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Original Article

Pediatric Open-Globe Injuries: Clinical Characteristics and Outcomes of Repair in a Tertiary Center in Istanbul, Turkey

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Abstract

Objectives: To evaluate the epidemiology, etiology, and outcomes of pediatric open-glob injury patients treated at a tertiary medical center in Istanbul, Türkiye.

Methods: The records of 56 pediatric patients who underwent primary open-globe injury repair at our clinic between 2016 and 2021 were retrospectively reviewed. Data about demographics, date-setting of the injury, type of the traumatizing object, injury size, and zone were collected. The initial and final best-corrected visual acuities (VAs), associated features, trauma-hospital admission, and hospital admission-surgery durations were also recorded. The Pediatric Penetrating Ocular Trauma Score (POTS) was calculated to evaluate its effect on the final VA.

Results: Fifty-six eyes of 56 patients with a median age of 8 years who were followed up for at least 6 months were included. The majority of the injuries took place at home (62.5%), while the most common traumatizing object was a knife (10.7%). The mean size of injury was 4.73±2.92 mm; of which 60.7% (34) cases were in zone 1, 33.9% (19) cases in zone 2, and 5.4% (3) cases in zone 3 injury according to Ocular Trauma Classification group. The mean VA of 1.48 ± 1.21 logMAR at presentation was improved to 0.83±1.13 logMAR at the last visit ($p<0.001$). The POTS was significantly correlated with the final VA ($p=0.001$; $r=-0.473$). Iris prolapse was observed in 31 patients (55.4%), whereas the lens was injured in 26 (46.4%) cases and displayed a significant influence on the post-operative visual outcome ($p=0.019$). The mean duration between trauma-hospital admission was 18.9±43.8 h; while hospital admission-surgery was 8.6±3.7 h.

Conclusion: Our study demonstrated that the VA at presentation and the presence of lens injury are visual prognostic factors for pediatric open-globe injuries.

Keywords: Open globe injury, ophthalmic surgical emergency, pediatric trauma, primary repair, visual prognosis.

Introduction

Open-globe injury is defined as trauma causing a full-thickness defect of the eyewall, with reported ratios of 28.9–49.7% occurring in the pediatric age group of all the injuries (1-3). Eye injuries account for 8-14% of all injuries in pediatric patients (4). Children are more vulnerable to ocular trauma due to their lesser ability to recognize environmental hazards and limited capability of motor skills (5,6). Apart from the high percentage of ocular trauma in children, however,

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the main distinction from adult ocular trauma is the difficulty in terms of assessment and management in pediatric cases (7). First of all, the initial assessment in pediatric eye injuries is challenging and may require general anesthesia for a thorough examination. Moreover, the visual outcome is limited even further by the subsequent amblyopia among children under 7 years of age (5,7,8). Pediatric ocular injuries cause destructive lifelong impacts on their academic/social performance and quality of life, as well as their adult life beyond childhood (9). Furthermore; it is reported that open-globe injuries in pediatric patients require a higher rate of hospitalization than other injuries in children, pointing out to its economic burden (10,11).

In despite of its devastating effects, fortunately, it is estimated that nearly 90% of pediatric ocular trauma cases can be potentially prevented by means of targeted preventive measures and with proper adult supervision (12,13). The key to injury prevention is understanding the epidemiology and identifying the risk factors leading to open-globe injury in the pediatric group of patients (14,15).

Our purpose in this retrospective study was to evaluate the epidemiology, etiology, and outcomes of pediatric open-glob injury patients diagnosed and treated at a tertiary medical center in Istanbul, Turkey; with an aim of making contribution to the data to establish specific preventative guidelines for ocular trauma within the pediatric population.

Methods

The medical records of patients ≤18 years old who underwent primary open-globe injury repair at our clinic from January 2016 to January 2021 were retrospectively reviewed. Patients with a minimum follow-up period of 6 months were included in the study. Patients with previous history of ocular disease, surgery, or trauma and patients who had follow-up periods of less than 6 months were excluded from the study. Data about demographic features including age, gender, laterality, date and setting of the injury, type of the traumatizing object, size, and zone of the injury (zone 1: confined to the cornea, zone 2: from the limbus to the anterior 5 mm of the sclera, zone 3: the rest of the posterior sclera >5 mm to the limbus; accordingly to the Ocular Trauma Classification group (16)) were collected. The initial and final best-corrected visual acuities (VAs), associated ocular features (iris prolapse, hyphema, lens injury/dislocation, vitreous hemorrhage, retinal detachment, presence of intraocular foreign body), the duration between trauma to hospital admission as well as from the hospital admission to surgery were also recorded. Any intraoperative and post-operative complications were noted. Injury severity was evaluated using Penetrating Ocular Trauma Score (POTS), (17) wherever applicable. The POTS for the patients was calculated by assigning raw scores to individual patient characteristics: initial VA, age of the patient, wound location, and concomitant eye conditions. Due to the variable follow-up periods, the problems associated with recording the final BCVA values were overcome by taking the measurements noted between the 6 and 12-month post-operative visits into account, using the closest measurements to 12 months if multiple results were available. The VA values were converted to logarithm of the minimum angle of resolution (logMAR) units for statistical purposes.

This study was conducted in accordance with the principles of the Declaration of Helsinki and approved by both the institutional ethical committee board of our institution (No: E-48670771-514.99). Written informed consent was obtained from the patients or their caregivers.

All statistical analyses were performed using SPSS software (version 21.0; IBM, Armonk, NY). Mean, standard deviation, minimum-maximum, and frequency values were used in descriptive statistical analyses. Categorical variables were expressed as absolute numbers and percentages. The distribution of the variables was analyzed using the Shapiro–Wilk test. One sample t-test was used to compare initial and final VA. Independent sample t-test or Mann–Whitney U test was used according to the normality of data for pairwise comparison of independent groups. The Kruskal Wallis test was used to evaluate the effect of the injury zone on final VA. ANOVA test was used to compare age groups. The effect of the variables on final VA was evaluated using multivariate regression analysis. The relationship between pre-operative and post-operative VA was evaluated by performing correlation analysis with the Pearson correlation coefficient. A $p<0.05$ was considered to denote the results as statistically significant.

Results

A total of 56 eyes of 56 patients, who underwent primary open-globe injury repair at our clinic between January 2016 to January 2021 and were followed up for at least 6 months, were included in this study. All 56 of the injuries were unilateral. Thirty-five (62.5%) of the patients were male and 21 (37.5%) of them were female, with a mean age of median 8 (Range: 1–18) years. The surgical repairs for ocular trauma were performed on 25 (44.6%) right eyes and 31 (55.4%) left eyes.

The majority of the injuries took place at home (35 cases, 62.5%). There wasn't any statistically significant predominance with season or day of the week. The peak admission was recorded during the 18.00–24.00 time period of the day (42.8%). The most common traumatizing object was a knife in 10.7% of the cases, followed by broken glass in 10.7%, and a fork in 8.9%. The sources of injury are summarized in Table 1. In 3 (5.4%) of the cases, the injury source remained unspecified.

Table 1. The summary of injury sources in open-globe injury patients in the pediatric group

Sharp objects	Frequency (Percentage)	Blunt objects	Frequency (Percentage)	Projectiles	Frequency (Percentage)
Knife	6 (10.7)	Stone	4 (7.1)	Gunfire	2 (3.6)
Broken glass	6 (10.7)	Plastic objects	4 (7.1)	Fireworks	1 (1.8)
Fork	5 (8.9)	Metallic objects	3 (5.4)		
Pen/Pencil	4 (7.1)	Fist/blunt hit	2 (3.6)		
Scissors	3 (5.4)				
Nail/screwdriver	3 (5.4)				
Arrow/stick	3 (5.4)				
Metallic piece	3 (5.4)				
Own Glasses	2 (3.6)				
Fingernail	1 (1.8)				
Tree branch	1 (1.8)				

The mean size of injury was 4.73±2.92 mm (Range: 1–15 mm). According to the Ocular Trauma Classification group; (16) 60.7% (34) cases involved zone 1, 33.9% (19) cases zone 2, and 5.4% (3) cases zone 3 injury.

Due to a lack of patient cooperation; it was possible to take visual measurements in 76.8% (43 children) of the cases at the presentation time, and in 89.3% (50 children) at the final visit. Of the patients with available VA data, the number of patients with hand motion or lower vision was 13 (23.2%) preoperatively, and 7 (12.5%) post-operatively. The mean VA of 1.48±1.21 (Range: 3.7–0.1) logMAR at presentation was improved to 0.83±1.13 (Range: 4.7–0.0) logMAR at the last visit ($p<0.001$). The initial and final VA values were found to be correlated with each other ($p<0.001$; $r=0.568$). The POTS was found to be significantly correlated with the final VA ($p=0.001$; $r=-0.473$). The distribution of final VA according to the POTS categories are displayed in Table 2.

The concomitant intraocular injuries at the presentation time were analyzed as well. Nearly half (55.4%, 31 patients) of the patients presented with iris prolapse. The lens was injured in almost half (46.4%, 26 patients) of the cases, and it was dislocated in 4 (7.1%) of these patients. Hyphema was observed in 23.2% (13 patients) of the eyes and intravitreal hemorrhage in 8.9% (5 patients). Retinal detachment was present only in 1 (1.8%) eye which had presented with zone 3 injury. An intraocular foreign body was involved in 9 (16.1%) of the eyes; 2 (3.6%) of them were detected in the anterior chamber while the remaining (12.5%) were in the vitreous cavity.

The effects of age, iris prolapse, hyphema, lens injury, vitreous hemorrhage, presence of an intraocular foreign body, size of the injury, or duration to surgery on the final VA were analyzed ($p=0.006$, adjusted $r^2=0.271$). Only the presence of lens injury displayed a statistically significant influence on the post-operative visual outcome ($p=0.019$). Moreover, the mean post-operative VA of eyes with lens injury was 1.33±1.36 logMAR, and without lens injury was 0.37±0.58 logMAR; the difference was statistically significant ($p=0.002$). The presence of hyphema did not yield any statistically significant influence on the final VA with the regression analysis. However, both the mean pre- and-post-operative VA values were significantly better in the group of patients without

Table 2. Final visual acuity according to POTS categories

POTS category	NLP, n (%)	LP/HM, n (%)	CF, n (%)	1-0.3 logMAR, n (%)	<0.3 logMAR, n (%)	Total, n (%)
1	1 (9.1)	3 (27.3)	1 (9.1)	4 (36.4)	2 (18.2)	11 (100.0)
2	0	2 (13.3)	0	4 (26.7)	9 (60.0)	15 (100.0)
3	0	0	1 (20.0)	3 (60.0)	1 (20.0)	5 (100.0)
4	0	0	0	2 (22.2)	7 (77.8)	9 (100.0)
5	0	0	0	0	3 (100)	3 (100.0)

POTS: Penetrating Ocular Trauma Score; NLP: No light perception; LP: Light perception; HM: Hand movement; CF: Counting fingers.

hyphema (p=0.033 and p=0.049, respectively). The association between presenting features and initial-final VA values is summarized in Table 3.

The patients were grouped according to their age ranges for statistical purposes: 0–6 years (26 patients, 46.4%), 7–12 years (16 patients, 28.6%), and 13–18 years (14 patients, 25.0%). When VA measurements were examined according to the age groups, there was no statistically significant difference between the groups in terms of the mean pre-operative and post-operative VA values (p=0.384, p=0.594; respectively). Although there was no statistically significant difference, the best post-operative VA was in the group of patients aged 13–18 years (Table 4). There was a statistically significant difference in terms of setting of the injury

Table 3. The association between the presenting ocular features and the mean visual acuity values

Ocular features	Initial VA (mean±SD) (logMAR)	p	Final VA (mean±SD) (logMAR)	p
Injury zone				
Zone 1	1.26±1.08 (n=24)	0.396*	0.53±0.76 (n=28)	0.117*
Zone 2	1.75±1.39 (n=17)		1.07±1.24 (n=19)	
Zone 3	2.00±0.99 (n=2)		2.08±2.35 (n=3)	
Injury source				
Sharp	0.77±0.97 (n=32)	0.734*	1.51±1.17 (n=28)	0.864*
Blunt	0.79±1.36 (n=12)		1.23±1.13 (n=10)	
Projectile	1.00±1.47 (n=3)		1.44±1.97 (n=3)	
Iris prolapse				
Yes	1.74±1.35 (n=23)	0.137**	1.06±1.36 (n=27)	0.118**
No	1.19±0.99 (n=20)		0.56±0.71 (n=23)	
Hyphema				
Yes	2.24±1.33 (n=9)	0.033***	1.53±1.50 (n=13)	0.049***
No	1.28±1.12 (n=34)		0.58±0.87 (n=37)	
Lens injury				
Yes	2.05±1.39 (n=25)	0.008**	1.33±1.36 (n=26)	0.002**
No	1.08±0.88 (n=18)		0.37±0.58 (n=24)	
Vitreous hemorrhage				
Yes	1.68±1.22 (n=4)	0.746***	1.16±0.42 (n=5)	0.496***
No	1.47±1.23 (n=39)		0.79±1.18 (n=45)	
Presence of IOFB				
Yes	1.53±1.40 (n=6)	0.972***	0.67±1.06 (n=6)	0.670***
No	1.51±1.23 (n=35)		0.88±1.17 (n=42)	

VA: Visual acuity; SD: Standard deviation; IOFB: intraocular foreign body; P* values based on the Kruskal–Wallis test, P** based on the independent sample t-test, and P*** based on the Mann–Whitney U-test.

Table 4. Evaluation and comparison of age groups in terms of visual acuity

	0–6 years	7–12 years	13–18 years	p
Initial VA (mean±SD) (logMAR)	1.88±1.35	1.30±1.12	1.33±1.19	0.384
Final VA (mean±SD) (logMAR)	0.87±0.97	0.99±1.46	0.58±0.94	0.594

VA: Visual acuity; SD: Standard deviation. p-value based on the ANOVA test

between the age groups: 62.9% of the home injuries were in the group of patients aged 0–6 years, 25.7% in the group of patients aged 7–12 years, and 11.4% in the group of patients aged 13–18 years (p=0.002). There wasn't any statistically significant difference in terms of injury sources, however. The presence of iris prolapse, hyphema, lens injury/dislocation, vitreous hemorrhage, retinal detachment, or intraocular foreign body did not demonstrate any significant difference between the age groups, as well (p>0.05).

When the cases were grouped according to their presentation time; it was observed that 49 (87.5%) of the patients presented within 24 h, 4 (7.1%) patients between 24 and 48 h, and 4 (7.1%) patients after 48 h of the initial trauma. All of the patients were operated for primary surgical repair of open-globe injury within 24 h after presentation. The mean duration between trauma to hospital admission was 18.9±43.8 h (Range: 1–240 h). The mean time from the hospital admission to surgery was 8.6±3.7 h (Range: 2–20 h). The presentation time didn't show any correlation in terms of better visual outcomes (p=0.155; r=−0.204). No intraoperative or post-operative complications were observed except hypotonia in 3 (5.4%) eyes and prolonged inflammatory reaction in 2 (3.6%) eyes; all of which resolved spontaneously.

Discussion

Open-globe injuries, which are caused by a traumatic breakdown in the integrity of the eyewall, are of particular importance in the pediatric age group of patients due to its high incidence as well as the difficulties in assessment and treatment. The condition constitutes a serious public health problem in children with a destructive lifelong impact on their quality of life as well as devastating psychological and sociological effects in their adult life. Therefore, a better understanding of the characteristics of this condition is essential in building up preventive measures as well as establishing better management strategies.

The predominance of boys over girls with a ratio of 1.67:1 was consistent with the literature as demonstrated in many studies before with similar ratios from all over the world from different countries (France, United Kingdom, Sydney, Thailand, India, Tunisia, etc.) as well as our country (5,7,14,15,18-21). This finding is frequently attributed to the fact that boys are more likely to get involved in dangerous games/sports or high-risk activities, which is observed commonly across different cultures (8,21). On the other hand; the most frequent range of age exposed to ocular trauma, the setting of the injury, and the most frequent objects causing injury are reported variably in the literature. Our study demonstrated the most frequent age range as 0–6 years (46.4%), the most common setting of injury as home (62.5%), and the most common traumatizing object as knife (10.7%) and broken glass (10.7%) followed by fork (8.9%). We think that these findings are consistent with each other since children aged 0–6 years are at home for most of their time, and kitchen utensils are frequent objects for home injuries. Other two studies reporting the highest incidence of ocular injury in older children (6–10 years, 39.3% (15) and 11–16 years 49.0%[8]) found the most common traumatizing object as wooden sticks; which is consistent as well since older children spend more time outdoors and subject to trauma with wood. In another study from our country with the peak age of ocular injury in 3–7 years (53%) (14) reported the most common causative object as scissors/knives, similar to our findings. Moreover, in a different report from our country studying perforating ocular injuries in all age groups, the most frequent age group was 0–7 years (48.2%) (22). The higher rate of ocular injury in pre-school children in our country points out to the importance of educating the parents and caregivers regarding close supervision and preventive measures at home.

All of the patients in our study were unilateral trauma cases with almost equally affected right and left eyes. These findings are in accordance with the literature, as Boret et al. (20) and Batur et al. (14) stated in their studies as well. The frequency of bilateral trauma in children is rarely experienced with a reported rate of 0% in several studies (8,23,24). This lower rate of bilaterality in the pediatric group compared to adults can be attributed to the lower possibility of children to be exposed to severe traumas, such as traffic accidents or gunshots, which can result in bilateral ocular injuries. Furthermore, consistent with the literature, the majority (60.7%) of the ocular traumas were zone 1 (8,23,25-27).

Although measuring the VA at the presentation time is one of the most challenging parts of the open-globe injury assessment in children; it should be performed to the extent the child's cooperation allows since it has a prognostic value as shown in the former studies (14,21,27-30). Consistently, our study demonstrated a positive correlation between initial and final VA values which can provide helpful information about the visual prognosis of the patient. Another prognostic factor about the final VA was found to be the presence of lens injury in this study. Liu et al. and AlDahash et al. presented a similar relationship in their studies, as well (5,6). According to the findings of Liu et al., however, the presence of a vitreous hemorrhage was also found to be a poor prognostic factor; about which we did not record any significant relationship in the present study (5). Similarly, the presence of a retinal detachment did not display a statistically significant influence on the post-operative visual prognosis in our study while Choovuthayakorn et al. claimed that it predicted a significantly worse visual outcome according to their findings (8). Although the previous studies reported the most com-

mon concomitant intraocular injuries as hyphema (26,31) and cataract, (23,32) our study documented iris prolapse and lens injury most frequently. On the other hand, our ratio for the presence of an intraocular foreign body (16.1%) was in agreement with the previously reported range in the literature: 4–22.1% (8,26,27,33,34). We think that the concomitance of an intraocular foreign body in pediatric open-globe injuries is especially important in the aspect that this subgroup requires a different treatment approach with possibly additional surgical interventions and different outcomes.

Due to the challenging situation about getting precise VA information, a new ocular trauma score system named Pediatric POTS was developed especially for children with open-globe injuries (17). As in previous studies, the present study demonstrated that POTS and the final VA were significantly correlated, and the cases with lower POTS had worse visual outcomes (17,21,35).

There wasn't any clinical significant influence of hospital admission delay in terms of visual outcome in our study. Similarly, Wadeai et al. and Malek et al. did not found the delay in presentation time as a poor prognostic factor in their studies (21,36). These findings may be due to the fact that the patients are usually admitted to the hospital more urgently after more severe traumas. Yet, a cautious consideration about infection in delayed cases should always be kept in mind when evaluating pediatric open-globe injuries.

Although the visual outcome demonstrated a statistically significant improvement after the treatment in our study, the mean VA of 0.83±1.13 logMAR at the last visit displays a considerable loss compared to normal vision in terms of the visual ability of the children. This finding is supported also by many other studies in the literature focusing on pediatric ocular trauma (5,14,27). The undesirable visual outcome after pediatric ocular traumas despite of the advancements in microsurgery points out to the significance of further preventive measures reducing the probability and severity of ocular injuries to avoid substantial visual morbidity in children.

The limitations of the present study include its retrospective nature, variable follow-up period, and the relatively small size of the patient group. The difficulty of obtaining accurate VA measurements in children should be kept in mind when interpreting the results. The evaluation of functional success only by VA is another limitation of the current study; other signs of daily activity independence such as visual aid requirement or enrollment in school could be addressed in evaluating functional outcomes. Moreover, the compliance of the families in amblyopia treatment may have affected the visual outcome. A more detailed analysis of the factors effecting the visual prognosis can be achieved through long-term randomized prospective studies with larger sample sizes. The inclusion of the assessment regarding academic or social success and employment status related to visual outcome in future studies would provide a more elaborate evaluation of the effect of pediatric ocular traumas on the children's quality of life. Furthermore, the addition of the evaluation of imaging findings in future researches can make an objective contribution in terms of estimating visual prognosis, to overcome the difficulty of obtaining accurate examination findings in children.

Conclusion

Our study demonstrated that the VA at presentation and the presence of lens injury are prognostic factors for open-globe injuries in the pediatric age group. These findings can be useful in terms of predicting the prognosis and managing the expectations of the children with open-globe injury and their parents. However, we believe that the adoption of appropriate protective measures to avoid unnecessary injuries are far more effective in terms of preventing visual impairment than advancements in any kind of treatment or management strategies after the injury.

Disclosures

Ethics Committee Approval: This study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the institutional ethical committee board of our institution (No: E-48670771-514.99). Written informed consent was obtained from the patients or their caregivers.

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