CEOTI
Clinical and Experimental
Ocular Trauma and Infection

ORIGINAL ARTICLE

Received Date: 8 January 2019 Accapted Date: 28 March 2019 Publication Date: 23 April 2019

Prognostic Factors In Open Globe Injuries

**Selda Koyuncu,MD[1]; Ayşe Burcu,MD[2]; Evin Şingar,MD[2];
Ümit Ekşioğlu,MD[3]; Firdevs Örnek,MD[2]**

1 Ophthalmology Clinic, Alsancak Nevvar Salih İşgören State Hospital, İzmir, Turkey
2 Ophthalmology Clinic, University of Medical Science Ankara Training and Research Hospital, Ankara, Turkey
3 Ophthalmology Clinic, Başkent University Hospital, Ankara,Turkey

Abstract

Purpose: To detect the factors affecting the final visual acuity in open globe injuries.
Material And Methods: Fifty eight eyes of 58 patients who were treated for open globe injuries were analysed prospectively. Factors which are deemed to have effect on visual prognosis were examined statistically.
Results: Forty five patients (%77.6) were male, with a mean age of 29.6 ±19.4. Final visual acuity was 0.1 and lower in 28 (%48.3) cases. The prognostic factors predicting the final visual acuity were initial visual acuity, wound size, mechanism of the injury, presence of relative afferent pupillary defect (RAPD), zone of the injury, anterior chamber finding, lens injury, posterior segment finding, uveal injury and Ocular Trauma Score . According to multiple retrospective logistic regression analysis, those factors having the highest effect on final visual acuity were found to be presence of an RAPD, female gender, old age and large laceration respectively.
Conclusion: Initial examination findings are helpful for predicting the visual outcome in open globe injuries. Therefore, standardization in classification of the initial examination findings is compulsory.

Keywords: open globe injury, ocular trauma, penetrating eye injury, visual outcome

Introduction

Eye injuries are one of the leading reasons of low vision and blindness all over the world (1).
The aim of treatment in cases with open globe injury is both to provide the integrity of the globe and to reach the best possible final visual acuity (VA). In these cases, knowing the factors which may affect the final visual acuity will provide an insight for ophthalmologists during surgical intervention as well as clarifying patient and his/her family in pre-operative period regarding visual prognosis. Also, it will reveal the parameters to be valued during the follow-up period of cases post-operatively.
In this study, it was aimed to search the factors having effect on final visual acuity in open globe injuries.

Material And Methods

After obtaining approval of Clinical Research Ethics Committee of our institution, 58 eyes of 58 patients treated for open globe injury in Unversity of Medical Science Ankara Training and Research Hospital Ophthalmology Clinics between October 2007 - October 2008 were examined in terms of final visual acuity and factors affecting it prospectively.
While final visual acuity was evaluated, legal blindness limit (0.1 with Snellen's chart) and below was accepted

Corresponding author: Dr. Selda Koyuncu, MD; Alsancak Nevvar Salih İşgören Devlet Hastanesi,
Ali Çetinkaya Bulvarı, No: 6 Konak, İzmir, TURKEY e-mail: seldakoyuncu@gmail.com Tel: +90 505 272 00 36

as unsuccessful outcome. Effects of pre-operative variables on unsuccessful outcome was searched. Unconscious patients and children who could not cooperate for detecting visual acuity and patients who had a history of previous vision lowering eye condition in the injured eye were excluded. Cases whose follow-up period was less than 6 months were excluded, however, cases who were eviscerated not later than 6 months were included.

Open globe injury was defined as a full thickness (sclera and/or cornea) injury of the eye wall as determined in Birmingham Eye Trauma Terminology (2). Cases were classified according to ocular trauma classification system defined by Ocular Trauma Classification Group (3). Accordingly, type of injury was described as [1] rupture ; [2] penetrating; [3] intra-ocular foreign body (IOFB); [4] perforating or [5] mixed , degree of injury was described according to initial best corrected visual acuity (BCVA) as; 1st degree: 0.5 and better, 2nd degree: visual acuity less than 0.5, including 0.2, 3rd degree: less than 0.2, including 0.1, 4th degree: less than 0.1, including light perception (LP) and 5th degree: no light perception (NLP), presence of relative afferent pupillary defect; as positive or negative in the affected eye, zone of injury was defined as zone I, II and III. Zones are described as follows; Zone 1: Limited to cornea or limbus, Zone 2: Limbus and up to 5mm of sclera, Zone 3: full thickness scleral injuries more than 5mm from limbus.

In addition to prognostic variables in ocular trauma classification system, other variables which were stated to have prognostic value in open globe injuries in the previous series were examined. Thus; type of injury, degree of injury, injury zone, presence of relative afferent pupilla defect (RAPD), wound size, time passed up to primary repair, surgical procedures apart from primary repair, accompanying anterior and posterior segment findings (hyphema, cell or fibrin reaction, shallow anterior chamber, presence of foreign body, lens damage, uveal damage, vitreous loss, vitreous hemorrhage, retinal hemorrhage, retinal detachment, choroid rupture or detachment, macular edema) were examined statistically in terms of effects on visual outcomes.

Ocular Trauma Scores (OTS) of cases were noted.

Statistical Analysis

Analysis of data was conducted in SPSS for Windows 11.5. While descriptive statistics were shown as mean ± standard deviation for continuous variables, nominal variables were shown as number of case and (%). Whether risk factors which may have effect on final visual acuity are statistically significant or not was evaluated with Single Variable Logistic Regression Analysis. Co-effects of risk factors which affect or are considered to affect the final visual acuity in single-variable statistical analyses result were evaluated with Multiple Variables Logistic Regression Analysis. In single-variable analyses, variables for which $p<0.25$ was found were included into multiple-variable model as candidate risk factor. Odds ratio and 95% confidence intervals belonging to each variable were calculated. Results for $p<0.05$ were accepted as statistically significant.

Results

Forty five (77.6%) of cases were male, 13 (22.4%) were female. Mean age was 29.6 ±19.4 (3-78) (Table 1). Time of admittance for medical care after the injury was 14.6 ± 20.8 (0.5 - 96) hours, period between injury and reparation was 23.2 ± 24.9 (1-120) hours.

Table 1. Demographical Features

Variables	N (58)
Age	29.6±19.4 (3-78 years)
Gender	
Male	45 (%77,6)
Female	13 (%22,4)
Injury Mechanism	
Penetrating	37 (63.8%)
Rupture	11 (19.0%)
IOFB	10 (17.2%)
Zone	
Zone 1	34 (58.6%)
Zone 2	11 (19.0%)
Zone 3	13 (22.4%)
RAPD positivity	21 (36.2%)
Final Visual Acuity	
≤ 0,1	28 (48.3%)
≥0,2	30 (51.7%)

IOFB: Intraocular foreign body

RAPD: Relative afferent pupillary defect

Table 2. Distribution of Cases by Degree of injury

Initial Visual Acuity	Degree of injury	Number of Cases (%)
NLP	5th degree	5 (8.6%)
<0.1, ≥LP	4th degree	44 (76%)
<0.2, ≥0.1	3rd degree	1 (1.7%)
<0.5, ≥0.2	2nd degree	3 (5.1%)
0.5 and above	1st degree	5 (8.6%)

NLP: No light perception

Final visual acuity of 0.1 and lower was found in twenty eight (48.3%) cases. Degree of injury was determined by initial BCVA and graded from 1 to 5 (Table 2.3). Each one degree of decrease in initial BCVA resulted in a 3.68 folds risk of attaining a final visual acuity of 0.1 or worse (95% confidence interval: 1.14-11.90) (Table 4).

Injury zones of the cases are showed in Table 1. There was no significant difference between Zone 1 and Zone 2 in terms of final visual acuity, however when Zone 3 injuries were compared with Zone 1 injuries, Zone 3

Table 3. Final Visual Acuity by Degree of Injury, Mechanism of Injury, Zone, RAPD and Distribution of OTS

	Final Visual Acuity (FVA)				
	Eviscerated (n=5)	NLP (n=7)	LP ≤FVA ≤0.1 (n=16)	0.1<FVA<0.5 (n=3)	FVA ≥0.5 (n=27)
Degree of Injury					
5th Degree	2 (3.4%)	3 (5.2%)	-	-	-
4th Degree	3 (5.2%)	4 (6.9%)	15 (25.9%)	3 (5.2%)	19 (32.8%)
3rd Degree	-	-	-	-	1 (1.7%)
2nd Degree	-	-	1 (1.7%)	-	2 (3,4%)
1st Degree	-	-	-	-	5 (8.6%)
Mechanism of Injury					
Rupture	1 (1.7%)	6(10.3%)	3 (5.2%)	-	1 (1.7%)
Penetrating	4 (6.9%)	1 (1.7%)	11 (19.0%)	3 (5.2%)	18 (31.0%)
IOFB	-	-	2 (3.4%)	-	8 (13.8%)
Zone					
Zone 1	2 (3.4%)	-	10 (17.2%)	3 (5.2%)	19 (32.8%)
Zone 2	1 (1.7%)	2 (3.4%)	2 (3.4%)	-	6 (10.3%)
Zone 3	2 (3.4%)	5 (8.6%)	4 (6.9%)	-	2 (3.4%)
RAPD					
Positive	5 (8.6%)	6(10.3%)	8 (13.8%)	-	2 (3.4%)
Negative	-	1(1.7%)	8(13.8%)	3 (5.2%)	25(43.1%)
OTS					
1	3 (5.2%)	6(10.3%)	2 (3.4%)	-	-
2	2 (3.4%)	-	6 (10.3%)	-	2 (3.4%)
3	-	1 (1.7%)	7 (12.1%)	3 (5.2%)	15 (25.9%)
4	-	-	1 (1.7%)	-	5 (8.6%)
5	-	-	-	-	5 (8.6%)

NLP: No light perception, IOFB: Intraocular foreign body, RAPD Relative afferent pupillary defect, OTS, Ocular trauma score

Table 4. Effects of Degree of Injury, Mechanism of Injury, Zone and RAPD on Final Visual Acuity

	Final Visual Acuity		
	≤ 0.1 (n=28)	≥ 0.2 (n=30)	P value
Degree of Injury			0.005
1st Degree	-	5 (16.7%)	
2ndDegree	1 (3.6 %)	2 (6.7%)	
3rd Degree	-	1 (3.3%)	
4th Degree	22 (78.6%)	22 (73.3%)	
5th Degree	5 (17.9%)	-	
Mechanism of Injury			0.003
Penetrating	16 (57.1%)	21 (70.0%)	
Rupture	10 (35.7%)	1 (3.3%)	
IOFB	2 (7.1%)	8 (26.7%)	
Zone			<0.001
Zone 1	12 (42.9%)	22 (73.3%)	
Zone 2	5 (17.9%)	6 (20.0%)	
Zone 3	11 (39.3%)	2 (6.7%)	
RAPD			<0.001
No	9 (32.1%)	28 (93.3%)	
Yes	19 (67.9%)	2 (6.7%)	

IOFB: Intraocular foreign body, RAPD Relative afferent pupillary defect

injuries resulted in 10.083 folds of attaining low final visual acuity (95% confidence interval:1.982-53.177).

Distribution of the cases according to the injury mechanism are presented in Table 3. There wasn't any case with perforating or mixed type injury. In cases having rupture, the possibility of low final visual acuity was found 13.12 folds (95% confidence interval: 1.52-113.362) higher compared with penetrating injury. It was seen that intra-ocular foreign body did not affect final visual acuity significantly compared with penetrating injury.

RAPD was positive in twenty-one cases (36.2%) and negative in 37 cases (63.8%). Presence of RAPD was increasing the possibility of worse visual outcome by 29.556 folds (95% confidence interval: 5.738-152.240) (p<0.001) (Table 4).

Wound size ranges between 0.5 mm and 40 mm with a mean value of 9.61±8.35 mm. Each 3mm of increase in wound size increased the possibility of finding low final visual acuity by 1.87 folds (95% confidence interval: 1.29-2.69) (p=0.001).

OTS score was 2 and below in 21 cases (%36.2), it was 3 and above in 37 cases (63.8%) The scorings were as follows: OTS equaled 1 in 11 cases (% 19), 2 in 10 cases (%17.3), 3 in 26 cases (% 44.8), 4 in 6 cases (%10.3) and 5 in 5 cases (%8,6).

Each one point decrease in OTS was increasing the deterioration possibility of final visual acuity as much as 8.13 folds (95% confidence interval: 2.56-25.64) (p<0.001).

Mean follow-up period of patients was 10.88 ± 5.3 months; they were followed at least 1 month, at most 24 months. Ones who had follow-up period less than six months were those who were eviscerated before six months of period.

In the initial examination, presence of an anterior chamber finding such as hyphema, cell or fibrin reaction, shallow anterior chamber and presence of a foreign body

Table 5. Effect of Lens Damage, Uveal Damage , Vitreous Loss and Posterior Segment Findings at the Initial Examination on Final Visual Acuity

	Final Visual Acuity		
	≤ 0.1 (n=28)	≥ 0.2 (n=30)	P value
Lens Damage	24 (85.7%)	13 (43.3%)	0.001
Uveal Damage	8 (28.6%)	-	0.002
Vitreous Loss	18 (64.3%)	4 (13.3%)	<0.001
Posterior Segment Finding	17 (60.7%)	7 (23.3%)	0.004

Table 6. Additional Surgical Interventions

Surgical Intervention	n
Cataract Surgery †	18
Secondary IOL implantation	5
Evisceration	5
Penetrating Keratoplasty††	1
Dura cover	1
Iris reposition	1
Suture revision	1

†: IOL implantation in nine eyes in the same session, synechiotomy, pupilloplasty were performed in 2 eyes.
††: On the same session; synechiotomy, pupilloplasty and secondary IOL implantation were performed.

was increasing the risk of decrease in final visual acuity (p=0.026). When hyphema was examined alone, it was seen that it affected final visual acuity negatively, how ever this result was not statistically significant (p=0.069). Lens damage, uveal damage and vitreous loss were decreasing the final visual acuity significantly (p<0.001, p=0.002, p<0.001, respectively) (Table 5).

In cases who had posterior segment finding such as vitreous hemorrhage, retinal hemorrhage, retinal detachment, choroid rupture or detachment and macular edema in the first examination, the possibility of having low final visual acuity was found to be significantly higher (p=0.004) (Table 5).

While thirty one cases did not require another surgical intervention after primary reparation, one additional surgical intervention was required for 18 cases (31%);

more than one additional surgical interventions were required for 9 cases (15.5%). Number of surgical operations applied had no significant effect on visual acuity (p=0.118). Applied surgical interventions were listed in Table 6.

Effect of initial visual acuity, wound size, mechanism of injury, RAPD, zone, anterior chamber finding, lens damage, posterior segment finding, vitreous loss and OTS on unfavorable prognosis of final visual acuity was found statistically significant according to single variable statistical analyses. Effects of candidate risk factors such as age, gender, hyphema, presence of intra-ocular foreign body which were anticipated to effect the final visual acuity in multiple variable analysis were examined together with these factors. According to the Multiple Retrospective Stepwise Logistics Regression analysis, those factors having the highest effect on final visual acuity were found to be presence of RAPD (p<0.001), female gender (p=0.020), large laceration (p=0.029) and advanced age (p=0.032), respectively.

Discussion

In our study, demographical features and initial examination findings of cases who were treated for open globe injury were determined and factors having effect on final visual acuity were searched.

Features related with injury itself as well as numerous anatomical and physiological features of the injured eye were defined among factors determining the prognosis in open globe injuries. There are initial visual acuity (4-11) , wound localization and size (5,7,9-12) , presence of RAPD (5,7,8) , injury mechanism (5,7-9), vitreous hemorrhage (5-7,13), lens damage (5-7), retinal detachment (8,12,14), intra-ocular foreign body and endophthalmitis (10) among these factors. Ocular Trauma Classification Group examined these factors in order to standardize the classification of eye injuries and selected four features for using in the classification. These criteria are injury type (mechanism), degree of injury, pupillary state (whether there is RAPD or not) and wound localization (zone) (3).

Factors having statistically significant effect on lowering the final visual acuity according to single-variable statistical analyses are initial visual acuity, incision size, injury mechanism, presence of RAPD, zone, lens damage, anterior chamber finding, posterior segment finding, vitreous loss and low OTS value.

The distribution of the cases by gender was similar to the literature (1): 22.4% female and 77.6 % male. Male to female ratio was 2/7. The reason why female cases had worse visual prognosis in our study may be because of statistical bias due to the low number of female patients. Strernberg et al. reported better visual results for cases younger than 18 (4). For our cases, the older the patient, the lower the final VA and this was statistically significant (p=0.032). This may be because of poorer wound healing and accompanying systemic conditions in older cases. Another possible reason is that, older cases usually had ruptures because of falls and antler hits whereas younger patients mostly had penetrating injuries.

Many studies showed that initial visual acuity is an important factor in prediction of visual outcome (4-6,12). In the study where Sternberg et al. stated that initial visual acuity is the most important factor; groups having initial visual acuity of above and below 20/800 were compared and the group with the higher initial visual acuity had better final results (4). Pieramici et al. noted that in cases whose initial visual acuity was 6/60 or above, enucleation rate was decreasing significantly, and 34% of cases with initial visual acuity of below 6/60 were enucleated (5). In study of Groessl et al., initial visual acuity of at least hand movements level achieved higher final visual acuity (12). Barr stated that initial visual acuity is a prognosis determinant in corneascleral laceration (6). In a similar way, each one degree of decrease in initial visual acuity in our cases was increasing the possibility of finding low final visual acuity as much as 3.68 folds (95% confidence interval:1.14-11.90).

Pieramici et al. noted that the best final visual acuity is in penetrating injuries by injury mechanism and intra-ocular foreign body, globe rupture and perforating injuries followed this respectively (16). Martin et al. stated that perforating injuries have the worst prognosis (17). In our study, there was not any perforating or mixed type injuries. Final visual acuity was better in penetrating injuries compared with rupture, a similar result with above mentioned series.

In our cases, intra-ocular foreign body did not affect the final visual acuity. Pieramici et al. compared two wide series, and reported similar prognosis for intra-ocular foreign body and penetrating injuries (5). Brinton (13) and Sternberg (4) stated that presence of intra-ocular foreign body is associated with better visual outcome. De Juan (7) and Esmaeli (9) noted that intra-ocular foreign body has no statistically significant effect on visual outcomes. Nevertheless, Ahmedieh et al. noted that intra-ocular foreign body is an important determinant of poor vision prognosis (18).

The size, shape, structure (metal, organic, glass etc.) of the IOFB, position and size of entry wound are the factors affecting prognosis in IOFB injuries. While final visual acuity was found better in intra-ocular foreign bodies smaller than 3mm in various studies (19); final visual acuity for intra-ocular foreign bodies which are not sharp (20,21), non-metal (22), glass (23) or localized to posterior segment was found to be poor.

Intra-ocular foreign bodies in our cases were mostly localized to anterior chamber, iris and lens. It was in retina in one case and in pars plana in 2 cases, all of them were smaller than 2mm. The relative anterior location, small size and sharp nature is thought to be responsible for the favorable visual outcome in our cases.

RAPD has been shown to be a significant risk factor (24-26). Similarly,in our cases presence of RAPD increased the possibility of low final visual acuity as much as 54,247 folds (95% confidence interval: 5.510-534.096) .

In the previous studies, it was stated that, the more posterior the wound extended, the greater the probability of poor visual outcome (4,5,7,8,12,13). In our cases there was no significant difference between Zone 1 and Zone 2, however when Zone 3 injuries attained 10.083 folds (95% confidence interval:1.982-53.177) risk for low visual acuity compared with Zone 1 injuries.

Wound size was affecting visual outcome significantly in our cases concurrent with the literature (5,7,8,13,27).

As OTS value of our cases decreased, final visual acuity decreased and this result was found statistically significant ($p<0.01$). Thus, importance of OTS in treatment plan of physician is addressed once more.

There are different opinions regarding effect of reparation time in open globe injuries on visual outcome. Ahmadieh et al. reported 1.16 fold risk increase for each one day of delay (18). On the other hand, Rofail et al. stated that in the series where reparation was applied within a mean of 35.8 hours, this period did not affect final visual acuity (24). Barr also showed no relation between period passed up to reparation and final visual acuity (6). Similarly, in our cases, visual prognosis was not affected by reparation time. It should be stated that, the elapsed time between injury and surgery is not as much long as the study of Ahmadieh et al. with an mean of 23.2 ± 24.9 (1-120) hours in our cases.

Pieramici et al.(5) , Barr (6) and Cruvinel et al. (27) found unfavorable visual results in presence of lens damage, in the study of Brinton et al.(13) , lens damage did not affect the visual prognosis. In our study, it was concluded that uveal damage , vitreous loss and lens damage were indicators of poor prognosis

Consistent with studies (7,13,25,27) which draw attention to the fact that posterior segment findings such as vitreous loss, vitreous hemorrhage, retinal hemorrhage, retinal detachment, choroid rupture or detachment and macular edema are correlated with poor visual outcome, presence of posterior segment findings was increasing the risk of poor visual prognosis.

In our study, need of additional surgical intervention did not effect the final visual outcome. While this is compatible with some studies (27,28), some series state that surgical interventions required for treatment of complications particularly in pediatric cases affected the visual prognosis negatively (29,30). Pieramici et al. (5) and Groessl et al. (12) showed significant effect of number of surgical interventions on the final visual acuity. It is not surprising that final visual acuity was poor in cases who required more surgical interventions for providing globe integrity. For our cases, lens extraction and intra-ocular lens implantation were left to the second session since open globe injuries are treated as an emergency approach, this situation increased the number of mean surgical procedures in our cases. Unlike in the literature, the reason why the number of additional surgical interventions did not negatively affect visual acuity in our study might be based on that. Also by the advancement of microsurgical technology in recent years, better results can be achieved in cases having serious injury and requiring additional surgical intervention .

It was found out that initial examination findings of patient who applies with open globe injury have important clues related with visual prognosis. Therefore, BCVA and the other findings should be noted carefully in the management of all open globe injuries. Standardization is compulsory in classification of injuries for evaluating the cases properly and applying the results obtained from previous studies on a given case. This will equip both the doctor and the patient with realistic expectations about the visual outcome.

References

1- May DR, Kuhn F, Morris R. The epidemiology of serious eye injuries from the United States Eye Injury Registry. Graefes Arch Clin Exp Ophthalmol. 2000;238:153-157.

2- Kuhn F , Morris R , Witherspoon D, et al. A standardized classification of ocular trauma. Ophthalmology .1996 ; 103 : 240-243.

3- Pieramici DJ , Sternberg P , Aaberg TM, et al. A system for classifying mechanical injuries of the eye (globe) . Am J Ophthalmol. 1997;123 : 820-831.

4- Sternberg PJ, De Juan EJ, Michels RG et al. Multivariate analysis of prognostic factors in penetrating ocular inju-

ries. Am J Ophthalmol .1984; 98: 467–72.
5- Pieramici DJ, MacCumber MW, Humayun MU, et al. Open globe injuries. Update on types of injuries and visual results. Ophthalmology. 1996; 103:1798–1803.

6- Barr CC. Prognostic factors in corneoscleral lacerations. ArchOphthalmol. 1983;101:919–924.

7- de Juan E, Sternberg P, Michels R. Penetrating ocular injuries: types of injuries and visual results. Ophthalmology. 1983;90:1318–1322.

8- Hutton WL, Fuller DG. Factors influencing final visual results in severely injured eyes. Am J Ophthalmol. 1984;97:715–722.

9- Esmali B, Elner SG, Schork A, et al. Visual outcome and ocular survival afte rpenetrating trauma. Ophthalmology. 1995;102:393–400.

10- Williams DF, Mieler WF, Abrams GW, et al. Results and prognostic factors in penetrating ocular injuries with retained intraocular foreign bodies. Ophthalmology. 1988;95:911–916.

11- Moncreiff WF, Scheribel KJ. Penetrating injuries of the eye: a statistical survey. Am J Ophthalmol. 1945;28:1212–1220.

12- Groessl S, Nanda SK, Mieler WF. Assault-related penetrating ocular injury. Am J Ophthalmol. 1993; 116: 26–33.

13- Brinton GS, Aaberg TM, Reeser FH, et al. Surgical results in ocular trauma involving the posterior segment. Am J Ophthalmol. 1982;93:271–278.

14- Fujikawa A, Mohamed YH, Kinoshita H,et al. Visual outcomes and prognostic factors in open-globe injuries. BMC Ophthalmol. 2018 Jun 8;18(1):138.

15- Han SB, Yu HG. Visual outcome after open globe injury and its predictive factors in Korea. J Trauma. 2010;69(5):E66–E72.

16- Lin H, Lema GM, Yoganathan P. Prognostic indicators of visual acuity after open globe injury and retinal detachment repair. Retina. 2016;36(4):750-757.

17- Pieramici DJ, AuEong K, Sternberg PJ, et al. Prognostic significance of a system for classifying mechanical injuries of the eye (globe) in open-globe injuries. J Trauma. 2003; 54: 750–754.

18- Martin DF, Meredith TA, Topping TM, et al. Perforating (through and through) injuries of the globe, surgical results with vitrectomy. ArchOphthalmol. 1991;109:951–956.

19- Beshay N, Keay L, Dunn H, et al. The epidemiology of open globe injuries presenting to a tertiary referral eye hospital in Australia. Injury. 2017;48(7):1348–1354.

20- Ahmadieh H, Soheilian M, SajjadiH, et al. Vitrectomy in ocular trauma; factors influencing final visual outcome. Retina.1993;13:107—113.

21- Stryjewski TP, Andreoli CM, Eliott D. Retinal detachment after open globe injury. Ophthalmology 2014;121:327–333.

22- Chiquet C, Zech JC, Gain P, et al. Visual outcome and prognostic factors after magnetic extraction of posterior segment foreign bodies in 40 cases. Br J Ophthalmol. 1998;82(7):801-806.

23- Chiquet C, Zech JC, Denis P, et al. Intraocular foreign bodies. Factors influencing final visual outcome. Acta Ophthalmol Scand. 1999 ;77(3):321-325.

24- Sternberg P Jr, de Juan E, Michels RG. Penetrating ocular injuries in young patients. Retina. 1984;4:5-8.

25- Pavlovic S, Schmidt KG, Tomic Z, et al. Management of intra-ocular foreign bodies impacting or embedded in the retina. Aust N Z J Ophthalmol. 1998;26(3):241-246.

26- Gopal L, Banker AS, Deb N, et al. Management of glass intraocular foreign bodies. Retina. 1998;18(3):213-220.

27- Rofail M, Lee GA, O’Rourke P. Prognostic indicators for open globe injury. Clin Experiment Ophthalmol. 2006;34:783–786.

28- Rahman I, Maino A, Devadason D, et al. Open globe injuries: Factors predictive of poor outcome. Eye. 2006; 20: 1336–1341

29- Schmidt GW, Broman AT, Hindman HB, et al. Vision survival after open globe injury predicted by classification and regression tree analysis. Ophthalmology. 2008;115(1):202-209.

30- Soni NG, Bauza AM, Son JH, et al. Open globe ocular trauma: functional outcome of eyes with no light perception at initial presentation. Retina. 2013;33(2):380–386.

31- Cruvinel-Isaac DL, Ghanem VC, Nascimento MA, et al. Prognostic factors in open globe injuries. Ophthalmologica. 2003; 217: 431–435.

32- Kuhn F, Maisiak R, Mann L, et al. The Ocular Trauma Score (OTS). Ophthalmol Clin North Am. 2002 Jun;15(2):163-165.

33- Farr AK, Hairston RJ, Humayun MU, et al. Open globe injuries in children: a retrospective analysis. J Pediatr Ophthalmol Strabismus. 2001;38:72-77.

34- MacEwen CJ, Baines PS, Desai P. Eye injuries in children: the current picture. Br J Ophthalmol. 1999;83:933-936.

35- Rostomian K, Thach AB, Isfahani A, et al. Open globe injuries in children. J AAPOS.1998;2:234-238.