
Congenital hypothyroid	1(1.50%)
Hearing impairment	1(1.50%)
Epilepsy	1(1.50%)

*Median (range)

Preoperative biometry was performed before surgery under anaesthesia in 94 (79.7%) eyes of uncooperative patients using A-scan biometry. The results of preoperative biometry for all eyes are shown in Table 2. The median of axial length (20.72 mm), corneal diameter (11.00 mm), and mean K (44.26 D) were within normal range. Based on the post-operative lens status, 71 patients (60.19%) were aphakic and the remaining 47 patients (39.81%) were pseudophakic. The details regarding post-operative refractive status, including PE and APE, can be found in Table 3. Both the PE and APE was found within the range of 1.00 D.

Table 2. Pre-operative Biometry

Parameter	n=118 (eyes)
Axial length (mm)	20.72(15.59-28.20)*
Keratometry	
Corneal diameter (mm)	11.00(8.00-12.80)*
K1 (D)	43.51(37.30-52.28)*
K2 (D)	45.59(39.43-53.55)*
Mean K (D)	44.26(39.11-52.72)*

*Median (range)

Pre-operative and post-operative PVA were detailed in Figure 1. A significant portion of the aphakic eyes had unquantifiable visual acuity both before (91.50%) and after (83%) surgery which may be attributed to the young age of the patients. However, in pseudophakic group, 34.05% eyes achieved post-operative visual acuity of ≥ 6/18. Notably, no eye in this group had pre-operative visual acuity of ≥ 6/18.

Table 3. Post-operative Refractive Status

Variables	Mean/Median
Aphakic (n=71 eyes)	
Actual refraction (D)	18.00(12.00 – 21.13)*
Pseudophakic (n=47 eyes)	
Actual refraction (D)	0,60 (±2,37)†
Predicted refraction (D)	0,61 (-0,30 - 6,03)*
PE (D)	0,83 (±1,37)†
APE (D)	1,00 (0,04 - 3,96)†

*Median (range); †Mean (standard deviation); PE: prediction error; APE: absolute prediction error.

DISCUSSION

Bilateral congenital cataracts are more commonly encountered than unilateral ones. These cataracts may present with or without associated systemic conditions. In a previous study conducted in Guatemala, it was also found that the majority of congenital cataract cases presented bilaterally (70%).[2] Bilateral presentation generally occurs due to mutations of gene that regulate proteins in the crystalline lens. As much as 70% of bilateral congenital cataract cases etiology in developed countries can be identified due to adequate available diagnostic modalities, including genetic testing. These findings differ with studies conducted in developing countries, where the etiology could be identified in only 37% of cases, consisting of 34% genetic cases and 3% infection-related cases.[1,2,7] In this study, it was also found that the majority of cases involved bilaterally. Infection-related etiology was identified in 4.60% of cases which was attributed to congenital rubella syndrome. Unfortunately, identification of gene mutations of pediatric cataract cases in this study were implausible due to the absence of genetic testing modalities in our institution.

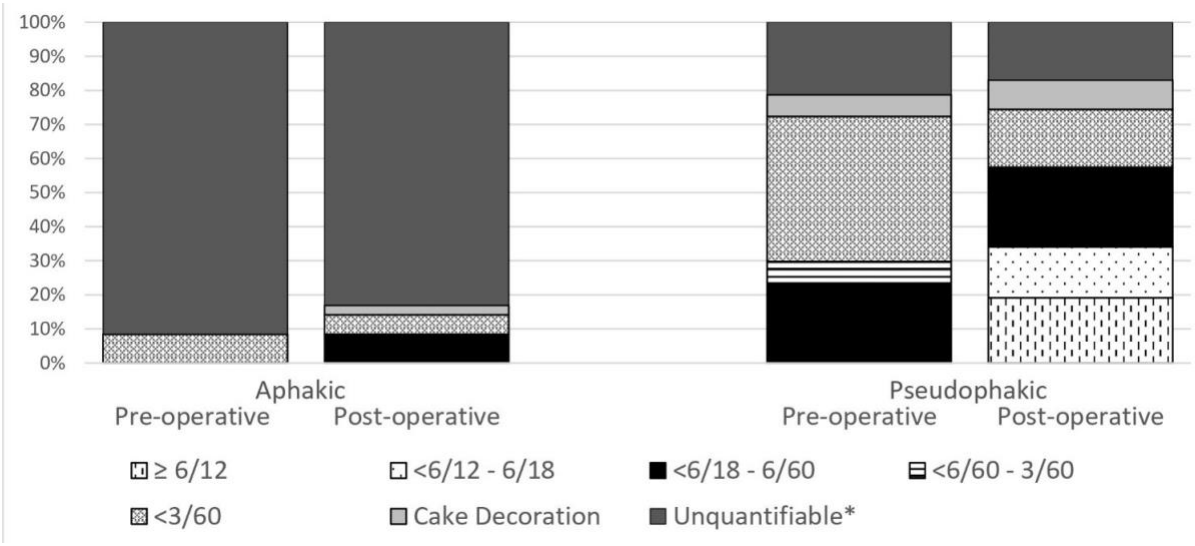

Figure 1. Presenting Visual Acuity Based on Post-Operative Lens Status.
*Unquantifiable visual acuity status includes blink reflex, fix & follow the light, and fix & follow the object

Nystagmus is one of the most commonly found associated ocular conditions in pediatric cataract. In Wilhelm's study, the prevalence of nystagmus in congenital cataracts was found to be 61%.[2] Significant bilateral cataracts can cause limited visual input on the retina, thus disrupting the normal development of ability to fixate. This leads to observable nystagmus within the first 3 months of life, although the onset of nystagmus can occur up to 2 years of age. The presence of nystagmus indicates a poorer visual prognosis in patients with bilateral congenital cataracts as nystagmus may be used as a marker for deprivation amblyopia.[3,8,9] Early

intervention is critical, but remains a challenge in developing countries. Data on the age at surgery for congenital cataracts in developing countries have been obtained from Kabylbekova et al.'s study in Kazakhstan, which found a median age at surgery for bilateral congenital cataracts at 52 months, and from Liu et al.'s study in China, which found a mean age of 0.92 years for aphakic group and 4.9 years for pseudophakic group.[8,10] In this study, nystagmus was observed in 35 (53.85%) patients and the median age at surgery was 18 months. This is quite unfortunate considering that the median age when cataract signs were noticed by the caregivers was 1.92 months, and for some patients, shortly after birth. Delay in surgical intervention may be attributed to several factors including existing healthcare systems and family knowledge regarding pediatric cataract signs. Previous study by Ratnaningsih et al showed that cost, both direct and indirect, is the major barrier for cataract surgery for adults in West Java Province in Indonesia.[5] Further research is needed to assess the factors causing such delays for pediatric cataract surgery in Indonesia.

A newborn infant undergoes significant physiological axial length growth up to the age of 2 years. Axial length increases from an average of 16.78 mm at birth to an average of 20.69 mm by 1-2 years of age. The rate of axial length growth then decreases as the patient ages from 2 to 5 years, with a total increase in axial length of 1.1-1.2 mm. A phase of slow axial length growth continues until approximately 13 years of age, with an increase in axial length of 1.1-1.2 mm. The rate of axial length increases then diminish until around 18 years of age. These changes in axial length are important considerations in determining refractive targets and selecting IOL for pediatric cataract surgery. Additionally, changes in corneal status as a child grows also need to be considered. In newborns, the physiological horizontal corneal diameter ranges between 9.5-10.5 mm with a mean K reading of 52.00 D. As age progresses, corneal diameter increases and corneal curvature flattens, reaching an average of 11-12 mm for horizontal corneal diameter and 42.00-44.00 D for mean K readings.[3,7] However, changes in refractive status of patients with pediatric cataracts undergoing surgical intervention, with or without IOL implantation, differ from children without history of aforementioned surgery as the patient ages. Studies by McClatchey et al. indicate a higher rate of refractive growth (RRG) variation in eyes that have undergone congenital cataract surgery compared to normal eyes in a 10-year follow-up post-operation. Thus, predicting refractive status changes in aphakic and pseudophakic children is more challenging.[11] Pre-operative median axial length (20.72 mm) and mean K readings (44.26 D) obtained in this study was in accordance with physiological axial length growth and corneal curvature changes in children. Several associated ocular disorder which may affect refractive status also present in this study, including microphthalmia

(7.69%), microcornea (3.08%), anterior segment dysgenesis (1.54%), microspherophakia (1.54%), retinopathy of prematurity (1.54%), and persistent fetal vasculature (6.15%), although in insignificant numbers.

Based on previous studies, primary IOL implantation is recommended when the patient is at least 2 years old. However, the ongoing development of the eye makes determining the refractive target and the accuracy of IOL calculation more challenging compared to adults. There is a high risk of complications and significant PE/APE for primary IOL implantation in younger patients.[4,10,12] A study conducted by Oke et al. indicates that the accuracy of IOL calculations increases as the patients age with a statistically significant result.[13] A review by Muslim and Barliana found that most studies on IOL accuracy in children assess outcomes 4-8 weeks post-operatively. The same study also found no superior formula for determining IOL power in pediatric patients.[12] In this study, 47 (39.81%) pseudophakic patients had a mean PE value of 0.83 D and median APE value of 1.00 D at the 1-month follow-up. This indicates good refractive outcomes of pediatric cataract surgery and in accordance with the follow-up examination timeframe for assessing PE and APE in previous studies. These results are also consistent with our prior research, which found an average APE of 1.34 D using the SRK/T formula.[14] The median age of patients undergoing primary IOL implantation in this study was 6.66 years, may also possibly contributing to the observed good accuracy.

WHO recommends pediatric cataract surgery as a means to reduce preventable blindness in children population. A study conducted by Asferaw et al. in Ethiopia showed improvement from 4% of eyes with visual acuity of 6/6-6/18 and 92% of eyes with visual acuity <6/60, to 37% of eyes with visual acuity 6/6-6/18 and 43% of eyes with visual acuity <6/60 post-operatively.[15] Higher RRG values and myopic shift in eyes that have undergone pediatric cataract surgery need to be considered during follow-up examinations to adjust refractive correction according to the patient's needs as they age. This is important to prevent a decrease in visual acuity, especially as patients reach school age.[11,16] Most aphakic patients in this study had PVA that could not be quantified either before (91.50%) or after (83%) surgery. This is due to the very young age of the patients, making it difficult to perform quantifiable visual acuity examinations. Improvement in visual status can be observed in patients undergoing primary IOL implantation. There was a decrease in the percentage of patients with visual acuity <3/60 post-operative (17.02%) compared to pre-operative (42.56%). The number of patients with visual acuity ≥6/18 also increased to 34.05% post-operatively, which was none in this category pre-operatively. Long-term follow-up is necessary for all patients, considering the dynamic changes in refractive status that occur in pediatric patients and the refractive adjustments for

ongoing visual needs.

In this study, there was an improvement in visual acuity after surgery, especially in the pseudophakic group. However, limited improvement may be attributed to deprivation amblyopia that had already occurred in the patients. The median age at surgery at 18 months and median age at recognition at 1.92 months may indicate a barrier that prevented the patients from being brought to our institution earlier. Literatures suggested that patients with unilateral cataract undergo surgery at 4-6 weeks of age and bilateral cataract before 10 weeks of age. The presence of cataract at this critical period causes limited visual input resulting in visual cortex deficiency. The prognosis of amblyopia due to deprivation is known to be worse. However, with appropriate post-operative occlusion therapy and refractive correction, the patient's visual function may be steadily improved during follow-up examinations.[3,6,7]

This study has several limitations. Regarding the nature of its retrospective design, several potential variables that could be analyzed such as cataract morphologies could not be documented due to incomplete medical records. Additionally, standardized examination protocols could not be implemented as in prospective studies. Some variables in this study showed non-normal distributions, suggesting a need for a larger sample size. This study was conducted at a national ophthalmology referral center in Indonesia with a relatively sufficient resources, thus the findings may not be generalizable to other healthcare facilities in Indonesia. However, to our knowledge, this is the first published reports regarding the outcomes of pediatric cataract surgery in Indonesia which includes both aphakic and pseudophakic group.

CONCLUSION

The majority of pediatric cataract patients who underwent surgery at an Indonesian tertiary eye referral center had bilateral cataracts. Post-operative lens status was predominantly aphakic, with a mean postoperative refractive power of 18.00 D. In patients with post-operative pseudophakia, a refractive power of 0.60 D was obtained. Both the PE and APE were within acceptable range. There was an improvement in visual acuity after surgery. However, a large number of the patients was not cooperative enough to be evaluated with quantifiable methods of visual acuity measurements. Limited visual potential may be attributed to the presence of amblyopia due to the late presentation.

REFERENCES

1. Bremond-Gignac D, Daruich A, Robert MP, Valleix S. Recent developments in the management of congenital cataract. Ann Transl Med. 2020 Nov;8(22):1545–1545.
2. Wilhelm EDB, Paiz MAZ, Rivas AMO, Del Cid NCQ, Elías VYB, Castillo NLO. Characterization of congenital cataract and postoperative visual outcome in a Pediatric Ophthalmology Unit in a middle-income

country. Andes Pediatrica. 2022 Jul 1;93(4):488–95.
3. Khan AO, Chang TCP, El-Dairi MA, Lee KA, Utz VM, Mireskandari K, et al. 2022-2023 Basic and Clinical Science Course Section 6 : Pediatric Ophthalmology and Strabismus. 2023.
4. Self JE, Taylor R, Solebo AL, Biswas S, Parulekar M, Dev Borman A, et al. Cataract management in children: a review of the literature and current practice across five large UK centres. Vol. 34, Eye (Basingstoke). Springer Nature; 2020. p. 2197–218.
5. Ratnaningsih N, Rini M, Halim A. Barriers for Cataract Surgical Services in West Java Province of Indonesia. Ophthalmol Ina. 2016;42(1).
6. Kraus CL. Pediatric Cataract Surgery and IOL Implantation [Internet]. Cham: Springer International Publishing; 2020. Available from: http://link.springer.com/10.1007/978-3-030-38938-3
7. Lambert SR, Lyons CJ. Taylor and Hoyt's Pediatric Ophthalmology and Strabismus. Elsevier; 2017.
8. Kabylbekova A, Meirmanov S, Aringazina A, Orazbekov L, Auyezova A. Age at recognition and age at presentation for surgery for congenital and developmental cataract in Kazakhstan. Ann Med. 2022;54(1):1988–93.
9. Tariq Bhatti M, John Chen CJ, Danesh-Meyer H V, Levin LA, Moss HE, Phillips PH, et al. 2022-2023 Basic and Clinical Science Course Section 5 : Neuro-Ophthalmology. 2022.
10. Liu ZZ, Long EP, Lin DR, Ye L, Xiang YF, Li WT, et al. Dynamic profile of ocular refraction in pediatric cataract patients after lens surgeries. Int J Ophthalmol. 2019;12(12):1839–47.
11. McClatchey SK, McClatchey TS, Cotsonis G, Nizam A, Lambert SR. Refractive growth variability in the Infant Aphakia Treatment Study. J Cataract Refract Surg. 2021 Apr 1;47(4):512–5.
12. Muslim F, Barliana JD. Prediction Errors and Accuracy of Intraocular Lens (IOL) Calculation Formulas in Pediatric Eyes. Vol. 46, Ophthalmol Ina. 2020.
13. Oke I, VanderVeen DK, McClatchey TS, Lambert SR, McClatchey SK. The accuracy of intraocular lens calculation varies by age in the Infant Aphakia Treatment Study. Journal of AAPOS. 2022 Jun 1;26(3):143–5.
14. Irfani I, Wahyu T, Oktarima P, Caesarya S, Sari M, Karfiati F. Accuracy of the SRK/T Formula in Pediatric Cataract Surgery. Clin Optom (Auckl). 2023;15:1–8.
15. Asferaw M, Mekonen SY, Woodruff G, Gilbert CE, Tesfaye S. Outcome of paediatric cataract surgery in Northwest Ethiopia: A retrospective case series. British Journal of Ophthalmology. 2019 Jan 1;103(1):112–8.
16. Weakley DR, Nizam A, VanderVeen DK, Wilson ME, Kruger S, Lambert SR, et al. Myopic Shift at 10-Year Follow-up in the Infant Aphakia Treatment Study. Ophthalmology. 2022 Sep 1;129(9):1064–5.