Open Globe Eye Injury Characteristics and Prognostic Factors in Southern Israel: A Retrospective Epidemiologic Review of 10 Years Experience

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ABSTRACT: **Background:** Open globe injury (OGI) is a common cause of unilateral visual loss in all age groups.

Objectives: To describe and identify clinical characteristics, prognostic factors and visual outcome in a group of patients with OGI in southern Israel.

Methods: We conducted a retrospective review of all cases of OGI examined in the ophthalmology department at Soroka University Medical Center, Beer Sheva, Israel, from 1996 to 2005. A total of 118 eyes with OGI were detected and analyzed statistically. We recorded demographic data, cause of injury, initial visual acuity (VA), associated globe morbidity and injuries, Ocular Trauma Score (OTS), surgical procedures, postoperative complications, and final VA.

Results: The mean age of the study group was 36.1 years and included 84% males. The median follow-up was 13.3 months (range 6–66 months). The annual incidence of open globe injuries was 3.1 cases/100,000. In 84 cases (71%) the mechanism of open eye injury was laceration. Most of the injuries were work related (45%). Bilateral injury was observed in two patients. An intraocular foreign body was observed in 45 eyes (38%). Primary surgical repair was performed in 114 eyes. Six patients (5.1%) had complications with post-traumatic endophthalmitis and 12 patients (10.1%) underwent evisceration or enucleation. Clinical signs associated with poor visual outcomes included reduced initial VA, eyelid injury, and retinal detachment at presentation.

Conclusions: In our study population the most important prognostic factors in open globe injury were initial VA, eyelid injury and retinal detachment.

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KEY WORDS: open globe injuries (OGI), prognostic factors, visual outcome, foreign body, penetrating injury

Open globe injury is a common cause of unilateral visual loss between the age of 20 and 45 [1]. In most cases, the eye trauma is preventable and it is our duty to educate toward protective and preventive care. Despite comprehensive efforts by the health services in various countries to prevent ocular trauma, eye injuries do occur and cause severe damage. In industrialized countries, OGI is one of the leading causes of admissions to ophthalmology departments [2]. OGI's cost is high, including expensive surgeries and procedures, long admission time in the hospital, compensation payment to the injured patients, and loss of working days [3]. The final visual outcome among OGI patients ranges from full recovery to complete visual loss.

Worldwide, approximately 200,000 people suffer from OGI [3]. Several clinical studies show that the incidence of OGI is 2–6 cases per 100,000 population per year [2,4-7]. The mean estimated incidence is about 3.5 cases in 100,000, i.e., about 203,000 OGIs per year worldwide [3].

OGI is defined as a full-thickness wound in the globe and is considered a severe trauma that threatens the patient's vision [8]. The final visual outcome post-OGI is usually severe and is unpredictable in many cases. Several studies show several risk factors that correlate with the final visual outcome in OGI patients. The poor prognostic factors of the final visual acuity, reported to be statistically significant, are the type and mechanism of the injury, the initial post-trauma VA, presence of relative afferent papillary defect, adnexal injury, wound location and size, lenticular damage, hyphema, vitreal hemorrhage, and retinal detachment [4-7].

Although there are two models to predict final visual outcome post-OGI, the Ocular Trauma Score (OTS) [9] and the Classification and Regression Tree (CART) [4], it is still difficult to predict final visual outcome. On average, around 30% of OGIs remains in the visual acuity of finger count only [7].

Limited information is available in Israel concerning the epidemiology of OGI. This study describes the clinical characteristics, prognostic factors and visual outcome in a group of patients with OGI in southern Israel. The results of this study can play an important role in developing effective planning of medical services and preventive strategies for a population.

OGI = open globe injury
VA = visual acuity

PATIENTS AND METHODS

We conducted a retrospective review of all cases of open globe injuries that were admitted to the Department of Ophthalmology at Soroka University Medical Center, Beer Sheva, Israel, from January 1996 to December 2005. Soroka University Medical Center is the main referral center for eye injuries, serving the southern part of Israel with a population of over 1 million. The study was approved by the institution ethics committee. A total of 153 eyes of 151 consecutive patients suffering open globe injuries were included in the study. The data on 118 eyes of 116 patients with open globe injury were statistically analyzed. The remaining 35 eyes were excluded from the study because they met some of the exclusion criteria, namely: a) less than 6 month follow-up period, in order to avoid underestimation of the rate of late posterior segment complication in cases without appropriate postoperative follow-up; b) previous ocular surgery; and c) missing information on initial or final visual acuity.

Each patient chart was reviewed and evaluated to determine demographic data (age and gender), eye involved, cause of injury, initial VA, location of the open globe injury, and associated globe morbidity and injuries. Injuries were classified according to the Birmingham Eye Trauma Terminology [8] as rupture or laceration.

In addition, details of the surgical intervention were recorded. Follow-up data, including final VA, postoperative complications, and duration of follow-up were documented. The outcome evaluation in this study was the final VA, measured at the last visit. For statistical analysis the final visual grade was divided into two groups: group 1 with vision retained (range 6/6 to count fingers) and group 2 with poor or no vision retained (hand motion, light perception, or no light perception). VA testing of the injured eye was performed at initial examination using a Snellen acuity chart for distance or Jaeger card for near vision. When possible, testing was performed with a pinhole and this result was used for statistical analysis. If VA was worse than 6/60, count fingers, detection of hand movements, and light projection were assessed. VA of no light perception was confirmed with a bright light source, such as an indirect ophthalmoscope, while the uninjured eye was completely occluded.

Wound location was defined according to the Ocular Trauma Classification Group [8]. For OGIs, zone I injuries were confined to the cornea and limbus, zone II involved the anterior 5 mm of the sclera, and zone III injuries involved full-thickness scleral defects more than 5 mm posterior from the limbus.

In our study we used the Ocular Trauma Scoring system, developed by Kuhn et al., since it provides prognostic information regarding final visual outcome post-eye injury. The OTS is a scoring system that takes into account: a) initial VA, b) globe rupture, c) endophthalmitis, d) perforating injury, e) retinal detachment, and f) relative afferent pupillary defect. Higher OTS scores tend to indicate a better prognosis [9].

OTS = Ocular Trauma Scoring

STATISTICAL ANALYSIS

Statistical analysis was carried out using SPSS for Windows (version 14.0.1, SPSS Inc., Chicago, IL, USA). Chi-square and Student's *t*-test analyses were used for evaluating the correlation of individual factors with final visual acuity when grouped as a dichotomous variable. Multivariate logistic regression analysis examined the final VA in relation to those variables found to be significantly associated with the outcome VA in the univariate analysis. A P value < 0.05 was accepted as statistically significant.

The variables included in the univariate analysis were chosen based on our clinical experience and previous studies. Factors that were found in previous studies to correlate significantly with poor visual outcome include: initial VA, type of injury, eyelid laceration, hyphema, lens damage, presence of vitreous hemorrhage, retinal detachment, and presence of intraocular foreign body. We included additional variables in our univariate analysis: race, iris deformity, corneal injury (lamellar laceration or abrasion), primary scleral buckle, and ocular trauma score.

RESULTS

A total of 153 eyes with OGI were treated between 1996 and 2005 at the Soroka University Medical Center. Thirty-five patients were excluded from the study as they did not meet the eligibility criteria. The study group included 118 eyes with OGI: 84 with perforating injury (laceration) and 34 following blunt trauma (rupture) of the globe. Among the 84 eyes with perforated eye injury, 45 had a retained intraocular foreign body, 32 had a penetrating wound without retained foreign body, and 7 eyes suffered from perforation trauma. Two patients had bilateral OGI [Table 1].

The average incidence of OGI for 10 years of follow-up was 3.1/100,000 per year for the whole population; for the working age population (16–65 years old) the incidence was 5.3/100,000 per year. The incidence for Jewish and Bedouin patients was 2.9 and 3.7 per 100,000, respectively. In males the incidence was 5.1 and in females 0.9 per 100,000. The average age was 19.2 years. The Jewish patients were older than the Bedouin patients (41.1 ± 19.6 and 25.7 ± 13.8, respectively), with statistical significance (P = 0.005). The average age of affected males was lower compared to females (32.3 ± 15.7 and 56.1 ± 23.4 years, P = 0.005). Most of the patients were male (84%). The mean follow-up was 13.8 ± 6.8 months (range 6–66 months). Most OGI occurred at work (45%). Demographic and clinical characteristics are shown in Table 1.

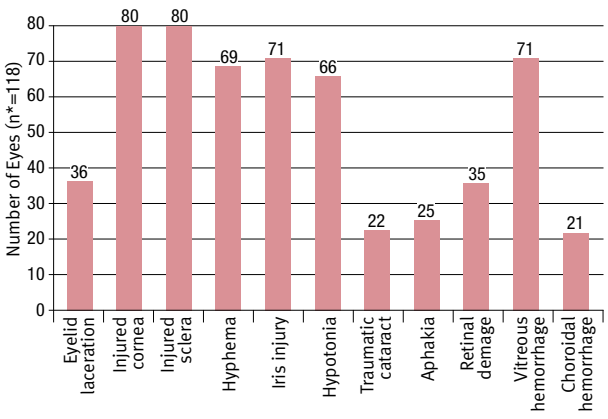
Men's injuries occurred mostly from sharp objects (78%), while among females blunt force trauma was more common (63.2%). The mean arrival time to the hospital post-injury

Table 1. Demographic and clinical characteristics of the study population

	No. (n=118)	%
Male/Female	99/19	83.9/16.1
Right eye/Left eye	57/61	48.3/51.7
Ethnic group		
Jewish	79	67.0
Bedouin	36	30.5
Others	3	2.5
Age group (yrs)		
‹ 15	10	8.5
16–40	67	56.8
41–65	27	22.8
› 65	14	11.9
Place where injury occurred		
Work	53	44.9
Home	37	31.4
Army	16	13.6
Recreation	6	5.9
Sport activity	6	5.9
Mechanism of injury		
Laceration	84	71.2
Rupture	34	28.8
BETT		
Penetration	32	27.1
Perforation	7	5.9
Foreign body	45	38.1
Rupture	34	28.9
Zone injury		
I	45	38.1
II	35	29.7
III	38	32.2
Initial VA		
6/6–6/12	20	17.0
6/15–6/60	28	23.7
CF	13	11.0
HM-LP	40	33.9
NLP	17	14.4

BETT = Birmingham Eye Trauma Terminology, CF = count fingers, HM = hand motion, LP = light perception, NLP = no light perception, VA = best visual acuity

Figure 1. Distribution of eye injuries among OGI patients



* Each eye can have more than one type of injury

was 6.6 ± 4.9 hours; the Jewish patients' arrival time compared to the Bedouin patients was 4.6 ± 3.8 and 9.4 ± 6.8 hours, respectively, with statistical significance ($P = 0.02$).

Most injuries were in the cornea and sclera (each occurred in 80 eyes); 71 eyes had vitreal hemorrhage and iris trauma. Figure 1 shows the distribution of eye injuries among the OGI patients.

Most patients (91.5%) underwent surgery within less than 24 hours post-trauma. The mean time between injury and surgery was 7.6 ± 11.9 hours. For the Jewish patients elapsed time was 5.3 ± 10.8 hours compared to 9.8 ± 13.3 hours for the Bedouin patients; the difference was not statistically significant ($P = 0.09$).

Forty-five eyes (38%) had an intra-ocular foreign body. In 15 eyes the foreign body was in the anterior segment of the eye, anterior to the lens, and in 30 eyes it was in the posterior segment. The entrance of the foreign body was through the cornea in 40%, nasal to the cornea in 33.3%, and temporal to the cornea in 26.7%. Metal was the material in 87% of the foreign bodies.

All OGI patients were treated by systemic and topical antibiotics. The study population (116 patients) had brain and orbit computed tomography scan and 116 eyes underwent surgical intervention. Two eyes (1.7%) were treated with contact lens wearing and self-sealing of corneal penetration; 48 eyes (41%) underwent one surgery, 50 (43%) eyes had two surgeries, and 16 (14%) eyes had three or more surgeries. On average, each patient had 1.5 surgeries.

During the follow-up, 12 eyes underwent enucleation or evisceration; 8 eyes underwent enucleation in the primary surgery. The most common primary surgery was corneal or scleral repair; each was done in 69 eyes (59.0%). Twenty-four eyes (21%) had scleral buckle as a preventive or therapeutic procedure, 21 eyes (18 %) had vitrectomy. The lens was removed in 16 eyes (14%) and in 6 (5%) of them an intra-ocular lens was implanted in the primary surgery.

An additional 32 lens-removal surgeries for traumatic cataract were performed at the end of the follow-up. Twenty-seven eyes (23%) remained aphakic, 28 (24%) pseudo-phakic, and 46 (39%) remained with an undamaged natural lens. Penetrating keratoplasty was performed as a late procedure in 4 eyes (3.4%) for severe corneal opacities and decreased vision. These patients had a marked visual improvement at the end of the follow-up period.

Eight eyes (6.0%) developed high intra-ocular pressure and needed topical anti-glaucoma treatment. Six (5.1%) were complicated with endophthalmitis. All patients had a laboratory diagnosis of the bacteria. The most common bacterium was coagulase-negative Staphylococcus, which caused four cases of endophthalmitis. The bacteria in the other two cases of endophthalmitis were *Streptococcus viridans* and *Streptococcus pneumoniae*. At the end of the follow-up period, 8 eyes (6.8%)

Table 2. Initial and final visual acuity among OGI patients

Initial visual acuity	Final visual acuity					
	6/6–6/12	6/15–6/60	CF	HM-LP	NLP	Total N (%)
6/6–6/12	17	3				20 (17)
6/15–6/60	12	14		1	1	28 (24)
CF	3	5	4	1		13 (11)
HM-LP	2	15	11	11	1	40 (34)
NLP				4	13	17 (14)
Total N (%)	34 (29)	37 (31)	15 (13)	17 (14)	15 (13)	118 (100%)

CF = count fingers, HM = hand motion, LP = light perception, NLP = no light perception

Table 3. Multivariate model of logistic regression in study population (n=118 eyes) of the risk factors for low visual acuity post-OGI

	Odds ratio	95% CI	*P* value
Initial VA	0.74	1.8–32.5	0.006
Lid injury	0.68	0.1–1.0	0.04
Retinal detachment	0.26	0.2–0.6	‹ 0.0001

VA = best visual acuity

suffered from phthisis bulbi and one patient developed sympathetic ophthalmia.

In 48.3% eyes with OGI the initial VA was non-functional (HM, LP, NLP); 41% had initial VA 6/60 or better. At the final visit this group showed an improvement in VA of 50%, and 60% of them had VA of 6/60 or better [Table 2].

Univariate logistic regression for risk factors for low vision (HM, LP, NLP) post-OGI indicated the variables with statistical significance ($P < 0.05$): poor initial VA, blunt trauma injury, trauma in zone III (5 mm posterior to limbus), low OTS score on admission, and adnexal eye injury.

The multivariate logistic regression for risk factors for low vision post-OGI showed three independent variables: initial poor vision, eyelid injury, and retinal detachment [Table 3].

DISCUSSION

Previous clinical studies from industrial countries showed that the incidence of OGI was 2–6/100,000 per year [2,5,6]. In our study the incidence of OGI in southern Israel was about 3.1/100,000, similar to that worldwide. In accordance with previous studies, OGIs are more common in the younger population and occur mainly among males; the average age was 36 years and 84% were male. The male predominance is a universal characteristic and has been demonstrated in several studies in different countries [4,10-15]. The risk is higher for men due to greater occupational risk, dangerous hobbies and sports, aggressive behavior, and alcohol consumption.

Approximately 170,000 Bedouins live in the Negev region and comprise 25% of the total population in southern Israel. The majority live in eight Bedouin towns and the rest live in small and temporary settlements (huts, tents). A small minority still conducts a semi-nomadic lifestyle. Our study found that Bedouin OGI patients were younger than their Jewish counterparts. This is attributed to the fact that 57% of the Bedouin population are under the age of 14 years and 80% of the Bedouins are under 30, as compared to only 27% and 50% for the Jewish population respectively. In addition, Bedouins usually start working at younger ages than Jews [16].

Eye-removal surgery (enucleation and evisceration) is a last resort procedure and imposes a heavy burden of decision for both the ophthalmologist and the patient. During the 10 year follow-up, 12 eyes were removed (10.2%); in 8 eyes it was performed during the primary surgery. The incidence of eye-removal surgery was compatible with some studies [14,17,18] but was lower than the 26% and 24% in the studies of Schmidt et al. [4] and Pieramici et al. [8] respectively. In a multi-center study, which screened eye trauma in Israel from 1981 to 1983, Koval et al. [12] found that eye-removal surgery was performed in 7.1% of OGI patients. The incidence of eye removal in the southern part of Israel between 1987 and 1993 was 7% [13] and is compatible with the incidence in our study.

We found that patients who suffered injury from a sharp object (laceration) had better final VA than patients who suffered blunt trauma (rupture). This difference was statistically significant ($P = 0.009$). This finding correlates with the literature and is explained by limited tissue damage due to different velocity and mechanism of injury with sharp edges of the wound that promote accurate and less disfiguring wound closure [17].

The anatomic distribution of OGIs demonstrates that most injuries (38%) occurred in zone I, while OGIs occurred in 30% and 32% in zones II and III, respectively. Similar results were found in other studies [19].

Endophthalmitis is one of the most dangerous complications of OGI. The reported incidence of endophthalmitis post-OGI varied between 4% and 8%, and up to 30% in rural environments [20]. The risk factors for endophthalmitis are delayed primary surgery, delayed systemic antibiotic treatment for more than 24 hours post-trauma, trauma in a rural environment, and a retained intraocular foreign body. The common pathogens for endophthalmitis are coagulase-negative Staphylococcus, *Streptococcus viridans*, and in rural conditions Bacillus spp. [20,21]. Our findings correlate with the literature: endophthalmitis was diagnosed in six of our patients (5.1%). In all cases the bacteria underwent laboratory identification. The most common bacterium was coagulase-negativee Staphylococcus.

HM = hand movement
LP = light perception
NLP = no light perception

In order to define the prognostic risk factors for visual outcome, a univariate statistical analysis was performed, and after recognition of the significant factors a multivariate logistic regression analysis was done [Table 3]. The three variables found to be significant risk factors for low visual acuity outcome were poor VA on admission, eyelid injury, and retinal detachment. These findings correlate with the literature, with most reports showing poor primary VA as an important risk factor for poor visual outcome [4-10,17-22]. Eyelid injury and retinal detachment were also reported as poor prognostic factors [4,14,15,19]. Regarding eyelid injury, Schmidt and co-authors [4] found it to be a very important prognostic factor for final visual acuity and included it in the CART analysis (Classification And Regression Tree). This is explained by the fact that OGI patients with eyelid injury were more commonly injured by blunt trauma, which correlates with poor final VA [23].

Our study has several limitations. First, the study design is retrospective and is likely to carry a recording bias. We were limited in documenting some important characteristics, such as nature of injury, eye protection, relative affect pupillary defect on admission, length of wound, and size of foreign bodies. For this reason these variables were not included in the statistical analysis. Secondly, there was a demographic bias (heterogenic population groups) and, therefore, the results are representative of OGI in southern Israel and not of the whole population of Israel. Finally, due to the retrospective collection of the data, in most cases best spectacle-corrected visual acuity was not recorded; therefore, the visual acuity performed with a pinhole was used for statistical analysis.

In summary, the demographic and clinical characteristics in this study, as well as the final outcome, correlate with previous reports in other countries. We found several prognostic factors for poor visual outcome: initial VA at admission, eyelid trauma, and retinal detachment. Recognition of these prognostic factors will help the ophthalmologist estimate the severity of eye injury and its prognosis.

Although we observed that young working men constitute the more risky group, OGI could occur in any place, at any age and in both men and women, and the outcome could be severe. It is therefore recommended that efforts be invested in education for eye protection in order to prevent OGI in the entire population.

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"We should take care not to make the intellect our god; it has, of course, powerful muscles but no personality"

Albert Einstein (1879-1955), German-born theoretical physicist who developed the general theory of relativity, one of the two pillars of modern physics