KJO
pISSN: 1011-8942 eISSN: 2092-9382

Korean J Ophthalmol 2021;35(5):368-375
https://doi.org/10.3341/kjo.2020.0004

Original Article

The Effect of Secondary Intraocular Lens Implantation Time on Visual Prognosis in Aphakia Cases after Open Globe Injury

Nilay Kandemir Besek[1], Senay Asik Nacaroglu[1], Mehmet Onur Er[1], Ahmet Kirgiz[1], Fevziye Ondes Yilmaz[1], Burçin Kepez Yildiz[1], Mevlut Celal Ocal[2]

[1]*Department of Ophthalmology, Beyoğlu Eye Training and Research Hospital, University of Health Sciences, Istanbul, Turkey*
[2]*Department of Ophthalmology, Akcakale Public Hospital, Sanliurfa, Turkey*

Purpose: We investigated the effect of the time of secondary intraocular lens (IOL) implantation on final visual acuity and other causes affecting visual prognosis in cases left aphakic after open globe injury.

Methods: The study included 62 eyes of 62 patients left aphakic after the repair of open globe injury between 2012 and 2019. Demographic characteristics, trauma zone, ocular trauma score, type of injury, time of secondary IOL implantation, final best-corrected visual acuity (BCVA), and complications were recorded for each patient.

Results: The mean follow-up time of 62 patients was 25.05 ± 12.59 months. The preoperative BCVA was found to be 2.40 ± 0.86 logarithm of the minimum angle of resolution (logMAR), while the postoperative final BCVA was found to be 0.53 ± 0.70 logMAR ($p < 0.01$). The mean interval timing of secondary sulcus foldable IOL implantation was determined to be 3.79 ± 4.04 months. No correlation was observed between secondary IOL implantation time and final BCVA (r = 0.140, $p = 0.319$). Furthermore, when only pediatric patients were taken, an excellent positive correlation was found between the secondary IOL implantation time and final BCVA logMAR (r = 0.895, $p < 0.01$). Multiple linear regression on final BCVA with age, revealed a significant model explaining 48.0% of the variability with younger age and better final BCVA with as significant coefficients ($p = 0.007$).

Conclusions: Although time interval between primary repair and secondary IOL implantation to correct aphakia does not effect final BCVA in adult patients, earlier surgery should be considered for amblyopia management in pediatric patients.

Key Words: Aphakia, Eye injuries, Intraocular lenses, Trauma

Open globe injuries are one of the major causes of visual morbidity [1]. The main factors affecting visual prognosis are initial visual acuity, damage mechanism, central corneal injuries, traumatic cataract, retinal detachment, and posttraumatic endophthalmitis [2-4].

The involvement of lens and subsequent cataract represent the most frequently observed reasons for decreased vision in open globe injuries [5]. The timing of secondary intraocular lens (IOL) implantation in aphakia after traumatic cataract extraction is still a controversial issue [6]. Many studies have shown positive results of IOL implantation performed during primary repair [7,8]. At the same time, uveitis, synechia, pupillary block, retinal detachment,

Received: November 16, 2020 *Final revision:* July 4, 2021
Accepted: July 9, 2021

Corresponding Author: Nilay Kandemir Besek, MD. Department of Ophthalmology, Beyoğlu Eye Training and Research Hospital , University of Health Sciences, Bereketzade Cami Sokak No:2 Beyoglu, Istanbul, Turkey. Tel: 90-532-673-6093, Fax: 90-212-245-0948, E-mail: kandemirnilay@hotmail.com

and other posterior segment complications were reported as disadvantages of primary implantation [9-11]. Therefore, secondary IOL implantation is usually recommended. However, secondary IOL implantation delays visual rehabilitation, impairs binocular vision, and makes amblyopia management more difficult due to the resulting high anisometropia. Furthermore, if IOL implantation is delayed, the risk of strabismus development and the need for another surgery can make the situation more complicated [7,10,12]. Both methods have their advantages and disadvantages. The correct timing should be customized according to the patient's age, the condition of the eye at the time of admission, and complications developing after primary repair.

To the present time, it still remains unclear whether the timing of secondary IOL implantation in aphakia affects the visual outcome, and the topic is open to discussion because of the lack of research. In this study, we examined factors affecting visual prognosis, especially the time of implantation, in cases undergoing secondary IOL implantation.

Materials and Methods

This study was performed by retrospectively examining the clinical data of 62 eyes of 62 patients who had undergone secondary sulcus foldable IOL implantation due to aphakia after open globe injury in Beyoğlu Eye Training and Research Hospital between 2012 and 2019. Ethics committee approval (no. 1383) was obtained from Okmeydani Training and Research Hospital. After receiving a detailed description, all patients provided written informed consent for treatment. The principles of the Declaration of Helsinki were adhered to during the study process. Cases with eye pathologies that could adversely affect vision other than trauma such as iris defect, recurrent uveitis, and proliferative diabetic retinopathy, who had undergone eye surgery before the trauma, had a foreign body in the eye and the follow-up period less than 6 months were excluded from the study. Eyes without zonular dialysis and with sulcus support were included in the study. The critical age for amblyopia in children was reported as ≤10 [13]. We divided the time of secondary IOL implantation of the cases as under 10 years of age and above 10 years of age. All patients' slit lamp examination findings at the time of admission, ocular trauma score (OTS), trauma types, and uncorrected visual acuity measurements were recorded. The final best-corrected visual acuity (BCVA) on 12th months was examined with a Snellen chart before secondary IOL implantation. Visual acuity could not be measured in 1 cases since they were aged ≤4 years, and these cases were not included in statistical evaluation. Cases with visual acuity of 0.1 and above before secondary IOL implantation were included in the study. The final BCVA with the Snellen chart after secondary IOL implantation, slit lamp examination, intraocular pressure measurement with a Goldmann applanation tonometer, and dilated fundus examination were performed. The time of secondary IOL implantation, follow-up time, and postoperative complications were recorded. Kuhn et al. [14] described a trauma scoring system, which is named the OTS to predict the visual prognosis of patients with open globe injuries. The OTS was computed on the basis of the subject's initial visual acuity and according to whether globe rupture, endophthalmitis, perforating injury, afferent pupillary defect, and retinal detachment were present. The scores which previously described by Kuhn et al. [14], given according to the visual acuity of the patient at the time of trauma are shown in Table 1. Then, the OTS raw point was calculated by subtracting the value or the sum of the values corresponding to diagnosis, which matched the situation or situations in the b-f lines in Table 1 according to the severity of the trauma. The OTS raw point obtained to calculate the visual acuity of the patient after 6 months of follow-up was

Table 1. Computational method for deriving the ocular trauma score

Variable	Raw point
a. Initial visual acuity	
NLP	60
LP/HM	70
1 / 200–19 / 200	80
20 / 200–20 / 50	90
≥20 / 40	100
b. Rupture	-23
c. Endophthalmitis	-17
d. Perforating injury	-14
e. Retinal detachment	-11
f. RAPD	-10

Ocular trauma score calculation chart from Kuhn et al. [14].
NLP = no light perception; LP = light perception; HM = hand motions; RAPD = relative afferent pupillary defect.

Table 2. Characteristics of patients with secondary IOL implantation in open globe injury (n = 62)

Paramater		Value
Sex		
Male : female		50 (80.6) : 12 (19.4)
Age (yr), median (min–max)		
≤10, 7.00 (4–10)		16 (25.8)
>10, 34.50 (11–55)		46 (74.2)
Injured eye		
Right : left		32 (51.6) : 30 (48.4)
Children and adult/OTS raw points, median (min–max)*		
≤10 yr, 70 (56–90)		-
>10 yr, 56 (47–100)		-
OTS categories of all cases		
OTS raw points / OTS category		
0–44 / 1		-
45–65 / 2		29 (46.8)
66–80 / 3		27 (43.5)
81–91 / 4		5 (8.1)
92–100 / 5		1 (1.6)
Injury type		
Globe rupture		5 (8.1)
Penetrating injury		55 (88.7)
Perforating injury		2 (3.2)
Children and adult injury zone†		
≤10 yr	Zone I	11 (68.7)
	Zone II	2 (12.5)
	Zone III	3 (18.8)
>10 yr	Zone I	14 (30.4)
	Zone II	12 (26.1)
	Zone III	20 (43.5)

Values are presented as number (%) unless otherwise indicated.
OTS = ocular trauma score.
*$p = 0.026$, †$p = 0.027$.

matched with the OTS categories classified from 1 to 5 (Table 2).

The BETT (Birmingham Eye Trauma Terminology) [15] and the ocular trauma classification were utilized to define all injury types and injury zones. We performed the classification of the wound location as follows: zone I, isolated to the cornea, involving the corneoscleral limbus; zone II, limbus to a point 5 mm posterior into the sclera; or zone III, posterior to the anterior 5 mm of the sclera. Final BCVA values were converted to logarithm of the minimum angle of resolution (logMAR) for statistical analysis.

The corneal sutures of all patients were removed prior to the IOL dioptry measurement. The IOL dioptry measurement was calculated with the SRK/T formula using the optical biometry (Nidek AL-Scan; Nidek, Gamagori, Japan) device. It was calculated with ultrasonic biometry in patients in whom it could not be measured with the IOL Master device, and the SRK/T formula was used.

Surgical technique

The operation was performed by two experienced specialist surgeons. A temporal corneal incision was made with a 2.75-mm slit knife under local anesthesia. A viscoelastic (1% sodium hyaluronate; Provisc, Alcon Laboratories, Fort Worth, TX, USA) substance was administered to the anterior chamber. Posterior capsulorhexis was performed in all cases aged ≤10 years with an intact posterior capsule. Synechiolysis was performed in eyes developing synechiae between the iris and anterior capsule. The sulcus support was controlled 360 degrees and a 3-piece foldable IOL (Model MN60AC, Alcon Laboratories) was implanted to the sulcus with Monarch II IOL injector (Alcon Laboratories). The viscoelastic substance in the anterior chamber was cleaned. The surgery was terminated after the wounds were inflated and leak tightness was checked.

Statistics

All statistical analyses were performed with IBM SPSS Statistics ver. 22.0 (IBM Corp., Armonk, NY, USA). Distributions of the variables were measured by Kolmogorov-Smirnov test. Descriptive statistics included mean values ± standard deviation for normally distributed variables. Median (min–max) was used for variables without normally distributed. Categorical results were compared by Pearson chi-squared test (exact 2-sided). For repeated quantitative analysis, Wilcoxon signed-rank test was used. Spearman rank correlation was used to evaluate final visual acuity, secondary IOL implantation timing and other variables correlation. Multiple linear regression analysis was used to show between regression coefficient of the secondary IOL implantation time and the independent variables. A p-value <0.05 was considered statistically significant.

Results

In our study, 62 eyes of 62 patients left aphakic after open globe injury and undergoing secondary IOL implantation were included. Of them, 50 (80.6%) were males and 12 (19.4%) were females. The male : female ratio was 4.16. The mean follow-up time was 25.05 ± 12.59 months (12–64 months), patients 16 (25.8%) were younger than 10 years, and 46 (74.2%) patients were older than 10 years. The mean age of the patients was 27.82 ± 16.22 (average 4–67 years). There was zone I injury in 25 eyes (40.3%), zone II injury in 14 (22.6%) eyes, and zone III injury in 23 (37.1%) eyes. There was a penetrating trauma in 55 (88.7%) eyes, a perforating trauma in two (3.2%) eyes, and a blunt trauma in five (8.1%) eyes. The characteristics of patients with secondary IOL implantation in open globe injury were demonstrated in Table 2.

Timing of secondary IOL implantation

The mean time of secondary IOL implantation was 3.79 ± 4.04 months in 62 patients. The time of secondary IOL implantation in pediatric and adult patients is shown in Table 3.

Visual acuity

The preoperative BCVA was found to be 2.40 ± 0.86 logMAR, while the postoperative final BCVA was found to be 0.53 ± 0.70 logMAR ($p < 0.01$). The final BCVA was 0.55 ± 0.75 logMAR in 12 (19.4%) eyes with a central corneal scar, and it was 0.44 ± 0.52 logMAR in 50 (80.6%) eyes without a central corneal scar ($p = 0.818$). The visual outcomes after secondary sulcus IOL implantation and distrubition of visual acuity in terms of zones are presented in Table 4. Also means of visual acuity according to the zones were shown in Fig. 1 [15]. However, no correlation was observed between secondary IOL implantation time and final BCVA (r = 0.140, $p = 0.319$). A correlation between final BCVA and secondary IOL implantation timing and other variables were demonstrated in Table 5. Furthermore, when only pediatric patients were taken, an excellent positive correlation was found between the secondary IOL implantation time and final BCVA logMAR (r = 0.895,

Table 3. Timing of secondary IOL

	Age ≤10 yr	Age >10 yr	*p*-value
Timing of secondary IOL (mon)	3.07 ± 2.91, 2.26 (1–10.10)	3.21 ± 3.17, 2.00 (1–14.00)	0.079

Values are presented as mean ± standard deviation, median (min–max).
IOL = intraocular lens.

Table 4. Visual outcomes after secondary sulcus intraocular lens implantation

Paramater	Preoperative final BCVA (logMAR)	Postoperative final BCVA (logMAR)	*p*-value
≤10 yr	2.15 ± 0.94, 2.39 (3.00–0.70)	0.57 ± 0.76, 0.26 (3.00–0.00)	<0.01*
>10 yr	2.46 ± 0.83, 3.00 (3.00–0.10)	0.52 ± 0.69, 0.30 (3.00–0.00)	<0.01*
p-value	0.263	0.815	
Zone I	2.12 ± 0.94, 1.79 (3.00–0.10)	0.56 ± 0.83, 0.22 (3.00–0.00)	0.189
Zone II	2.49 ± 0.89, 3.00 (3.00–0.70)	0.42 ± 0.32, 0.40 (1.00–0.00)	
Zone III	2.58 ± 0.74, 3.00 (3.00–0.70)	0.55 ± 0.73, 0.30 (3.00–0.00)	
p-value	0.143	0.911	
With central corneal scar	2.40 ± 0.84, 3.00 (3.00–0.10)	0.55 ± 0.75, 0.30 (3.00–0.00)	<0.01*
Without central corneal scar	2.29 ± 1.00, 3.00 (3.00–0.70)	0.44 ± 0.52, 0.30 (1.80–0.00)	0.002*
p-value	0.964	0.818	

Values are presented as mean ± stadard deviation, median (min–max).
BCVA = best-corrected visual acuity; logMAR = logarithm of the minimum angle of resolution.
*Statistically significant ($p < 0.05$).

$p < 0.01$). Multiple linear regression on final BCVA with age, corneal astigmatism, secondary IOL implantation time, injury type and injury zone was performed. This revealed a significant model explaining 48.0% of the variability with younger age and better final BCVA with as significant coefficients ($p = 0.007$).

Complications

Our postoperative complications were the cellular reaction in the anterior chamber in six eyes (9.6%), temporary intraocular pressure elevation in three eyes (4.8%), drug-controllable intraocular pressure elevation in three eyes (4.8%), and central corneal scar 12 eyes (19.4%). There were no retinal detachment or endophthalmitis.

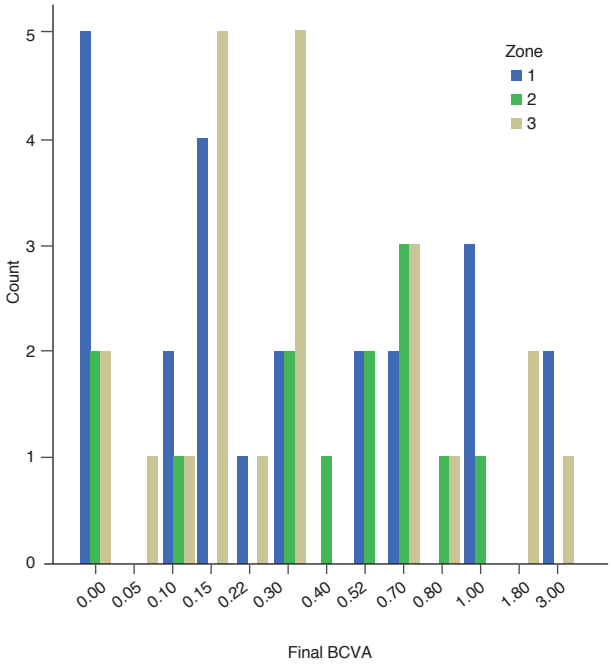

Fig. 1. Showing the means of final best-corrected visual acuity (BCVA; logarithm of the minimum angle of resolution) according to the traumatic zones. BETT (Birmingham Eye Trauma Terminology) from Kuhn et al. [15].

Discussion

Insufficient capsule support, a ruptured anterior and/or posterior capsule, irregular pupil dilation, zonular fiber loss, and posterior synechiae may complicate IOL implantation in traumatic patients. There is a higher risk of developing synechia between the anterior capsule and the iris after cataract extraction in traumatic patients, and it may be necessary to perform synechiolysis when carrying out secondary IOL implantation [16]. It is crucial to comply with treatment and follow-up to choose the proper timing for secondary IOL implantation [16,17]. The most discussed subjects in this type of cases are the timing of removing cataract and IOL implantation. It has been reported that secondary IOL implantation planned after the inflammation of the eye decreases after primary repair can give an idea about visual prognosis [16]. Rumelt and Rehany [16] reported that IOL implantation time did not effect postoperative visual acuity in adult patients and the IOL implantation timing should be decided individually for every patient and with the surgeons experience. To the best

Table 5. Secondary IOL implantation timing and other variables correlation in all cases

	Final BCVA (logMAR)	Age (yr)	Timing of secondary IOL implantation (mon)	OTS categories	OTS raw point	Corneal scar	Zone
Final BCVA							
r	1.00	0.065	0.204	-0.256	-0.223	-0.102	0.035
p-value		0.627	0.143	0.056	0.099	0.577	0.792
Timing of secondary IOL implantation							
r	0.204	0.322	1.00	-0.108	-0.162	0.140	0.055
p-value	0.143	0.017*		0.451	0.256	0.459	0.692

IOL = intraocular lens; BCVA = best-corrected visual acuity; logMAR = logarithm of the minimum angle of resolution; OTS = ocular trauma score.
*Statistically significant ($p < 0.05$).

of our knowledge the only study in the literature about secondary IOL implantation time in aphakic cases that open globe injury was performed by He et al. [6]. They reported that 2.8 months between vitrectomy and secondary IOL implantation was an appropriate and safe time interval to correct aphakia in patients undergoing pars plana vitrectomy after open globe injury and it would be more correct to make an IOL implantation decision based on the anatomical and functional status of the retina after pars plana vitrectomy. He et al. [6] reported that the duration between vitrectomy and secondary IOL implantation was not significant in terms of visual rehabilitation in aphakia. In this study, after eliminating the problems that may adversely affect the surgery, such as the removal of corneal sutures, improvement of corneal biomechanics, and the reduction of inflammation, our time to perform IOL implantation can be stated as 3.79 months. During the postoperative period, there was an increase in final BCVA and IOL was centralized in all cases. Similarly in our study, timing of secondary IOL implantation was found to not effect the visual prognosis in adult patients.

There are also studies reporting that the age of the patient is the most important factor affecting visual prognosis [18]. Rumelt and Rehany [16] suggested that surgery delay in children may result in a poor visual outcome, despite a good anatomical outcome. Sen et al. [17] reported that the risk of developing strabismus increases if the timing for IOL implantation is delayed. Therefore, it may be appropriate to perform secondary IOL implantation earlier in pediatric patients. Although secondary IOL implantation is recommended in the early period to prevent amblyopia in children, it has been reported that complications caused by intense postoperative inflammation may increase the number of subsequent surgeries [19,20]. However, in late surgeries, besides the risk of amblyopia, it may become difficult to put IOLs in the proper position, especially due to adhesions formed between the iris and anterior capsule. Therefore, each case should be evaluated under his/her own conditions, and the timing of surgery should be customized for the patient [20]. All of the pediatric cases were followed up by our pediatric ophthalmology unit in the postoperative period, and amblyopia treatment was performed meticulously. In this study a statistically significant difference was not found between outcome and secondary IOL implantation timing in pediatric and adult patients. OTS raw point value and zone III trauma was significantly higher in pediatric patients compared to adult patients. According to the multiple linear regression analysis visual acuity increased with younger age. Domestic injury is more common in pediatric cases, while in adult cases, injury due to work accident is more common this may explain the greater severity of injury in adult cases.

The anatomical and functional outcomes of secondary IOL implantation after open globe injury depend on the degree and severity of the initial injury. Studies in the literature have shown that OTS and initial visual acuity confirmed the effectiveness in predicting the visual prognosis [21,22]. Guven et al. [23] reported the rate of OTS category 1 and 2 cases with poor functional prognosis as 69.3%. In this study, 90.3% of the cases were OTS 2 and 3. There was a negative correlation between final BCVA logMAR and OTS raw point in adult patients. No correlation was found between OTS and final BCVA logMAR in pediatric patients.

There is a correlation between poor BCVA in open globe injury and the larger zone of the injury [24], and zone III has been shown to be a poor prognostic factor [23,25]. Smith et al. [26] reported that zone I injury was more common in penetrating injuries, and globe rupture patients mostly had zone III injury. They reported that the poor visual prognosis in zone II and zone III injury may be due to injury extending to posterior segment. Chuang et al. [27] reported that 30 eyes, 63.3% with zone I and 36.7% with zone II injury, 17 eyes (56.7%) obtained final BCVA of 20 / 40 or better which they performed secondary IOL implantation after open globe injury. In this study, we had 23% of patients with zone III, and although the visual acuity of these patients was found to be clinically low compared to zone I and II, we did not find a correlation between the final BCVA and the zone. Cases with retinal involvement were not included in this study may explain why there was no statistically significant difference between final BCVA logMAR in zone I, zone II and zone III.

Chuang et al. [27] showed that central corneal scar, glaucoma, macular pucker, and retinal detachment among the leading causes of not being able to provide an increase in vision with secondary IOL implantation after open globe injury. They reported that the most common cause of a BCVA worse than 20 / 40 is a corneal scar affecting the visual axis. Similarly, Weinand et al. [28] suggested that the major cause of limited visual acuity was central corneal scarring. Sen et al. [17] showed that the corneal lacera-

tions involving the central 3.0 mm of the cornea were the reason for not achieving the desired refractive results in their studies. However, they reported the central corneal scar was not found to be a poor prognostic factor in that study. In another study, it was statistically confirmed that the main factor affecting visual prognosis was the central corneal injury and retinal detachment [16]. In this study, they had a small number of patients with corneal scar and did not include patients who required a pars plana vitrectomy; which may account for why there was no correlation found between final BCVA and corneal scars.

The limitations of our study were its retrospective design, being noncomparative and nonrandomized, and including only sulcus-implanted eyes.

In conclusion, there is currently no definite information about the timing of secondary IOL implantation after open globe injury. In order to prevent amblyopia in pediatric patients, IOL implantation may be preferred with lens aspiration in the same session or as soon as possible. Especially after the detection of increased visual acuity with aphakia correction in adult patients. According to the results of this study, if there was a sulcus support in cases left aphakic after open globe injury, secondary IOL implantation was found to be safe after 3.79 months in cases. The fact that OTS raw point values are higher and zone III involvement is less likely in pediatric patients, with postoperative intensive amblyopia management visual prognosis can be good with secondary IOL implantation. However, further studies with larger numbers of participants are necessary before any conclusions can be drawn.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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