

Secondary glaucoma after pediatric cataract surgery

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Received: 2012-11-09 Accepted: 2013-03-05

Abstract

• **AIM:** To determine the incidence and risk factors of secondary glaucoma after pediatric cataract surgery.

• **METHODS:** Two hundred and forty nine eyes of 148 patients underwent cataract surgery without intraocular lens (IOL) implantation (group 1), and 220 eyes of 129 patients underwent cataract surgery with IOL implantation (group 2) retrospectively, were evaluated between 2000 and 2011. The outcome measure was the presence or absence of post-cataract surgery glaucoma, defined as an intraocular pressure (IOP) ≥ 26 mmHg, as measured on at least two occasions along with corneal or optic nerve changes.

• **RESULTS:** The mean follow-up periods of group 1 and 2 were (60.86 \pm 30.95) months (12–123 months) and (62.11 \pm 31.29) months (14–115 months) respectively. In group 1, 12 eyes of 8 patients (4.8%) developed glaucoma. None of the patients developed glaucoma after surgery in group 2. The mean age of the patients at the cataract surgery was (2.58 \pm 0.90) months (1 month–4 months) and the average period for glaucoma development after surgery was (9.50 \pm 4.33) months (4–16 months) in group 1. Three of the 12 glaucomatous eyes were controlled with antiglaucomatous medication and 9 eyes underwent trabeculectomy+mitomycin C surgery. One patient underwent a second trabeculectomy+mitomycin C operation for both of his eyes.

• **CONCLUSION:** The incidence of glaucoma after pediatric cataract surgery is very low in patients in whom IOL is implanted. The aphakic eyes after pediatric cataract surgery are at an increased risk for glaucoma development particularly if they underwent surgery before 4 months of age.

• **KEYWORDS:** intraocular lens implantation; pediatric cataract; secondary glaucoma

DOI:10.3980/j.issn.2222-3959.2013.02.21

Şahin A, Çaça I, Cingü AK, Türkcü FM, Yüksel H, Şahin M, Çınar Y, Ari Ş. Secondary glaucoma after pediatric cataract surgery. *Int J Ophthalmol* 2013;6(2):216–220

INTRODUCTION

Secondary glaucoma development after pediatric cataract surgery is an important postoperative complication. The diagnosis and treatment of aphakic glaucoma is difficult. These children can remain asymptomatic, despite their high IOP^[1]. Early surgical interventions result in better visual outcomes in pediatric cataract cases^[2,3]. On the other hand, early pediatric cataract surgery increases the postoperative glaucoma incidence^[4,6]. There is a direct relationship between the time of cataract surgery or the necessity of after-cataract removal and the development of aphakic glaucoma which remains a matter of controversy^[7]. After pediatric cataract surgery the effect of an IOL implantation on the incidence of glaucoma is undetermined. In some reports the incidence of glaucoma is lower in patients who underwent IOL implantation in pediatric cataract surgery^[8,9]. Trivedi *et al*^[4] reported that IOL protects against glaucoma, and IOL implantation decreases the incidence of glaucoma after pediatric cataract surgery. In this study, we aimed to evaluate the incidence of secondary glaucoma after pediatric cataract surgery with and without IOL implantation.

SUBJECTS AND METHODS

Subjects The medical records of the patients who underwent pediatric cataract surgery in the Dicle University Medical Faculty Department of Pediatric Ophthalmology between January 2000 and December 2011 were evaluated. Patients were divided into two groups according to the simultaneous implantation of IOL as follows, group 1 (without IOL implantation) and group 2 (with IOL implantation).

Methods Exclusion criteria were a traumatic cataract, infection, steroid-induced cataract, congenital glaucoma, uveitis, optic nerve or other fundic abnormalities, retinopathy of prematurity, Lowe syndrome, microcornea, less than 12 months postoperative follow-up. Microcornea is defined as a horizontal corneal diameter of ≤ 10 mm at the time of surgery or ≤ 9.5 mm if measured in the first 4 months of life and it is believed by some to be an important predictor of post-cataract surgery glaucoma in children^[10,11]. These measures were chosen because they represent corneal

diameters at least 1mm less than the age-adjusted average for most ages^[11]. The diagnosis of glaucoma was made if the IOP was measured as ≥ 26 mmHg, combined with at least one of the following criteria; corneal edema or enlargement, optic nerve cupping (asymmetry >0.2 or cup-to-disk ratio >0.4), or abnormal asymmetric axial length elongation^[5,7]. The IOP was measured by Tonopen (Reichert Inc, Depev, NY, USA) on at least two occasions, either in the clinic or under general anesthesia in the operation room. The IOP was measured in most patients before or at the time of the cataract surgery, and an eye was excluded if the preoperative pressure was ≥ 22 mmHg or if there were other preoperative signs of glaucoma such as corneal enlargement, corneal clouding, or excessive optic nerve cupping as judged by the examining physician, or as documented by an optic nerve cup-to-disk ratio >0.4 or by an asymmetry between the eyes of ≥ 0.2 ^[12]. The ages, gender, family histories, follow-up duration, and the visual acuity before and after operation of the patients have been recorded. The details of the operation technique and the complications that occurred during and after operation have also been recorded.

All patients had an informed consent form signed by their parents or caregivers for the surgical procedure, data collection and the establishment of a database. All surgeries were performed by the same surgeon (IC). Cyclopentolate 1% and phenylephrine 10% eye drops were instilled to dilate the pupil before surgery. The eyes and surrounding adnexa were cleaned using a 5% and 10% povidone-iodine solution respectively. To the eyes cataract surgery without IOL implantation, a 3.2mm wide corneal tunnel incision was centered on the 12-o'clock position entrance to the anterior chamber. Then, the viscoelastic material was injected into the anterior chamber. An anterior continuous curvilinear capsulorhexis of 5.5mm diameter was performed with a capsulorhexis forceps. The nucleus and cortex were removed using a manual irrigation/aspiration device. The central posterior capsule was perforated and an anterior vitrectomy was performed with an anterior vitrectomy probe. Then by the use of a vitrectomy probe, a posterior capsulotomy was widened so that it enlarged to a diameter of 5mm. The cornea was sutured with a 10/0 monofilament nylon suture. Subconjunctival steroid and antibiotic injections were given, and a topical steroid/antibiotic combination was continued postoperatively. The bilateral cataracts patients, to whom the IOL wasn't implanted, were operated on the same session. The preparations for the second eye were done as if it was a new operation, to avoid the complications. The surgical crew was sterilized for second time and a new surgical operation set was used in the operation. The postoperative visual rehabilitation was started as soon as possible with aphakic contact lens correction. Patching for amblyopia was instituted by adhesive eye patches when indicated within one to two weeks after surgery.

The entrance to the anterior chamber was achieved with a scleral tunnel incision in 118 of 220 eyes that had cataract surgery done with an IOL implantation, and it was done by a corneal tunnel incision centered on the 12-o'clock position in the rest of the 102 eyes. The viscoelastic material was injected into the anterior chamber, and an anterior continuous curvilinear capsulorhexis of 5.5mm diameter was performed with a forceps. The lens material was aspirated with an irrigation/aspiration cannula. The central posterior capsule was perforated and the posterior vitrectomy was performed with an anterior vitrectomy probe. Then by the use of a vitrectomy probe, the posterior capsulotomy was widened so that it became a diameter of 5mm. The viscoelastic material was injected into the anterior chamber again. Then the implantation of a posterior chamber IOL in the capsular bag was performed. All of the implanted IOLs were AcrySof® (Alcon, Fort Worth, TX, USA). The MA30BA IOL was implanted in 115 eyes, the SA30AT in 57 eyes and the SN60AT in 48 eyes. The viscoelastic matter was cleaned by an irrigation/aspiration cannula. A 10/0 monofilament nylon suture was used to close the corneal tunnel incision or the scleral incision. The conjunctiva was closed with an 8/0 vicryl suture. Subconjunctival steroid and antibiotic injections were given, and a topical steroid/antibiotic combination continued postoperatively. In this group, the bilateral cases were operated on under separate sessions with an interval of 15 days.

Statistical Analysis The Statistical Package for Social Sciences (SPSS) 11.5 for Windows was used for the statistical analysis. Continuous variables between the groups were analyzed with Student's *t*-test and nominal variables were analyzed with Chi-square or Fischer's exact Chi-square test. A *P* value of less than 0.05 was accepted as statistically significant.

RESULTS

There were 249 eyes of 148 patients operated for pediatric cataracts without the implantation of an IOL (group 1), and 220 eyes of 129 patients were operated for pediatric cataracts with the implantation of an IOL (group 2). One hundred and one patients underwent bilateral, and 47 patients underwent unilateral cataract surgery in group 1 and 91 patients underwent bilateral and 38 patients underwent unilateral cataract surgery in group 2.

The mean follow-up period of the patients in group 1 was (60.86 \pm 30.95) months (12-123 months), whereas it was (62.11 \pm 31.29) months (14-115 months) in group 2 (*P*=0.66). The mean age of patients without and with IOL implantation were (8.04 \pm 5.90) months (1-22 months) and (46.55 \pm 19.66) months (24-96 months) respectively (*P*<0.0001).

In group 1, 12 eyes of the 8 patients (4.8%) developed glaucoma, but in group 2 none of the patients developed glaucoma after surgery. The development of glaucoma was

Table 1 Clinical characteristics of the patients with and without IOL implantation $\bar{x} \pm s$

	Aphakic eyes	Pseudophakic eyes	P
Number of eyes	249	220	-
Age of cataract surgery (mo)	8.04±5.90 (1-22)	46.55±19.66 (24-96)	<0.001
Mean follow-up period (mo)	60.86±30.95 (12-123)	62.11±31.29 (14-115)	0.66
Incidence of glaucoma development	12 (4.8%)	-	0.001
The mean age of cataract surgery in glaucoma developed patients (mo)	2.58±0.90 (1-4)	-	-
The mean age of diagnosis of glaucoma in aphakic eyes (mo)	9.50±4.33 (4-16)	-	-

mo: Month; IOL: Intraocular lens.

Table 2 Clinical characteristic of 12 aphakic eyes (8 patients) that developed glaucoma after pediatric cataract surgery

Number/ (Gender)	Cataract surgery age (mo)	Cataract Bilateral	Glaucoma diagnosed age (mo), Bilateral (B)	Max IOP (mmHg)	Cup to disc ratio	Glaucoma surgery performed	Latest follow-up (mo)
1/(M)	1	-	5	30	0.5	Trabeculectomy + Mitomycin C	25
2/(M)	2	+	8 (B)	33/43	OD 0.5 OS 0.7	Trabeculectomy + Mitomycin C (Bilateral)	65
3/(F)	3	+	16 (B)	37/47	OD 0.6 OS 0.7	Trabeculectomy + Mitomycin C (Bilateral)	48
4/(M)	3	-	4	32	0.5	---	56
5/(F)	4	+	12 (B)	40/36	OD 0.7 OS 0.6	Trabeculectomy + Mitomycin C (Bilateral)	77
6/(F)	2	+	6	28	0.4	---	98
7/(M)	3	-	14(B)	35/38	OD 0.7 OS 0.7	Trabeculectomy + Mitomycin C (Bilateral)	65
8/(F)	2	-	4	29	0.4	---	12

mo: Month; IOP: Intraocular pressure; M: Male; F: Female.

statistically significantly higher in group 1 than in group 2 ($P=0.001$). In patients who developed glaucoma, the mean age at the time of the cataract surgery was (2.58±0.90) months (1 month-4 months) and the average period for glaucoma development after surgery was (9.50 ±4.33) months (4-16 months) (Table 1).

Three of the 12 glaucomatous eyes were given antiglaucomatous medication and in these 3 eyes the IOPs were less than 21mmHg with the combination of a beta-blocker and dorzolamide eye drops (Table 2). Nine eyes that were unresponsive to medical treatment underwent a trabeculectomy + mitomycin C surgery. After surgery 5 eyes had an IOP under 21mmHg without medication at the follow-up. In 2 eyes the IOP could be reduced to under 21mmHg with the combination of a beta-blocker and dorzolamide eye drops. One of the patient's IOPs could not be reduced to under 35mmHg bilaterally in spite of antiglaucomatous medication and he underwent a second trabeculectomy + mitomycin C operation for both of his eyes. The IOPs were 20mmHg in both of his eyes with beta-blockers in the last visit (Table 2).

DISCUSSION

Pediatric cataracts constitute 10% of childhood blindness and may cause irreversible amblyopia without early diagnosis and intervention. However, early surgery in pediatric cataracts may cause postoperative glaucoma [1,4-7]. Two-thirds of children need 3 or more medications to control their IOP, but it is difficult to control secondary glaucoma after pediatric cataract surgery with medications. Also, pediatric aphakic

glaucoma surgery is very difficult to manage; however, glaucoma surgery is needed in many of the patients. In this group of patients there is a high failure rate with the trabeculectomy, with 50% requiring two or more surgeries to control their IOP [1]. In the present study, nine of the 12 aphakic eyes underwent surgery due to uncontrolled IOP with medications. Of them, in one eye of a patient, IOP was controlled after the second trabeculectomy. These findings indicate that a higher risk of glaucoma developed in early cataract surgery.

The mechanism of glaucoma formation after pediatric cataract surgery is not well understood. Lin and Wei [13] suggested that the filtration angle of the infant eye is susceptible to postoperative inflammation. The immaturity of the developing infant's angle leads to increased susceptibility to surgical trauma [7]. Simon *et al* [14] reported that the mechanical absence of a lens may induce aphakic glaucoma. Russell-Eggitt and Zamiri [15] have reported that early cataract surgery may interfere with the maturation of the trabecular meshwork ultra structure, leading to an increased lifetime risk of open-angle glaucoma. This could be explained by exposure of the immature trabecular meshwork to the factors such as the lens material or the vitreous and mechanical surgical trauma [7]. Phelps and Arafat speculated that a single underlying ocular syndrome is the cause of both the cataract and the post-cataract surgery glaucoma, or that the cataract surgery or postoperative state somehow cause the glaucoma [16]. None of our patients had infantile glaucoma prior to cataract surgery. However, an anterior vitrectomy was performed in

all patients. We suggest that both secondary angle closure due to vitreous gel and trabecular immaturity caused secondary glaucoma in our patients.

Gimbel *et al*^[17] reported an intact posterior capsule that might protect the angle from a toxic vitreous chemical. Rabiah^[5] reported that the primary posterior capsulotomy/ anterior vitrectomy was identified as a predictor of glaucoma. Some reports point an early surgery age as a risk factor for glaucoma in aphakic eyes^[4,6,18]. Trivedi *et al*^[4] reported that all of the patients who developed glaucoma underwent cataract surgery when they were 4.5 months or younger. Rabiah^[5] reported that glaucoma developed in 37% of the patients undergoing surgery at 9 months of age or younger and 6% of patients undergoing surgery thereafter. The same study also reported that the risk of glaucoma development in the patients that underwent pediatric cataract surgery before the age of 9 months was 3.8 times more than those who were operated on after the age of 9 months. Parks *et al*^[18] reported that the patients that underwent pediatric cataract surgery before 2 months of age without IOL implantation developed glaucoma at the rate of 54%. Kuhli-Hattenbach^[7] reported postoperative complications after pediatric cataract surgery in the first 18 months of life and they showed late-onset open-angle glaucoma as the most common complication (10.8%), whereas early-onset glaucoma was less common (4.6%). Vishwanath *et al*^[6] reported that the development of glaucoma was 50% in the patients that underwent pediatric cataract surgery before 1 month of age in a 5 year follow-up period but it decreased to 15% if these patients were operated on after 1 month of their lives. They proposed to perform pediatric cataract surgery after 4 weeks of age to reduce the postoperative complications. In our study, all of the patients that developed glaucoma after cataract surgery have been operated on with an age under 4 months. This result particularly indicates that the immaturity of the trabecular architecture in these infants may contribute the pathogenesis of secondary glaucoma after cataract surgery. In the present study, the patients who developed glaucoma after cataract surgery had a relatively smaller cornea, but normal for their age when compared to older infants, which may be a factor for challenging surgery and contributing to the pathogenesis of glaucoma development.

Some authors claimed that IOL implantation decreases the incidence of glaucoma after cataract surgery. Asrani *et al*^[9] reported only 1 case of glaucoma after primary intraocular lens implantation among 377 eyes, and 14 eyes (11.3%) with glaucoma among 124 aphakic eyes. They proposed that the IOL prevents toxic vitreous metabolites from entering the anterior chamber or that support for the trabecular meshwork is lost in aphakia. In the series of Trivedi *et al*^[4] 10 (3.8%) of 266 eyes with primary intraocular lens implantation were

diagnosed with glaucoma, whereas 8 (17.0%) of 47 aphakic eyes were diagnosed with glaucoma after pediatric cataract surgery. Yorston *et al*^[19] determined that glaucoma developed in 2 (1.7%) eyes in their series of 118 eyes with primary intraocular lens implantation. This suggests that IOL, in some way, is protective against glaucoma. However, these results should be interpreted with caution, as the eyes selected for primary IOL may be considered as "normal", and the eyes predisposed to secondary glaucoma may be excluded from the primary IOL implantation^[1]. In this study none of the patients developed glaucoma after surgery in the IOL implanted group. We don't exactly know that the high incidence rate of glaucoma development in our aphakic group related with absence of IOL or early age of operation or both. To understand these further prospective studies should be designed.

In a study it was reported that it may eventually be shown that cataract development in the first month of age is often associated with other ocular anomalies (especially angle structure anomalies) and, therefore, these patients are intrinsically at a higher risk for glaucoma development, irrespective of their age at surgery^[4].

On the contrary, Watts *et al*^[20] reported a reduced incidence of glaucoma in children who underwent congenital cataract surgery without IOL implantation before 2 weeks of age compared with those undergoing surgery at 2 to 12 weeks of age. Chen *et al*^[21] determined that the risk of aphakic glaucoma is similar regardless of the time of cataract surgery, if it is performed in the first year of life. This variability has been linked to the differences in the patient population, the type of cataract, the age at surgical correction, the definition of the glaucoma, and the length of the follow-up^[7]. In our study, the age at the surgery is also a confounding factor for IOL implantation versus aphakia, because invariably it is the younger patients are left aphakic.

Asrani *et al*^[9] noted that glaucoma was diagnosed at a mean interval of 12.2 years (146.4 months) after cataract surgery in their series but mentioned that glaucoma could occur at any time, from months to decades after cataract surgery. In our study, the mean interval of the diagnosis of glaucoma was 9.5 months after surgery. Compared to the report of Asrani and colleagues, our study has a shorter follow up period, which may result in a lower glaucoma incidence. The incidence of glaucoma in aphakic eyes has been reported as greater when patients were followed-up for longer periods^[22]. Swamy *et al*^[11] reported that secondary glaucoma can occur years after the initial operation, and the range in this series was 10 days to 16.8 years, highlighting the need for the lifelong surveillance of these children^[1]. The frequency of secondary glaucoma in pediatric cataract surgery varies, depending on the length of the follow-up^[4].

Secondary glaucoma after pediatric cataract surgery

Several reports have been documented the predictive factors to secondary glaucoma such as young age at the time of surgery, congenital anterior segment abnormalities, a family history of aphakic glaucoma, nuclear cataract [7], secondary membrane surgery, primary posterior capsulotomy/anterior vitrectomy, microcornea [1,5], and persistent hyperplastic primary vitreous [1]. None of our patients have risk factors other than a young age at the time of the surgery. Moreover, a posterior capsulorrhexis and anterior vitrectomy was performed in all patients in the study. However, the iridocorneal angle obstruction due to a prolapsed vitreous gel may contribute to the development of a secondary glaucoma after surgery.

In conclusion, secondary glaucoma is an important complication of pediatric cataract surgery. Particularly the patients operated on before 4 months of age without an IOL implantation are at higher risk and should be followed carefully. Further prospective studies including larger patient groups should be designed to understand the mechanisms and predictive factors of secondary glaucoma after pediatric cataract surgery.

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