Original Article

Refractive and visual outcomes of traumatic cataract surgery: a ten-year perspective

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ABSTRACT

Background: Traumatic cataract is a major consequence of penetrating and blunt ocular injuries, often requiring surgical intervention. We evaluated the visual and refractive outcomes of traumatic cataract surgery and intraocular lens (IOL) implantation in adults who sustained open- or closed-globe injuries.

Methods: Patients who underwent cataract surgery and IOL implantation due to closed or open eye injuries were included in this descriptive-analytical, retrospective, case-series study. Eligible patients were scheduled for re-evaluation and a complete ocular re-examination, and individuals who returned and had a follow-up of at least 6 months were ultimately recruited. Because the accuracy of IOL power calculation was a primary outcome, patients who were left aphakic were excluded. Medical records were also reviewed to document baseline data, surgical details, and complications.

Results: We included 72 eyes of 72 patients with a mean (standard deviation [SD]) age of 39.5 (13.6) years and a male-to-female ratio of approximately 6:1. Forty-one (56.9%) eyes sustained open-globe injuries and 31 (43.1%) closed-globe injuries. The mean (SD) initial best-corrected distance visual acuity (BCDVA) was 1.1 (0.6) logarithm of the minimum angle of resolution (logMAR) and improved significantly to 0.3 (0.3) logMAR at the final visit ($P < 0.001$). A final BCDVA better than 20/40 was detected in 43 (59.7%), 23 (74.2%), and 20 (48.8%) eyes in the entire series, eyes sustaining closed-globe injuries, and those with open-globe injuries, respectively. The absolute prediction error was 1.0 diopter or less in 42 (58.3%) eyes in the entire series. A mean absolute prediction error of 1.0 D or less was more frequent in closed-globe than in open-globe injuries (n = 22 [71.0%] vs. n = 20 [48.8%], respectively). The mean absolute prediction error differed significantly between groups ($P < 0.05$). Eyes that sustained open-globe injury were less likely to obtain a BCDVA better than 20/40 (odds ratio, 0.33; 95% confidence interval, 0.12 – 0.91; $P < 0.05$).

Conclusions: Visual acuity significantly improved after traumatic cataract extraction with IOL implantation. Most cases achieved satisfactory visual and refractive outcomes. Eyes with open-globe injuries might have less favorable visual prognosis. These initial findings must be confirmed through large-scale, multi-center longitudinal studies.

KEYWORDS

cataracts, trauma, open-globe injury, closed-globe injury, intraocular lenses, intraocular lens implantations, prognoses, prognostic factors

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INTRODUCTION

Ocular trauma is a major cause of monocular blindness worldwide, particularly in developing countries [1]. Traumatic cataract, a substantial consequence of ocular injuries, occurs in 26–65% of cases [2, 3]. Both penetrating and blunt ocular injuries can lead to the development of traumatic cataracts, which often necessitate surgical intervention [4].

Despite modern advancements in cataract surgery, managing traumatic cataracts presents a challenge for ophthalmologists. Several factors can complicate traumatic cataract surgery, including posterior capsular tears, zonulolysis, iris defects, and poor vision [5]. Additionally, accurately calculating the power of the intraocular lens (IOL) can be difficult in these cases, as reliable keratometry may be difficult to obtain with a traumatized and irregular cornea. Furthermore, in some cases, the absence of adequate capsular support prevents the placement of IOLs in the capsular bag [5, 6]. Concomitant injuries, such as corneal scarring and retinal detachment, can also impact visual and refractive outcomes [7].

Although many recent studies have focused on the outcomes of traumatic cataract surgery in pediatric populations [8-10], less research has examined these outcomes in adults [7, 11]. The purpose of this study was to describe the refractive and visual outcomes of traumatic cataract surgery with IOL implantation and to evaluate the potential factors influencing these outcomes in adults.

METHODS

This descriptive-analytical, retrospective, case-series study recruited individuals with traumatic cataracts who underwent cataract surgery with IOL implantation in a tertiary referral center, Tehran, Iran, between January 2010 and December 2020. The study protocol received approval from the regional ethics committee. The study followed the tenets of the Declaration of Helsinki, and written informed consent was obtained from all included patients.

We reviewed the original medical records of patients with traumatic cataracts during the ten-year interval, and adults aged >18 years who underwent traumatic cataract surgery with IOL implantation were selected. Files with absent variables or failing to verify a history of trauma were excluded. All eligible patients were scheduled for re-evaluation, and individuals who returned for re-examination and had a follow-up of at least 6 months were ultimately recruited. Because the accuracy of IOL power calculation was a primary outcome, patients who were left aphakic were excluded.

The medical information retrieved included demographic data, laterality of the traumatized eye, type of injury (closed- or open-globe), zone of injury in open-globe trauma, visual acuity at the first examination (converted to logarithm of the minimum angle of resolution [logMAR] notation), type of surgical intervention (either combined with primary repair or delayed), use of the same or fellow-eye keratometry reading for IOL power calculation, presence of posterior capsule rupture, implantation of capsular tension rings during cataract surgery, the IOL implantation position (either in the bag, sulcus, or iris-clipped anterior chamber) [5], time interval between primary repair and cataract surgery in open-globe injuries, complications, and follow-up duration.

For all individuals, IOL calculation was performed using third-generation IOL formulas (SRK/T, Hoffer Q, and Holladay) [12, 13] using IOLMaster 500 (Carl Zeiss Meditec, Germany) or ultrasound biometer (Pacscan 300A; Sonomed Inc., Chicago, IL, USA). Keratometry (measured using IOLMaster 500) of the traumatized eye was used for IOL measurements if possible; otherwise, keratometry of the fellow eye was utilized.

Eligible individuals returned for a complete ophthalmic examination including refraction, evaluation of uncorrected and best-corrected distance visual acuities (UCDVA and BCDVA, respectively) using a Snellen chart (Snellen Chart Projector, CP-770; NIDEK, Japan) with values converted to logMAR notation, intraocular pressure measurement using Goldmann applanation tonometry (Haag-Streit, Koeniz, Switzerland), slit-lamp examination (BQ 900, Haag-Streit), and dilated fundoscopy under a slit lamp using a 78-diopter auxiliary lens (Volk Optical Inc., Mentor, OH, USA). Visual acuities using finger counting and hand motion were converted to logMAR values of 1.7 and 2.0, respectively [14, 15].

Initially, an auto-kerato-refractometer (KR-800; Topcon Co., Tokyo, Japan) was used to conduct both manifest and cycloplegic refractions 30 min after the application of 1% tropicamide (Mydrax 1%; Pharma Sina Darou, Tehran, Iran). Results were then subjectively refined. If we were unable to perform autorefraction, manual retinoscopy was conducted using a streak retinoscope (Heine Beta 200; HEINE Optotechnik, Herrsching, Germany) for both manifest and cycloplegic refraction, with the results subjectively refined. To calculate the spherical equivalent of the refractive error in diopters (D), the spherical component of the refractive error was added to half of the cylindrical component. The mean absolute prediction error was computed as the absolute difference between the final spherical equivalent and the refractive target (which assumed emmetropia) [16].

Injuries were classified as closed- or open-globe using the Birmingham Eye Trauma Terminology [17]. The zone of injury in open-globe trauma was determined based on the International Ocular Trauma Classification Group: Zones I, II, and III were defined as injuries limited to the cornea, injuries confined to the anterior 5 mm of the sclera, and injuries extending more than 5 mm posteriorly from the limbus, respectively [18].

In eyes that sustained open-globe injuries, those with a substantial mature cataract or ruptured anterior capsule with lens material extruded into the anterior chamber underwent lensectomy and IOL implantation at the time of primary repair of corneal laceration. In other cases, a two-step surgical approach was performed, and traumatic cataract surgery was performed a few months after primary repair when the visual acuity had diminished, or based on the patient's desire and the discretion of the managing ophthalmologist after detailed ocular examination.

Surgeries were performed under general anesthesia or monitored anesthesia care [19]. All cases underwent phacoaspiration/phacoemulsification or lensectomy using a vitrectomy probe through a limbal incision, as detailed in the literature [5, 20, 21]. In brief, anterior vitrectomy was performed when vitreous loss was determined. A standard one-piece IOL (RUBY IOL, Hydrophobic Acrylic Aspheric; Abzar Teb Pouya Co., Qom, Iran) was primarily implanted into the capsular bag. In cases with inadequate capsular support, a hydrophobic acrylic three-piece IOL (MA60AC, Alcon Co., Switzerland) was implanted into the ciliary sulcus, or an iris-clipped IOL (Artisan®) was used based on the discretion of the managing ophthalmologist [22-25].

Statistical analysis was performed using IBM SPSS version 21.0 for Windows (IBM Corp., Armonk, NY, USA). The normality of data distribution was determined using the Shapiro – Wilk test. Data are expressed as mean (standard deviation [SD]) or median (range) for continuous variables, and as frequency (percentage) for categorical variables. The Mann – Whitney U test and chi-square/Fisher's exact test were used to compare continuous and categorical variables, respectively, between eyes that sustained closed- and open-globe injuries. The Wilcoxon test was used for comparison of baseline and postoperative BCDVA. Binary logistic regression was applied to determine the factors affecting the final visual acuity and refractive outcome. A P-value less than 0.05 was considered statistically significant.

RESULTS

The demographic and clinical characteristics of 72 pseudophakic eyes of 72 eligible patients, all with unilateral traumatic cataract, are summarized in Table 1. The mean (SD) patient age was 39.5 (13.6) (range: 21 to 68) years, and the male-to-female ratio was approximately 6:1. Forty-one (56.9%) eyes sustained open- and 31 (43.1%) eyes closed-globe injuries. Most eyes with open-globe trauma had zone 1 involvement (n = 36, 87.8%). Individuals with open- and closed-globe injuries were comparable in terms of age, sex ratio, laterality of involved eye, and follow-up duration (all $P > 0.05$) (Table 1).

In eyes with open-globe injury, 37 (90.2%) underwent cataract surgery and IOL implantation at least 3 months after primary repair, and in 4 eyes (9.8%), cataract surgery was performed in conjunction with primary repair. In eyes with open-globe injury, keratometry of the traumatized eye was used for biometry in 35 (85.4%) eyes, and in the remaining 6 (14.6%) eyes, keratometry of the fellow eye was used because of the irregular cornea of the traumatized eye. However, in all eyes with closed-globe injury, keratometry of the traumatized eye was used for biometry ($P < 0.05$) (Table 1). The frequencies of complications, cataract surgery types, positions of IOL implantation, posterior capsule rupture, and severe zonulysis requiring a capsular tension ring were comparable between the two groups (all $P > 0.05$) (Table 1). In all eyes, a non-toric IOL was implanted.

The mean (SD) initial BCDVA (1.1 [0.6] logMAR) improved significantly to 0.3 (0.3) logMAR at the final visit ($P < 0.001$), in the entire series. Forty-three eyes (59.7%) attained a BCDVA better than 20/40 at the final follow-up visit, and only 3 eyes (4.2%) obtained a BCDVA worse than 20/200 (Table 2) due to macular scar. The mean (SD) absolute mean deviation from emmetropia was 1.1 (0.8) D in all eyes. A mean absolute prediction error of 1.0 D or less was more frequent in closed-globe than in open-globe injuries (n = 22 [71.0%] vs. n = 20 [48.8%], respectively) (Table 2).

One (3.2%) eye with closed-globe injury and 6 (14.6%) eyes with open-globe injury displayed a mean absolute prediction error of more than 2 D. The final mean BCDVAs were comparable between the groups of eyes with closed- and open-globe injuries ($P > 0.05$); however, the mean absolute prediction error differed significantly between groups ($P < 0.05$) (Table 2).

Potential factors affecting the refractive and visual outcomes were analyzed, as presented in Table 3. None of these (injury type [open- vs. closed-globe injury], laterality of eye used for keratometry [traumatized vs. fellow eye], and lens position [capsular bag vs. non-capsular bag]) significantly contributed to a worse refractive outcome, defined as a mean absolute prediction error of 1 D or more (Table 3).

Evaluating similar potential factors revealed that open-globe injury was associated with poorer visual outcome; eyes with open-globe injury were 70% more likely to achieve a BCDVA of 20/40 or worse than eyes that sustained closed-globe injury (odds ratio, 95% confidence interval: 0.33 [0.12 – 0.91]; $P < 0.05$). However, other factors (IOL position [capsular bag vs. non-capsular bag] and laterality of eye used for keratometry [traumatized vs. fellow eye]) did not significantly influence the visual outcome (both $P < 0.05$) (Table 3).

Table 1. Demographic and clinical characteristics of study participants

Variables	Total (n = 72)	Closed-globe injury (n = 31)	Open-globe injury (n = 41)	*P*-value
Age (y), Mean ± SD, Median (Range)	39.5 ± 13.6, 34.5 (21 to 68)	40.6 ± 14.9, 41 (21 to 68)	38.7 ± 12.6, 34 (22 to 62)	0.567
Sex (Men / Women), n (%)	61 (84.7) / 11 (15.3)	24 (77.4) / 7 (22.6)	37 (90.2) / 4 (9.8)	0.188
Laterality (Right eye / Left eye), n (%)	32 (44.4) / 40 (55.6)	11 (35.5) / 20 (64.5)	21 (51.2) / 20 (48.8)	0.234
Zone of injury (I / II / III), n (%)	36 (87.8) /4 (9.8) /1 (2.4)	-	36 (87.8) / 4 (9.8) / 1 (2.4)	-
Follow up duration (m), Mean ± SD, Median (Range)	42.6 ± 23.0, 46 (7 to 84)	43.5 ± 25.1, 49 (7 to 84)	41.8 ± 21.5, 45 (10 to 81)	0.645
Cataract surgery type (Combined with primary repair / Delayed), n (%)	4 (5.6) / 68 (94.5)	0 (0.0) / 31 (100.0)	4 (9.8) / 37 (90.2)	0.129
Using CTR, n (%)	6 (8.3)	4 (12.9)	2 (4.9)	0.392
Posterior capsule rupture, n (%)	19 (26.4)	7 (22.6)	12 (29.3)	0.596
IOL position (Bag / Sulcus / Iris-clipped), n (%)	53 (73.6) / 16 (22.2) / 3 (4.2)	24 (77.4) / 5 (16.1) / 2 (6.5)	29 (70.7) / 11 (26.8) / 1 (2.4)	0.428
Keratometry (Traumatized eye / Fellow eye), n (%)	66 (91.7) / 6 (8.3)	31 (100) / 0 (0.0)	35 (85.4) / 6 (14.6)	**0.029**
Complications, n (%)				0.802
Glaucoma	5 (6.9)	2 (6.5)	3 (7.3)	
RRD	2 (2.8)	1 (3.2)	1 (2.4)	
IOL dislocation/subluxation	4 (5.6)	1 (3.2)	3 (7.3)	
PCO	16 (22.2)	8 (25.8)	8 (19.5)	
Total	22 (30.1)	10 (32.3)	12 (29.3)	

Abbreviations: n, number of eyes; y, years; SD, standard deviation; m, month; CTR, capsular tension ring; IOL, intraocular lens; RRD, rhegmatogenous retinal detachment; PCO, posterior capsule opacification. Note: *P*-value < 0.05 is shown in bold; *P*-value is derived from Mann–Whitney U test or chi-square/Fisher's exact test; Closed- or open-globe injury, Injuries were classified as closed- or open-globe using the Birmingham Eye Trauma Terminology [17]; Zone I, II, and Zone III, The zone of injury in open-globe trauma was determined based on the International Ocular Trauma Classification Group: Zones I, II, and III were defined as injuries limited to the cornea, injuries confined to the anterior 5 mm of the sclera, and injuries extending more than 5 mm posteriorly from the limbus, respectively [18]; Bag, IOL implantation in capsular bag; Sulcus, IOL implantation in sulcus; Iris-clipped, iris-clipped anterior chamber IOL (Artisan®).

Table 2. Visual and refractive outcomes of study participants

Variables	Total (n = 72)	Closed-globe injury (n = 31)	Open-globe injury (n = 41)	*P*-value
Final BCDVA (logMAR)				
Mean ± SD	0.3 ± 0.3	0.2 ± 0.3	0.3 ± 0.3	0.247
Better than 20/40, n (%)	43 (59.7)	23 (74.2)	20 (48.8)	0.073
20/200 – 20/40, n (%)	26 (36.1)	7 (22.6)	19 (46.3)	
Worse than 20/200, n (%)	3 (4.2)	1 (3.2)	2 (4.9)	
Final absolute prediction error (D)				
Mean ± SD	1.1 ± 0.8	0.8 ± 0.7	1.2 ± 0.8	**0.020**
Below 0.5 D, n (%)	19 (26.4)	11 (35.5)	8 (19.5)	0.304
0.51 – 1.0 D, n (%)	23 (31.9)	11 (35.5)	12 (29.3)	
1.01 – 1.5 D, n (%)	17 (23.6)	6 (19.4)	11 (26.8)	
1.51 – 2.0 D, n (%)	6 (8.3)	2 (6.5)	4 (9.8)	
Above 2.0 D, n (%)	7 (9.7)	1 (3.2)	6 (14.6)	

Abbreviations: n, number of eyes; BCDVA, best-corrected distance visual acuity; logMAR, logarithm of the minimum angle of resolution; SD, standard deviation; D, diopters. Note: *P*-value < 0.05 is shown in bold; *P*-value is derived from Mann–Whitney U test or chi-square/Fisher's exact test; Closed- or open-globe injury, Injuries were classified as closed- or open-globe using the Birmingham Eye Trauma Terminology [17]; Absolute prediction error, The mean absolute prediction error was computed as the absolute difference between the final spherical equivalent and the refractive target (which assumed emmetropia) [16].

Table 3. Factors affecting visual and refractive outcome of traumatic cataract surgery

Outcomes	Covariates	OR (95% CI)	*P*-value
Refractive error (Mean absolute prediction error > 1 D)	**Injury type (open globe)**	2.57 (0.96 – 6.90)	0.059
	Keratometry (same eye)	1.44 (0.27 – 7.70)	0.667
	Lens position (other than capsular bag)	2.46 (0.84 – 7.17)	0.094
Visual outcome (BCDVA better than 20/40)	**Injury type (open globe)**	0.33 (0.12 – 0.91)	**0.032**
	Keratometry (same eye)	0.87 (0.15 – 5.05)	0.869
	Lens position (other than capsular bag)	0.71 (0.24 – 2.15)	0.710

Abbreviations: OR, odds ratio; CI, confidence interval; D, diopter; BCDVA, best-corrected distance visual acuity. Note: *P*-value < 0.05 is shown in bold; *P*-value is derived from binomial logistic regression; Closed- or open-globe injury, Injuries were classified as closed- or open-globe using the Birmingham Eye Trauma Terminology [17]; Mean absolute prediction error, the mean absolute prediction error was computed as the absolute difference between the final spherical equivalent and the refractive target (which assumed emmetropia) [16].

DISCUSSION

Traumatic cataract management in adults poses several challenges, including intraoperative complications [26, 27] and IOL selection [27, 28]. In this ten-year, retrospective study, we have described the visual and refractive outcomes of cataract surgery in 72 eyes that sustained open- or closed-globe injuries with a median follow-up of 46 months. Visual outcomes of traumatic cataract surgery were satisfactory in most cases in our study, with 59.7% (n = 43) of eyes attaining a BCDVA better than 20/40 at the final follow-up visit and only 4.2% (n = 3) of eyes obtaining a BCDVA worse than 20/200. The mean (SD) absolute mean deviation from emmetropia was 1.1 (0.8) D in all eyes and differed significantly between groups.

Because of our inclusion criteria, visual outcomes in our series were more favorable than those of similar studies [2, 29, 30]. As one of the primary outcomes of our study was the accuracy of IOL power calculation, we excluded patients who were left aphakic. Therefore, severely traumatized eyes with poor visual prognosis and no suitability for IOL implantation [31] were not included. In addition, most of the penetrating injuries in this series, involved zone I or II (n = 40, 97.6%) [18, 32], which indicates less severe ocular damage in our participants sustaining open-globe injuries. Moreover, in our series, most eyes (n = 53, 73.6%) had IOL implantation into the capsular bag.

In a two-year, retrospective, clinical, observational study, Serna-Ojeda et al. [29] reviewed the records of 80 adult patients with a mean age of 46 years (range: 18–82 years), most of whom were men (n = 67, 83.75%). Eyes with closed-globe blunt ocular trauma (n = 64, 80%) outnumbered those with open-globe penetrating trauma (n = 16, 20%). Seventy-seven (96.25%) patients underwent phacoemulsification; in 53% of the cases, the IOL was implanted into the capsular bag. The authors observed a statistically significant improvement in visual acuity, mostly reaching 20/40 or better, in individuals with IOL implantation into the capsular bag compared to those with implantation into the sulcus [29]. In the current study, a final BCDVA better than 20/40 was detected in 43 (59.7%), 23 (74.2%), and 20 (48.8%) eyes in the entire series, eyes sustaining closed-globe injuries, and those with open-globe injuries, respectively. The final mean BCDVAs were comparable between the groups of eyes with closed- and open-globe injuries

Forty-one (56.9%) eyes sustained open- and 31 (43.1%) eyes closed-globe injuries. Most eyes with open-globe trauma had zone 1 involvement (n = 36, 87.8%). Eyes with open-globe injuries were more likely to obtain worse visual outcomes in our study. This finding is consistent with results of studies recruiting children and adults [7, 33, 34]. Worse visual prognosis in open-globe injuries may be the result of corneal scars or other concomitant ocular injuries [35, 36]. The site of IOL placement (ciliary sulcus vs. in-the-bag) [29], the time interval between the injury and first intervention [37], worse initial visual acuity [29], and cataract morphology [38] are among the other possible influencing factors reported in previous investigations.

We also evaluated the refractive outcomes after IOL implantation in traumatic cataract surgery. The mean absolute prediction error was 1.0 D or less in 22 (71.0%) eyes with closed-globe injuries and in 20 (48.8%) eyes with open-globe injuries. Chuang et al. [39] reported a deviation of final refraction and target refraction of 1 D or less in 76.7% of eyes with penetrating injuries based on biometry of the traumatic eye. In a study by Moisseiev et al. [40], the deviation from emmetropia was within 1 D in 52% of eyes. The IOL calculations currently used in elective adult cataract surgery are accurate to the degree that 95% to 97% of patients achieve a mean absolute prediction error of 1.0 D or less after surgery [41]. However, calculations in traumatic cataract surgery have lower accuracy because of the distorted and irregular cornea [42] and because of inability to perform in-the-bag IOL implantation in most cases, as in-the-bag implantation yields a smaller mean prediction error [43].

Keratometry is an important element in IOL power calculation formulas [44]. In eyes with substantial corneal scar or irregularity, reliable keratometry may be difficult to obtain [45]. In addition, keratometry usually cannot be performed in cases requiring a simultaneous primary repair and cataract extraction [42]. In such cases, keratometry of the fellow eye could be used [42]. Arora et al. [10] observed similar final refractions using traumatized and fellow-eye keratometry [10]. Goyal et al. [42] conducted a study on pediatric traumatic cataract surgery involving IOL implantation. They concluded that when corneal scars prevent accurate keratometry in one eye, it is possible to use measurements of the fellow eye for IOL power calculation. This approach does not increase postoperative prediction error [42]. In contrast, other studies reported a better postoperative refractive error using keratometry of the traumatized eye [39, 40]. In our study, using keratometry of the non-traumatized eye did not affect absolute prediction error. However, cases using keratometry of the fellow eye were limited.

This study offers a ten-year perspective on the visual and refractive outcomes associated with the surgical management of traumatic cataracts. However, it has several limitations, primarily because of its retrospective, single-center design. Not all cases had available ocular biometry data, and some used uncertain IOL power calculation formulas, leading to the exclusion of some individuals from the study. Additionally, cases using keratometry of the fellow eye were limited; as a result, the logistic regression results may have low statistical power in evaluating the effect of this factor. Further prospective, longitudinal studies are necessary to establish the factors influencing visual and refractive results in traumatic cataract surgery for eyes affected by open- and closed-globe injuries.

CONCLUSIONS

In our ten-year study on the management of traumatic cataracts in adults, most patients with less severe injuries achieved satisfactory visual acuity and refractive outcomes. However, eyes affected by open-globe injuries tended to have a less favorable visual prognosis. These initial findings must be confirmed through large-scale, multi-center, longitudinal studies.

ETHICAL DECLARATIONS

Ethical approval: The study protocol received approval from the regional ethics committee. The study followed the tenets of the Declaration of Helsinki, and written informed consent was obtained from all included patients.

Conflict of interests: None.

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