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Pediatric Open Globe Injury in a University-Based Tertiary Hospital in the Anatolian Region

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ABSTRACT

Objective: Evaluation of the epidemiological and clinical features of pediatric open globe injury.

Methods: Medical records of 51 patients under the age of 18 who presented to the emergency department with open globe injury (OGI) between 2009 and 2021 were evaluated retrospectively. Patient demographics, Birmingham Eye Trauma Terminology (BETT) category, pediatric ocular trauma score (POTS), visual acuity (VA), site of injury, and seasonal distribution were evaluated.

Results: Of all patients included, 40 (78.4%) were male, 11 (21.6%) were female, and the mean age was 9.6±5.2 years. Zone I injury was detected in 31 (60.8%) patients. The most common cause of injury was sharp objects such as metal or wood splinters. Of all injuries, 29 (56.9%) occurred outdoors. Ocular trauma occurred more frequently in boys, especially in the summer months. Initial VA was less than 0,1 in 21 (41.2%) of the patients, between 0.1-0.5 in 9 (17.6%) and 0.6 and above in 5 (9.8%) patients. At the final visit, VA was less than 0.1 in 9 (17.6%) patients, 0.1-0.5 in 10 (19.6%) patients, and 0.6 and above in 18 (35.3%) patients. Final VA was related to the Zone and was lower as the Zone increased (p:0.011). VA and POTS scores were positively correlated at the final visit (p=0.001).

Conclusion: It is substantial for emergency physicians to have a comprehensive understanding of pediatric globe injuries so that children with suspected ocular trauma should be evaluated by an ophthalmologist to prevent medicolegal problems.

Keywords: Children, open globe, trauma, prognosis

1. INTRODUCTION

Globe injury is an important health problem causing globe deformities and visual impairment leading to psychological and sociological effects worldwide (1). According to a previous study, approximately 1.6 million people are blind, 2.3 million people have bilateral visual impairment, and 19 million people have unilateral vision loss due to eye trauma (2). Globe injury accounts for 7% of all bodily injuries and 10-15% of all ocular pathologies (3). Ocular trauma is one of the leading causes of unilateral vision loss and non-congenital unilateral blindness in children (4). Poor visual outcome is a result of amblyopia due to prolonged visual deprivation besides the damage to the ocular structures leading to vision loss (5).

Children are more prone to ocular injuries as a result of immature motor skills and limited experience since they are driven by curiosity and may impersonate others neglecting the risks and outcomes of a certain activity (6). The diagnosis and treatment of pediatric ocular injuries have their challenges due to the uncooperative nature of children to the ophthalmic examination and poor compliance to the treatment (1). Population-based studies on pediatric globe injury have revealed that two-thirds of these traumas in children occur at home and are closed globe trauma in boys (7, 8). However, severe visual impairment is mainly due to open globe injuries (9). Traumatic globe injury in children is a significant socioeconomic problem as it requires long-term follow-up and treatment. Furthermore, it affects the social, emotional, and psychological development of the child along with the caused physical disability. Previous studies on pediatric eye injuries suggested that up to 90% of eye injuries can be prevented with better education, supervision of children's activities, and proper protective eyewear (10). Therefore, defining the risk factors and taking preventive measures is beneficial to reduce perilous outcomes of globe injuries in children.

The aim of this study is to describe the epidemiology and characteristics of globe injuries in children over a 12-year period who applied to our clinic. The study also evaluates the frequency and causes of eye injuries in children and the main factors associated with the occurrence of these injuries

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therefore we aim to offer specific recommendations for the formation of primary prevention measures. The results of the study will provide data in terms of prospective follow-up and prognosis by comparing the type and cause of trauma, surgery, and treatment with the findings of follow-up examination.

2. METHODS

This retrospective study consisted of medical records of 51 patients younger than 18 years of age who were referred to the Department of Ophthalmology, which is located in the central Anatolian region and provides tertiary healthcare services for the surrounding cities, with traumatic globe injury between January 2009 and March 2021. The study was approved by the administration and the local ethics committee of Sivas Cumhuriyet University Faculty of Medicine on 10/03/2021 with the number 2021-03/20 and carried out in accordance with the principles outlined in the Declaration of Helsinki. The medical records of patients were reviewed and the data including epidemiological characteristics such as age and gender, laterality, cause of injury, zone of injury, place of injury, the initial and final best-corrected VA with Snellen, anterior and posterior segment findings, and seasonal distribution were noted. Pediatric penetrating ocular trauma score (POTS) was calculated for each patient (3). The raw points for each variable affecting POTS is presented in Table 1. The following equation: 2 × (age + location of injury) − corresponding pathologies was used to determine POTS for those whose initial VA was absent. The scores were utilized to divide patients into five groups. Group 1 being the poorest and Group 5 the best prognosis. The necessity for additional surgery (e.g. traumatic cataract removal) or any observed secondary complication following primary closure was also noted down. The OGI was classified as globe rupture, penetrating injury, perforating injury, and intraocular foreign body according to Birmingham Eye Trauma Terminology (BETT) (11). Zone of injury was classified according to Ocular Trauma Classification Group as follows: Zone I as wound involvement isolated to the cornea, Zone II as full-thickness wound including the sclera but no more posteriorly than 5 mm from the limbus, and Zone III as full-thickness wound more than 5 mm posterior to the sclera (12). Patients with known systemic diseases, who have a history of any ocular pathology or surgery, who had major head trauma which might result in a negative impact on the visual pathways, and who had a follow-up period of less than 3 months were excluded from the study.

2.1. Statistical Analysis

The data analysis was performed with Statistical Package for the Social Science (SPSS version 20.0. Armonk, NY: IBM Corp.) software for Windows. The normality of the data will be checked with the Kolmogorov-Smirnov test. Independent sample t-test for two independent groups and F-test (ANOVA) for more than two groups were used if parametric conditions were met., Tukey test will be used for those who provide the homogeneity assumption and Tamhane's T2 tests for those who do not provide the homogeneity assumption to determine which group is different from the others when using ANOVA for comparisons with more than two groups. If any or all of the assumptions were not met, the Mann Whitney U test for two independent groups and the Kruskal Wallis test for more than two independent groups were used. Pearson correlation coefficient for parametrics and Spearman correlation coefficient for non-parametrics were used to determine the relationship between variables. In addition, regression analysis was performed to determine the effect. The Chi-square test was used to evaluate the categorical data. A value of $p \leq 0.05$ was considered statistically significant.

Table 1. *Calculating the POTS and raw points for variables*

Variables	Raw Points
Initial visual acuity	
NLP	10
LP/HM	20
CF	30
0.1-0.5	40
0.6-1.0	50
Age (years)	
0-5	10
6-10	15
11-15	25
Wound location	
Zone I	25
Zone II	15
Zone III	10
Concomitant eye pathologies	
Iris prolapse	-5
Hyphema	-5
Organic/unclean injury	-5
Delay of surgery (>48 h)	-5
Traumatic cataract	-10
Vitreous haemorrhage	-20
Retinal detachment	-20
Endopthalmitis	-30

*POTS: Pediatric penetrating ocular trauma score, NLP: No light perception, LP: Light perception, HM: Hand motion, CF: Counting fingers. *POTS = 2 × (age + location of injury) – corresponding pathologies*

3. RESULTS

The mean age of 51 patients was 9.6±5.2 years. The mean age was 10.7±5.0 in boys, and 5.6±4.0 in girls. There was a statistically significant increase in the male to female ratio as the age increased (p=0.02). Of 51 patients, 40 (78.4%) were male and 11 (21.6%) were female. Right eye was involved in 25 of the cases where the remaining 26 injuries were left-sided. There was no statistically significant difference between the genders in terms of the laterality of the affected eye (p=0.8). Evaluation of the location of the injury revealed that 22 (43.1%) were indoors and 29 (56.9%) were outdoors. Outdoor

injury was more common as the age increased. Regarding the cause of the injury, 19 (37.3%) were metal objects such as knives and scissors, 14 (27.5%) were wood, 6 (11.8%) were glass, 6 (11.8%) were stone, 4 (7.8%) were plastic, 1 (2%) was by finger, and 1 (2%) was by a sparkler. The demographics of the study population are summarized in Table 1. The most common zone of injury was Zone I and was observed in 31 (60.8%) patients. Zone II injury occurred in 19 (37.3%) patients, and Zone III injury in only 1 (2%) patient. The distribution of the laterality of the injured eye and the zone of injury are given in Table 2. We observed that ocular trauma occurs more frequently in boys, especially in the summer months. Seasonal distribution of pediatric open globe injuries was given in Figure 1. Immediate primary suturing of the wound was performed under general anesthesia for all patients initially. Prophylactic intravenous cefuroxime sodium, topical moxifloxacine were administered following hospitalization. Postoperative intravenous antibiotic prophylaxis is continued for 3 consecutive days in total and topical antibiotics and and steroid eye drops steroids are tapered based on the findings of the biomicroscopic examination during follow-up. The mean VA was 0.18±0.28 at the initial examination increasing to 0.49±0.40 at the final visit. The increase in VA between the initial and the final ophthalmologic examination was statistically significant (p<0.001). The VA was below 0.05 in 21 (41.2%) of the patients, between 0.1-0.5 in 9 (17.6%), and above 0.6 in 5 (9.8%) patients at the initial examination. However, we were not able to assess VA in 16 (31.4%) patients due to young age, incompliance to examination, or agitation. The initial, postoperative day 1, and final VA of the patients were presented in Table 3. The mean calculation using raw points for POTS was 64.8±19.4 and the mean POTS was 2.7±1.2. The majority of children (66.7%) were in either Group 2 or 3 regarding POTS. The mean follow-up time was 16±13.5 months (3-36 months). A total of 4 (7.8%) patients required vitrectomy. Surgical removal of an intraocular foreign body was performed in 6 patients. Traumatic cataract was present in 13 (25.5%) patients at the initial examination. Additional 6 patients either developed cataract subsequently or were observed to have cataract at the following examinations. A total of 19 (37.3%) patients underwent lensectomy and the mean time interval from primary suturing to lensectomy was 62.6±170 days (1-730 days). Iris prolapse was observed in 8 (15.7%) patients, hyphema in 7 (11.8%), vitreous prolapse in 4 (7.8%), iridodialysis in 1 (2%), and vitreous hemorrhage in 1 (2%) patients at the initial ophthalmic examination. Enophthalmos secondary to orbital floor fracture was observed in 1 (2%) patient. Initial ocular examination findings concomitant with open globe injuries were summarized in Table 5. Following the primary suturing, retinal detachment was observed in 7 (13.7%) patients, vitreous hemorrhage in 6 (11.7%) patients, and hyphema in 3 patients on the postoperative first day. At the final visit, we were not able to assess VA in 14 (27.5%) patients due to young age or incompliance to examination. VA was below 0.05 in 9 (17.6%) patients, between 0.1-0.5 in 10 (19.7%) patients, and above 0.6 in 18 (35.2%) patients. At the last visit, the following pathologies were observed; corneal scarring in 38 (74.5%) patients, retinal detachment in 7 (13.7%) patients, and synechia in 6 (11.8%) patients. A total of 13 (25.4%) patients were pseudophakic, 5 (9.8%) patients were aphakic, and 1 (2%) patient had IOL dislocation. Seven children (13.7%) who had retinal pathologies such as retinal detachment and persistent vitreous hemorrhage were referred for pediatric retinal surgery. The final VA was found to be negatively correlated to the Zone as VA decreased while the Zone increased (p=0.011). Initial VA was positively correlated with the final VA (p=0.02). Also, there was a positive correlation between VA and POTS in children at the last visit (p=0.001). Traumatic cataract was found to be related with poor final VA (p=0.04).

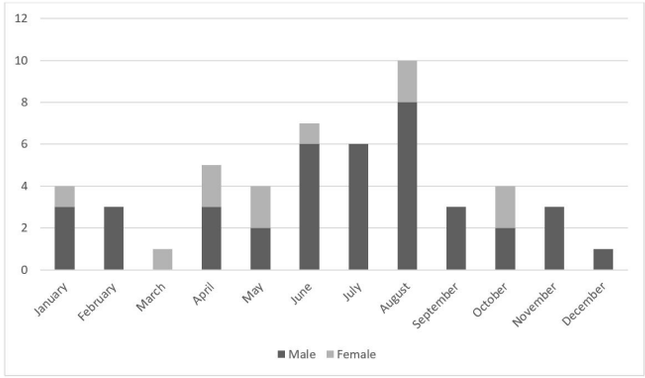

Figure 1. *Seasonal distribution of open globe injuries*

Table 2. *Demographics of the study population (n:51)*

		Mean±SD, n (%)
Age (years)		9.6±5.2
Gender	Male	40 (78.4)
	Female	11 (21.6)
Location of injury	Outdoor	29 (56.9)
	Indoor	22 (43.1)
Cause of injury	**Sharp objects**	44 (86.2)
	Metallic	19 (37.3)
	Wood splinter	14 (27.5)
	Glass	6 (11.8)
	Plastic	4 (7.8)
	Body part (Nail)	1 (2)
	Blunt objects	6 (11.8)
	Stone	6 (11.8)
	Projectiles	1 (2)
	Firework	1 (2)

Table 3. *Distribution of the laterality of the injured eye and the zone of injury*

	n	(%)
Laterality of the globe injury (right/left)	25 / 26	49 / 51
Zone I	31	60.8
Zone II	19	37.3
Zone III	1	2
Total	51	100

Table 4. *The initial, postoperative day 1, and final visual acuity of the patients*

Visual acuity (Snellen)	Initial n (%)	Postoperative day 1 n (%)	Final n (%)
>0.6	5 (9.8)	6 (11.8)	18 (35.2)
0.1-0.5	9 (17.6)	19 (37.2)	10 (19.7)
<0.05	21 (41.2)	19 (37.2)	9 (17.6)
Not specified	16 (31.4)	7 (13.8)	14 (27.5)
Total	51	51	51

Table 5. *Initial ocular examination findings concomitant with open globe injuries*

Examination finding	n*	%
Traumatic cataract	13	25.5
Iris prolapsus	8	15.7
Hyphema	6	11.8
Vitreus prolapsus	4	7.8
Iridodialysis	1	2.0
Synechia	1	2.0
Vitreous hemorrhage	1	2.0

**Total number of patients*

4. DISCUSSION

Open globe injuries may cause visual impairment and at times result in blindness leading to lifelong morbidity. In the present study, the majority of the patients (78.4%) were male. Outdoor injury was more common (56.9%) and metal objects and wood were among the most frequent causes of injury. The most common zone of injury was Zone I and was observed in 31 (60.8%) patients. We also observed that ocular trauma occurs more frequently in boys, especially in the summer months. Presence of traumatic cataract, Zone II and III injury was observed to be in relation with poorer final VA.

In the literature, OGIs were reported to occur mostly in the male gender (13, 14). Our findings were similar with these studies reporting a 3.6:1 ratio. Soylu et al. evaluated the etiology of pediatric perforating eye injuries in southern Turkey and demonstrated a ratio of 2.6:1 (15). This preponderance might be explained by not only the brisk nature of boys but also due to greater physical contact compared to girls (16, 17). Similar to our findings, previous studies have also suggested no significant difference regarding the affected eye (18). Even though the open globe injuries are demonstrated to occur mostly at home (14), studies from developing countries suggest that outdoor injuries are more common (19, 20). Consistent with these studies, we found that most of the open globe injuries in our study occurred outdoors. We also observed that outdoor injury was more common as the age increased given the fact that older children are more likely to engage in outdoor activities without parental supervision compared to younger peers.

Previous studies have reported that injuries with sharp objects such as knives or scissors are the most common cause of globe injury in the pediatric population (21, 22). However, there are studies from Turkey indicating metal objects, pieces of wood or glasses are presumably the cause of injury (23-25). In our study, 86,2% of all injuries were caused by sharp objects in accordance with previous studies(14, 26). In the current study, the injuries due to sharp objects were mostly caused by metal objects, wood splinters, and glass. In addition, one of the 51 injuries was caused by projectiles such as fireworks. To protect children from hazardous injuries at home, objects like knives, scissors, and other sharp utensils should be kept in a drawer with a safety latch. Glass objects should be stored in a high cabinet far from reach. The cause of injury might not be determined at times when parents or caregivers were unable to witness the incident. Studies report various rates of unknown causes of injury yielding a percentage of 2.0%-13.4% (27). However, in our study cause of injury was determined in all patients.

Our findings demonstrated a seasonal alteration regarding OGI. The majority of the OGI occurred in the summer (45.1%) followed by injuries in autumn, spring, and winter (19.6%, 17.7%, 15.7%, respectively). These findings are in accordance with other studies on eye injuries from Turkey (21, 28). Furthermore, studies from other countries including Croatia, China, and Canada have also reported a high percentage of eye injuries during summer months (10, 29, 30). Since the weather is cold, children spend most of their time in school under the supervision of their teachers and occupied with curricular activities such as homework during winter may explain the lower rates of injuries. However, children have the freedom to spend more unsupervised time outside and are thus exposed to potentially hazardous activities during summer.

Similar to previous studies, the majority of the injuries in our study were in Zone I (21, 31, 32). Complete ophthalmic examination and proper assessment may not be possible in the pediatric population especially in the emergency room settings. Therefore, the emergency physicians and ophthalmologists might be unable to determine the VA at the initial examination which is a vital parameter in estimating prognosis. In our study, we were unable to determine the initial VA in 35.2% of the patients. There are studies on OGI reporting various final VA below 0.1, which is described as legal blindness, ranging from 31% to 58% (13, 18, 33). In our study, the final VA was below 0.05 in 17.6% of the patients. This lower percentage might be explained by the unrecorded final VA in 27.5% of the study population.

It is acknowledged that IOP tends to fluctuate following complex ocular surgeries including the globe repair due to penetrating ocular injury. Aldahash et al. documented a final intraocular pressure (IOP) in %74 of the children with OGI (13). However, they did not report the IOP measurements after surgery. We also were unable to obtain IOP measurements after surgery due to lack of patient cooperation in our study population.

There have been controversial studies on the factors affecting the prognosis of OGI in which lens damage is described as one

of the poor prognostic factors yet other studies stated that it does not affect the visual outcome (22, 34). In our study, 13 patients had traumatic cataracts followed by iris prolapsus in 8, and hyphema in 6 patients at the initial examination. In accordance with some of the aforementioned studies, we observed that the presence of lens damage such as traumatic cataract was associated with poor vision. In addition, corneal scars and irregular astigmatism as a consequence of ocular penetrating injury, may be considered as other causes of low final VA since the majority of the pediatric OGI implicate Zone I and II. Also, corresponding retinal pathologies due to ocular trauma may be among potentially sight threatining causes.

We were unable to obtain the initial VA from the medical records in 31.4% of the patients, which is essential for calculating the Ocular Trauma Score (OTS). Kuhn et al. designed the OTS to determine the potential final visual outcome in patients with eye injury (35). Even though it has been a substantial tool to evaluate the prognosis of VA in ocular trauma, some studies revealed its limited predictive efficacy in pediatric ocular injury (36). In addition, OTS requires the evaluation of relative afferent pupillary defect (RAPD), which is difficult to assess especially in children. Therefore, Acar et al. released the POTS which facilitates the challenges of the OTS eliminating the necessity to determine patients' initial VA (3). The POTS is a tool to predict prognosis and visual outcomes regarding eye injuries in the pediatric population (3). Several studies have demonstrated that it is a reliable prognostic scoring system in pediatric globe injury (36, 37). Similar to these aforementioned studies, we found that VA and POTS scores were correlated in children with visual acuity of 0.1 and above at the final visit.

Open globe injury is predominantly more severe and generally accompanies complications, the need for surgical intervention, and poorer prognoses (14). Younger age and lower initial VA were assessed as poor prognostic factors in patients with OGI (38, 39). Younger children are more prone to amblyopia since the visual development continues until the age of 9-10 years (3). Therefore, deprivation amblyopia may cause devastating visual outcomes than the injury itself (3). Due to the nature of pediatric globe injuries and the development of amblyopia, the final VA is worse in children compared to adults even if appropriate medical interventions are provided (16). Educating children to avoid potentially sight-threatening activities, informing parents to take preventive measures, and keeping a safe environment by supervising the child at all times possible may help prevent such injuries.

Difficulties in obtaining data of importance in children such as VA, retrospective setting of the study, variable follow-up times, lack of certain time interval between the onset of ocular trauma and hospital admission, and the timing of surgery following hospital admission were among the limitations of this study. Longer follow-up times may be valuable to observe long-term outcomes of pediatric OGI. Also, we were unable to measure IOP following surgical intervention. Therefore, potential IOP fluctuations following surgery were not documented. Since all patients needed to be operated under general anesthesia, patients that have recently ingested foods could not be operated immediately. Therefore, the timing of the surgery varied to prevent potentially life-threatening complications of general anesthesia. In addition, only patients with OGI applied or referred to our tertiary hospital were included in the study. Therefore, we may have encountered a lower incidence of pediatric OGI.

5. CONCLUSION

Penetrating eye injuries are of great importance among pediatric emergencies. Corneal injuries are more common during childhood in particular. This kind of ocular trauma may cause not only functional but also psychosocial problems ranging from a permanent decrease in visual acuity to eye loss. Child and parent education and taking preventive measures to prepare a safe environment for children are of utmost importance. Since the cause of injury might not be determined at times when parents or caregivers were unable to witness the incident, objects like knives, scissors, and other sharp utensils should be kept in a drawer with a safety latch. Glass objects should be stored in a high cabinet far from reach to protect children from hazardous injuries at home. In addition, it is substantial for emergency physicians to be informed about pediatric penetrating eye injuries and to refer all children with suspected ocular trauma to be evaluated by an ophthalmologist in order to prevent medicolegal problems. Studies with larger sample sizes and longer follow-up times are needed to confirm the long-term outcomes of pediatric penetrating ocular injury.

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