·Clinical Research·

Factors influencing stereoacuity levels after surgery to correct unilateral developmental cataracts in children

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Abstract

• AIM: To evaluate factors influencing stereoacuity after surgery to correct unilateral developmental pediatric cataracts.

• METHODS: We retrospectively surveyed 110 patients who had undergone removal of unilateral acquired developmental cataracts and primary posterior chamber intraocular lens implantation between February 1992 and December 2009. In all patients, stereoacuity was assessed using the Titmus test at the last follow-up period of minimum 2 years after surgery. Patients were divided into two groups according to the extent of stereoacuity: group 1 (n=42) had stereoacuity values ≤100sec/arc and group 2 (n=68) values >100sec/arc. The values of ten parameters associated with stereoacuity were measured in each group: Cataract types, preoperative best corrected visual acuity (BCVA) of the affected eyes, preoperative inter-ocular difference of BCVA, age at cataract surgery, operative method, secondary cataract, postoperative strabismus, postoperative BCVA of the affected eyes, postoperative inter-ocular difference of BCVA, and anisometropia.

• RESULTS: The extent of stereoacuity was significantly associated with both operative method and secondary cataract (P=0.000 and P=0.016, respectively). All patients in whom the posterior capsule was preserved, had poor stereoacuity >100sec/arc. Significant correlations with the extent of stereoacuity were found with postoperative strabismus (P=0.048),postoperative BCVA of the affected eyes (P=0.002), anisometropia (P=0.034).

• CONCLUSION: Postoperative stereoacuity was better in patients who underwent either optic capture or anterior vitrectomy after posterior continuous curvilinear capsulorhexis, and who didn't develop secondary cataracts or strabismus postoperatively. Furthermore, postoperative BCVA of the affected eyes, and anisometropia influenced the stereoacuity of the patients surgically treated for unilateral developmental pediatric cataracts.

• **KEYWORDS:** anisometropia; developmental cataract; secondary cataract; stereoacuity; stereopsis; strabismus; unilateral pediatric cataract; visual acuity

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INTRODUCTION

Pediatric cataracts are a common cause of childhood blindness, affecting 1.2-6 children per 10 000 births[1]. Surgical methods for removal of pediatric cataracts have changed greatly over the past 30 years. However, the optimal visual rehabilitation protocol remains unclear. Amblyopia may develop in pediatric cataract patients, caused by either a form vision deficiency by cataract, a failure to implement continuous precise optical correction of refractive errors caused by eyeball growth, or inadequate development of best corrected visual acuity (BCVA) caused by occlusion of the visual axis by secondary cataracts[2].

The aim of pediatric cataract treatment is the delivery of good binocular function and good BCVA. After cataract surgery, optical correction *via* intraocular lens (IOL) implantation is known to create better binocular function than that afforded by glasses or contact lenses [3]. Of the several aspects of binocular function, stereoacuity is the most demanding or the highest quality of binocularity. It was reported that 90% demonstrated strereoacuity≤400sec/arc in the children who had cataract removal and primary IOL implantation for unilateral cataract more than 2 years old[4]. Factors relevant to stereoacuity in adults with aphakia or pseudophakia include patient age; inter-ocular difference of BCVA; anisometropia; astigmatism; axial lengh; aniseikonia;

pupil size; and decentration or tilt of an IOL [5-11]. However, pediatric cataracts (unlike adult cataracts) are associated with problems such as amblyopia and strabismus. Especially in under developed countries, pediatric cataract can not be noticed until a later time, leading to delay of surgery or aggressive management for amblyopia. Also, the failure of continuous follow-up is frequent. Few reports on factors affecting postoperative binocularity and stereopsis in children with pediatric cataracts have appeared. We know congenital cataracts in general have worse visual outcome and stereoacuity than developmental cataracts due to critical period theory of visual development. That is why most previous studies focused on congenital cataracts, rather than developmental ones[12]. We are unaware of any previous study of stereopsis after surgery only for unilateral developmental cataracts. Accordingly, we investigated factors relevant to stereopsis in children who had undergone lens removal and primary posterior IOL implantation to treat unilateral developmental cataracts.

SUBJECTS AND METHODS

Subjects We retrospectively reviewed the medical records of 110 children who underwent removal of unilateral developmental cataracts and primary posterior IOL implantation, by a single surgeon, in Maryknoll Medical Center between February 1992 and December 2009. Children with congenital cataracts were excluded. The diagnostic criteria for congenital cataracts were as follows: Diagnosis within 12 months after birth, a family history of congenital cataracts, lamellar and sutural cataracts, cataracts accompanied by lentiglobus and persistent hyperplastic primary vitreous [13]. Other patients who had been determined previously as non-cataract patients under 2 years of age by pediatrician or ophthalmologist examination were diagnosed with developmental cataracts. Children with preoperative strabismus, glaucoma, uveitis, corneal opacity, any other eye disease, any systemic disease, trauma, mental retardation, or who had undergone ocular surgery prior to cataract surgery, were excluded. Children who had been followed-up for ≥2 years, and who were ≥5 years of age at the last follow-up, were included to increase data reliability.

The refractive power of each IOL was calculated using the SRK-T method. The IOLs with undercorrected power were implanted aiming for emmetropia at the time of adulthood[14]. The surgical technique involved creation of scleral incisions 5mm or 3.2mm in length, 1.5mm away from the superior limbus, to allow insertion of an IOL made of polymethyl methacrylate or a foldable acrylic lens, respectively. Cataracts were removed *via* irrigation and aspiration employing an ultrasonic emulsifier, after anterior continuous curvilinear capsulorhexis and hydrodissection. Three forms of cataract surgery were employed: IOL implantation in a bag and preservation of the posterior capsule (PC); optic capture after posterior continuous curvilinear capsulorhexis (PCCC); or IOL implantation in a bag after both PCCC and anterior vitrectomy. Before 1999 all patients underwent the first procedure. Beginning from 1999 all patients underwent the second or third procedure. Ethical approval was obtained by the Institutional Review Board of Maryknoll Medical Center, and the study conducted adhered to the Declaration of Helsinki.

Methods Patients with amblyopia received occlusion therapy after full correction of refractive errors for near as well as for distance postoperatively. Six-hour part time occlusion was done in the patients with BCVA <20/40, and 4-hour occlusion in the range of 20/40-20/25 was done according to BCVA immediately after surgery. Occlusion therapy was recommended until there was no further improvement in VA during 1 year. At the last follow-up of minimum 2 years after surgery, BCVA, the refractive error, and stereoacuity were measured. The Titmus test (Stereo Optical Inc., Chicago, IL, USA) was used to evaluate near stereopsis, and it was performed with near glasses or by adding +3.0 diopters (D) trial lenses on the pseudophakic eyes. Precautions were taken in the present study to ensure that the patients were perceiving true depth with Titmus test and not simply identifying one circle as different, in particular by inverting the test to reverse the disparity and checking that the stimulus changed from appearing in front of, to behind, the page. For all the patients with secondary cataracts, stereopsis was evaluated after Nd:YAG laser posterior capsulotomy or secondary optic capture. Anisometropia was defined as between-eye difference >1.25D in spherical equivalent. Postoperative strabismus was defined as an angle of deviation ≥10 prism diopters (PD).

Patients were divided into two groups based on the minimum value (100sec/arc) required for fine central useful stereopsis; group 1 had stereopsis values ≤100sec/arc and group 2 values >100sec/arc [13]. To identify the factors that influenced stereopsis, we selected ten parameters suggested, in earlier work, to be important in this respect, and analyzed the values in each goup. The ten factors were: Cataract types, preoperative BCVA of the affected eyes, preoperative inter-ocular difference of BCVA, age at the time of cataract surgery, operative method, secondary cataracts, postoperative strabismus, postoperative BCVA of the affected eyes, postoperative inter-ocular difference of BCVA, and anisometropia[5-11].

Statistical Analysis Pearson's Chi-square test was employed to compare discrete variables between groups. A two-sample *t*-test was employed to compare continuous variables such as age at surgery between the two groups. A *P*-value less than 0.05 was considered significant.

RESULTS

Of our 110 patients, 58 were male and 52 were female. The mean age at surgery was 5.4±2.3 years (range, 2-8 years; median, 5 years) and the mean follow-up period was 7.1 years (range, 2-14 years). The mean age at last follow-up was 11.6 (range, 5-21 years). The postoperative stereoacuity ranged from 70-800sec/arc. Group 1, with stereoacuity values ≤100sec/arc, contained 42 patients (38.2%), and group 2 (stereoacuity >100sec/arc) 68 (61.8%) (Figure 1). With respect to cataract type, posterior subcapsular cataract was the most common cataract type in both group 1 (45.2%) and in group 2 (39.7%). There was no statistically significant difference between the two groups in terms of the type of cataract (P=0.285, Table 1).

Preoperative BCVA of the affected eyes ranged from hand motion to 20/30. Patients were categorized into three groups according to preoperative BCVA of the affected eyes. The incidence of good stereopsis was the highest in the patients with VA ≥20/40 (46.4%). But this was not significant (P=0.294).

With respect to the inter-ocular difference of preoperative BCVA, good stereopsis was noted in 14 (46.7%) of 30 patients with difference <20/40, and 28 (35%) of 80 patients with difference ≥20/40. The inter-ocular difference of preoperative BCVA did not affect the extent of stereoacuity (P=0.262, Table 2).

The mean age at surgery was 5.4±2.4 years (range, 3-8 years) in group 1 and 5.0±2.2 years (range, 2-8 years) in group 2; this was not significant (P=0.519).

In 20 patients (18.2%), the PC was preserved when IOLs were implanted. Sixty patients (54.5%) underwent optic capture of the IOL after PCCC, whereas 30 (27.3%) underwent IOL implantation in a bag after both PCCC and anterior vitrectomy. There were no one in group 1 and 20 in group 2 (100%) of the patients who were treated using the first procedure. There were 24 patients (40%) in group 1 and 36 (60%) in group 2 of the patients who were operated by the second surgical method. There were 18 patients (60%) in group 1 and 12 in group 2 (40%) of the patients who were treated using the third method. The level of stereopsis was significantly associated with the operative method(P=0.000). Secondary cataracts developed in all 20 patients who underwent IOL implantation with preservation of the PC. Of

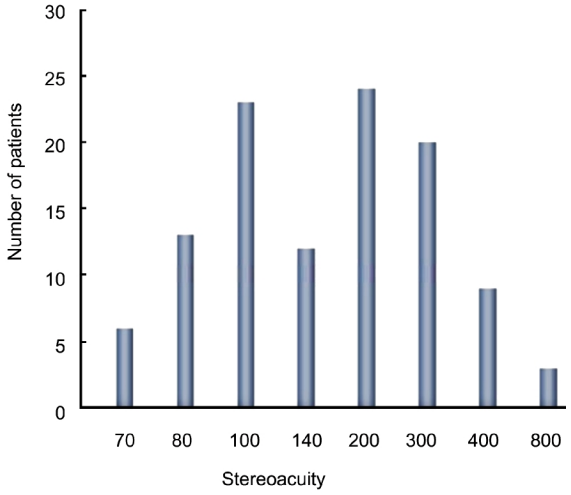

Figure 1 Distribution of stereoacuity of all patients.

Table 1 Associations of cataract types with stereoacuity *n*(%)

Cataract types	Group 1 (≤100sec/arc) *n*=42 (38.2)	Group 2 (>100sec/arc) *n*=68 (61.8)	*P*
Anterior subcapsular	13 (48.1)	14 (51.9)	0.285
Posterior subcapsular	19 (41.3)	27 (58.7)	
Nuclear	5 (41.7)	7 (58.3)	
Posterior polar	1 (14.3)	6 (85.7)	
Mature/Total	4 (22.2)	14 (77.8)	

Table 2 Associations of preoperative BCVA of the affected eye and inter-ocular difference of preoperative BCVA with stereoacuity *n*(%)

Factor	Group 1 (≤100sec/arc) *n*=42 (38.2)	Group 2(>100sec/arc) *n*=68 (61.8)	*P*
Preoperative BCVA			
-20/80	16 (42.1)	22 (57.9)	0.294
20/70-20/50	13 (29.5)	31 (70.5)	
20/40-	13 (46.4)	15 (53.6)	
Inter-ocular difference of preoperative BCVA			
<20/40	14 (46.7)	16 (53.3)	0.262
≥20/40	28 (35)	52 (65)	

BCVA: Best corrected visual acuity.

patients treated using optic capture or anterior vitrectomy, four and six, respectively, developed secondary cataracts. The preservation of PC affected the prevalence of after-cataracts (P=0.000). All 30 patients in whom secondary cataracts developed, underwent clearance of the visual axis at 2.2±1.7 years (range 2 months to 5 years) after cataract surgery. Thirteen (43.3%) underwent Nd:YAG laser posterior capsulotomy and 17 (56.7%) secondary optic capture after PCCC. Six of thirty secondary cataract patients (20%) were included in group 1 compared with 45% of the non-secondary cataract patients. Even after appropriate management for secondary cataract, a significant relationship was evident between the development of secondary cataracts and stereopsis (P=0.016, Table 3).

Postoperative strabismus developed in 6 of our 110 patients (5.5%). Among these six patients, two had exotropia of 30PD

Table 3 Associations of age at surgery, surgical methods, and secondary cataract with stereoacuity *n*(%)

Factor	Group 1 (≤100sec/arc) *n*=42 (38.2)	Group 2 (>100sec/arc) *n*=68 (61.8)	*P*
Age at surgery (a)	5.4±2.4	5.0±2.2	0.571
Surgical methods			
Intact PC	0 (0)	20 (100)	0.000
Optic capture through PCCC	24 (40)	36 (60)	
Anterior vitrectomy	18 (60)	12 (40)	
Secondary cataract			
(+)	6 (20)	24 (80)	0.016
(-)	36 (45)	44 (55)	

PC: Posterior capsule; PCCC: Posterior curvilinear continuous capsulorhexis.

and the other four exotropia of 20PD. None in the 6 patients with postoperative strabismus was included in group 1, and 42 of 104 patients (40.4%) without postoperative strabismus were included in group 1. The number of patients with bad stereopsis was about 1.7-fold greater in those with postoperative strabismus compared to patients with no such strabismus; this association was statistically significant (P=0.048, Table 4).

BCVA of the pseudophakic eyes after surgery ranged from 20/40 to 20/16. Patients were categorized into three groups according to postoperative BCVA. Thirty of 57 patients (52.6%) with postoperative BCVA of 20/20-20/16 were included in group 1. The next greatest incidence was noted in BCVA of 20/30-20/25, where 12 of 44 patients (27.3%) had good stereopsis. None of 9 patients with BCVA of 20/40-20/32 had good stereopsis. The level of postoperative BCVA and the extent of stereopsis were significantly associated (P =0.002). The inter-ocular difference of postoperative BCVA was between 0 and 20/40. There were 34 patients (38.6%) in group 1 and 54 (61.4%) in group 2 of the patients with difference by <20/70. There were 8 patients (36.4%) in group 1 and 14 (63.6%) in group 2 among the patients with difference by ≥20/70; this was not significant (P=0.524, Table 5).

Notably, in six patients with postoperative strabismus, postoperative BCVA ranged from 20/30 to 20/25, and postoperative inter-ocular difference of BCVA ranged from 20/70 to 20/40. These patients were all included in group 2, and had stereoacuity values of 600sec/arc (range, 400-800sec/arc), thus poorer than the mean value of 200.3sec/arc (range, 70-400sec/arc) and 189.6sec/arc (range, 70-400sec/arc) in the other patients with the same level of BCVA and inter-ocular difference of BCVA, respectively (P=0.006 and P=0.030, respectively).

The mean anisometropia was 0.9±0.7D (range 0-2.375D). When postoperative anisometropia was considered, there

Table 4 Associations of postoperative onset of strabismus with stereoacuity *n*(%)

Factor	Group 1 (≤100sec/arc) *n*=42 (38.2)	Group 2 (>100sec/arc) *n*=68 (61.8)	*P*
Strabismus			
(+)	0 (0)	6 (100)	0.048
(-)	42 (40.4)	62 (59.6)	

Table 5 Associations of postoperative BCVA of the affected eye and inter-ocular difference of postoperative BCVA with stereoacuity *n*(%)

Factor	Group 1 (≤100sec/arc) *n*=42 (38.2)	Group 2 (>100sec/arc) *n*=68 (61.8)	*P*
Postoperative BCVA			
20/40-20/32	0 (0)	9 (100)	0.002
20/30-20/25	12 (27.3)	32 (72.7)	
20/20-20/16	30 (52.6)	27 (47.4)	
Inter-ocular difference of postoperative BCVA			
< 20/70	34 (38.6)	54 (61.4)	0.524
≥20/70	8 (36.4)	14 (63.6)	

BCVA: Best corrected visual acuity.

Table 6 Associations of anisometropia with stereoacuity *n*(%)

Factor	Group 1 (≤100sec/arc) *n*=42 (38.2)	Group 2 (>100sec/arc) *n*=68 (61.8)	*P*
Anisometropia (D)			
≤1.25	34 (44.7)	42 (55.3)	0.034
>1.25	8 (23.5)	26 (76.5)	

D: Diopters.

were 34 patients (44.7%) in group 1 and 42 (55.3%) in group 2 of the patients with difference ≤1.25D. There were 8 patients (23.5%) in group 1 and 26 (76.5%) in group 2 of the patients with difference >1.25D. Anisometropia correlated positively with stereopsis (P=0.034, Table 6).

DISCUSSION

Stereopsis is important in enabling precise sensing of position and distance. Measurement of the extent of stereopsis can be used to evaluate the levels and response to treatment of strabismus and amblyopia, because stereopsis is fully acquired when visual function returns to normal[15].

Recent advances in surgical techniques and optical corrective methods for aphakia have greatly reduced the risk of amblyopia and have improved binocular visual function in children. However, distance and near fusion, and good stereoacuity ≤100sec/arc are difficult to achieve, even though the patients have good BCVA. This fact suggests that even a short period of visual deprivation caused by pediatric cataract or by occlusion to treat amblyopia may be sufficient to interrupt binocular vision development if it occurs before visual maturation[16].

In the present study, we found that the extent of stereoacuity was significantly associated with operative method,

development of secondary cataracts, or postoperative strabismus, postoperative BCVA of the affected eyes, and anisometropia.

In terms of the association of cataract type with stereoacuity, Kim and Plager [17] reported that posterior lenticonus was the most common type in the pediatric cataracts, and the type of cataracts was not related to the stereoacuity. We surveyed the patients with only developmental cataracts and excluded congenital cataracts, and found there was no relationship between cataract type and stereopsis.

It has not been reported previously about the effect of preoperative BCVA on stereoacuity. The age at surgery in our patients was 2 years or more. Thus, we could measure preoperative BCVA from all of them. There was no statistically significant difference in stereopsis between the two group with respect to preoperative BCVA.

During the last 40 years, much effort has been devoted to defining the critical period for development of binocular vision. Stereopsis occurs about 3 months after birth, matures rapidly between 8 and 18 months, and develops continuously (but gradually) until a child is at least 3 years of age[18]. Hosal *et al* [16] reported that visual acuity can attain 6/6 and that stereopsis develops to between 100 sec/arc and 200 sec/arc if surgery to remove congenital or acquired pediatric cataracts is performed between 44 and 96 months of age.

Daw [19] found that binocular vision develops before 24 months, and that good BCVA is important for retention of high-level fusion ability and stereoacuity. However, the mean age at cataract surgery in our present study was 5.4 ±2.3 years; surgery thus likely had little impact on stereoacuity.

Many surgeons prefer to perform PCCC with optic capture, or anterior vitrectomy after PCCC to decrease the incidence of after-cataracts in pediatric cataract [20]. Secondary cataracts prevent the maintenance of the clear visual axis, and can cause amblyopia. Amblyopia is reported to deteriorate the development of stereopsis[21].

Secondary cataracts occurred in all patients in whom the PC was preserved. In our cases, 8 of 30 patients with secondary cataracts had not been followed-up continuously, thus management for after-cataracts was delayed. Even after ND: YAG posterior capsulotomy or secondary optic capture, all patients who had preserved PC showed poor stereoacuity, *i.e.* >100sec/arc. The preservation of PC had impact on the prevalence of secondary cataracts. Therefore, either optic capture or anterior vitrectomy after PCCC may help improve postoperative stereoacuity by minimizing the risk of development of secondary cataracts.

Secondary strabismus is another reason which can negatively affect stereopsis after pediatric cataract surgery. Children with strabismus, extending beyond the Panum's area required for binocular vision, have low stereoacuity because they lack the ability to arrange the eyeballs to ensure that images are received at corresponding points on the retina of either eye[2]. Hosal *et al* [16] stated the presence of strabismus was the only contributable factor to good BCVA and binocular function. In our study, all the patients with postoperative strabismus had poor stereopsis, and this was significant.

Good levels of BCVA in pseudophakic eyes are also necessary to ensure high-level stereoacuity. Levy and Glick[22] found that adults with 20/20 visual acuity in both eyes exhibited a linear relationship between stereoacuity and visual acuity when visual acuity of only one eye varied. Goodwin and Romano[23] also stated that there is a statistically significant relationship between monocular degraded vision and stereoacuity using experimental fogging with a spherical lens. It was recognized that good vision is a prerequisite for developing high levels of stereopsis [16]. Lee and Isenberg[21] found that as BCVA improves with occlusion therapy for amblyopia, stereopsis also generally improves. In the present work, better stereopsis was evident in patients with good postoperative BCVA in pseudophakic eyes. However, the stereopsis level fell considerably when strabismus developed postoperatively compared with stereopsis in non-strabismus patients with the same level of BCVA or inter-ocular difference of BCVA. Therefore, we consider that onset of strabismus has a greater effect on stereopsis than does the level of postoperative BCVA or inter-ocular difference of BCVA. Kim and Plager [17] reviewed 38 children with unilateral pseudophakia and reported that stereopsis was better in absence of strabismus and in cases with a good postoperative vision.

Hayashi and Hayashi[3] and Lightholder and Phillips[8] found that the greater the extent of anisometropia, in patients with unilateral or bilateral aphakia or pseudophakia, the poorer was the stereoacuity of such patients. Lovasik and Szymkiw[24] also found that induced anisometropia caused a nonlinear loss of stereoacuity as measured by Titmus and Randot tests. We also found a positive relationship between anisometropia and the extent of stereoacuity. Thus, precise calculation of optic parameters guiding IOL selection for pediatric cataract patients is important to ensure appropriate stereopsis development.

In conclusion, subnormal stereopsis can be acquired after surgery to treat unilateral developmental cataracts when clear visual axis is achieved by either optic capture or anterior vitrectomy after PCCC, when secondary cataract or

strabismus does not develop postoperatively. Furthermore, high-level stereopsis can be attained when postoperative BCVA is high, and when the extent of postoperative anisometropia is low.

REFERENCES

1 Lambert SR, Drack AV. Infantile cataracts. *Surv Ophthalmol* 1996;40(6):427-458

2 Tytla ME, Lewis TL, Maurer D, Brent HP. Stereopsis after congenital cataract. *Invest Ophthalmol Vis Sci* 1993;34(5):1767-1773

3 Hayashi K, Hayashi H. Stereopsis in bilaterally pseudophakic patients. *J Cataract Refract Surg* 2004;30(7):1466-1470

4 Greenwald MJ, Glaser SR. Visual outcomes after surgery for unilateral cataract in children more than two years old. *J AAPOS* 1998;2(3):168-176

5 Suzuki R, Katayama T, Egi K. Binocular function in unilateral pseudophakia. *Jpn IOL Soc J* 1989;3:47-52

6 Kwapiszeski BR, Gallagher CC, Holmes JM. Improved stereoacuity: an indication for unilateral cataract surgery. *J Cataract Refract Surg* 1996;22(4):441-445

7 Laidlaw A, Harrad R. Can second eye cataract extraction be justified? *Eye* 1993;7(Pt 5):680-686

8 Lightholder PA, Phillips LJ. Evaluation of the binocularity of 147 unilateral and bilateral pseudophakic patients. *Am J Optom Physiol Opt* 1979;56(7):451-459

9 Highman VN. Stereopsis and aniseikonia in uniocular aphakia. *Br J Ophthalmol* 1977;61(1):30-33

10 Katsumi O, Tanino T, Hirose T. Effect of aniseikonia on binocular function. *Invest Ophthalmol Vis Sci* 1986;27(4):601-604

11 Katsumi O, Miyajima H, Ogawa T, Hirose T. Ansiseikonia and stereoacuity in pseudophakic patients; unilateral and bilateral cases. *Ophthalmology* 1992;99(8):1270-1277

12 Birch EE, Stager DR. The critical period for surgical treatment of dense congenital unilateral cataract. *Invest Ophthalmol Vis Sci* 1996;37 (8):1532-1538

13 Robb RM, Petersen RA. Outcome of treatment for bilateral congenital cataracts. *Ophthalmic Surg* 1992;23(10):650-656

14 Plager DA, Kipfer H, Sprunger DT, Sondhi N, Neely DE. Refractive change in pediatric pseudophakia: 6-year follow-up. *J Cataract Refract Surg* 2002;28(5):810-815

15 Hong SW, Park SC. Stereoacuity of normal subjects assessed by Fisby Davis Distance Stereotest. *J Korean Ophthalmol Soc* 2006;47(1):154-159

16 Hosal BM, Biglan AW, Elhan AH. High levels of binocular function are achievable after removal of monocular cataracts in children before 8 years of age. *Ophthlamology* 2000;107(9):1647-1655

17 Kim SH, Plager DA. Stereopsis in children with unilateral pseudophakia. *Br J Ophthalmol* 2009;93(3):333-336

18 Fawcett SL, Wang YZ, Birch EE. The critical period for susceptibility of human stereopsis. *Invest Ophthalmol Vis Sci* 2005;46(2):521-525

19 Daw NW. *Visual development* New York: Plenum Press, 1995:228

20 Apple DJ, Ram J, Foster A, Peng Q. Pediatric cataract. *Surv Ophthalmol* 2000;45(Suppl 1):S150-168

21 Lee SY, Isenberg SJ. The relationship between stereopsis and visual acuity after occlusion therapy for amblyopia. *Ophthalmology* 2003;110(11):2088-2092

22 Levy NS, Glick EB. Stereoscopic perception and Snellen visual acuity. *Am J Ophthalmol* 1974;78(4):722-724

23 Goodwin RT, Romano PE. Stereoacuity degradation by experimental and real monocular and binocular amblyopia. *Invest Ophthalmol Vis Sci* 1985;26(7):917-923

24 Lovasik JV, Szymkiw M. Effects of anisekonia, anisometropia, accommodation, retinal illuminance, and pupil size on stereopsis. *Invest Ophthalmol Vis Sci* 1985;26(5):741-750