ISSN: 2573-9573

Research Article

Journal of Ophthalmology & Clinical Research

Identification of Ocular Trauma Pattern with Risk and Prognostic Factors in the North Bund Area of Shanghai

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Submitted: 27 May 2021; **Accepted:** 03 June 2021; **Published:** 18 June 2021

Citation: *Jian Zhang, Fang Wei, Shimei Chen, Yan Suo, Xieyi Yao, et al. (2021) Identification of Ocular Trauma Pattern with Risk and Prognostic Factors in the North Bund Area of Shanghai. J Ophthalmol Clin Res 5(2): 93-100.*

Abstract

Background: *Ocular trauma is a leading cause of blindness. Identification of ocular trauma pattern is necessary for better ocular trauma prevention and treatment.*

Objective: *The aim of this study is to identify ocular trauma pattern in the North Bund area of Shanghai.*

Methods: *A retrospective cross-sectional study was conducted with 206 ocular trauma patients at Shanghai General Hospital.*

Results: *A gender related ocular trauma pattern was identified that consists of several risk and prognostic factors. Of 206 ocular trauma patients, 182 patients were males (88.35%) and only 24 patients were females (11.65%). Males had significantly higher percentage of penetrating/intraocular foreign body injuries compared to females, which is associated with age and occupation. A significantly higher average monthly percentage of ocular trauma is observed in summer, suggesting that season change alters the risk of eye injury. Although proper treatments of complications are beneficial for patients, the visual outcome is determined by the location and size of injuries.*

Conclusion: *We identified a gender related ocular trauma pattern with several risk and prognostic factors in the North Bund area of Shanghai.*

Keywords: Age, Ocular trauma, Occupation, Complications, Location and Size of injuries, Season change, Visual outcome

Abbreviations

VA: Vision acuity
LP: Light perception
NLP: No light perception
IOFBs: Intraocular foreign bodies
VH: Vitreous hemorrhage
RD: Retinal detachment
Y/O: Years old
PPV: Pars plana vitrectomy
PPE: Personal protection equipment

Introduction

Blindness is one of the top public health issues worldwide that has profound socioeconomic and psychological impacts on patients and their families. It is estimated that ocular trauma contributes to about 0.5 million new blind peoples every year. The number of blind peoples will continue to increase if no effective preventive actions are taken, which could be worse in the era of pandemics due to limited medical resources [1].

Studies have shown that the incidence of hospitalized eye injuries ranges from 6.5 to 27.7 cases per 100,000 persons annually in developing countries [2,3]. About 55 million ocular injuries cause restricted activities for more than one day per year. Among these patients, 0.75 million need hospitalization each year, and 1.6 million become blind owing to the severity of ocular trauma. In total, nearly 19 million people become blind unilaterally or with low vision eventually [4]. Blindness and the possibility of ophthalmectomy always put the patients and their families under much inconvenience and huge stresses, and inevitably lower their life quality. Therefore, it is necessary to identify ocular trauma pattern with risk and prognostic factors for eye injury prevention in different areas.

In recent years, millions of laborers pour into Shanghai, which increases the risk of ocular trauma in an intensive working environment. However, the ocular trauma pattern still remains unclear in Shanghai. Shanghai General Hospital, located in the Houkou district of Shanghai, is the largest health care centre for ocular disease treatment in the North Bund area of Shanghai that covers 800,000 native residents and more than 150,000 workers. In this study, we reviewed a 206-ocular trauma patient cohort at Shanghai General Hospital from January 2016 to December 2018, aiming to identify the ocular trauma pattern with risk and prognostic factors in this area, which could shed new light in eye injury prevention in current pandemic era.

Materials and Methods

Methods

This is a retrospective cross-sectional cohort study with 206 ocular trauma patients from January 2016 to December 2018 in the department of ophthalmology at Shanghai General Hospital. All research activities were performed in adherence to the Declaration of Helsinki and approved by the Research Council and the Research Ethics Committee of Shanghai General Hospital.

Patients who have trauma in one eye and being hospitalized for at least one day were enrolled into this study. None of the patients have a multi-system trauma. All enrolled patients received first evaluation at the emergency room, followed by careful eye examination by one of attending ophthalmologists and re-evaluation by one of the authors. Demographics and related patient's clinical data were recorded, including age, gender, occupation, cause, location and size of injury, type of trauma, type of surgery, and hospitalization time. Pieramici's standard classification was adopted for analysing the type of ocular trauma [5]. The trauma details were further classified into three groups according to the wound size (in mm): group 1 ≤ 5 mm, 5mm < group 2 ≤ 10 mm, and group 3 ≥ 10mm.

The grade and condition of eyeball injury is based on the visual condition of the initial examination. All patients were examined using the standard logarithmic vision acuity (VA) chart, and the best VA for each patient was recorded. VA score was divided into the following four levels: level I ≥ 0.3 (VA I), 0.05 ≤ level II < 0.3 (VA II), light perception (LP) ≤ level III <0.05 (VA III), and level IV = no light perception (NLP, or VA IV). The VA score of each patient at the first visit at the emergency room was recorded as initial VA. After surgeries or treatments were conducted on the first visit, all the patients had three follow-up visits: one week after first visit, one month after first visit, and three months after first visit. Because usually patient's visual function is stable around three months after surgery, we chose this follow-up visit to record final VA.

Wound locations were classified into three zones according to the Ocular Trauma Classification Group: 1) Zone I, injuries involved only cornea and limbus; 2) Zone II, injuries were confined to the anterior 5 mm from the limbus (no retina involved); and 3) Zone III, injuries extended into the posterior by more than 5 mm from the limbus [6]. In cases of multiple corneoscleral wounds, the zone was defined according to the most posterior openings. Also, in cases of intraocular foreign bodies (IOFBs), the zone was defined at the specific entry spot. For perforating wounds caused by explosive accidents, mainly occurred during firework display, however, the zone was defined by the most posterior spot, usually the exit site. Most of the injuries were classified into a specific zone at the time of the initial examination, unless in some cases, the wounds had to be more precisely determined during the surgical exploration.

Complications can be directly or indirectly caused by trauma. As previously reported, lens dislocation, vitreous hemorrhage (VH), retinal detachment (RD), and traumatic endophthalmitis are four common complications [6]. Hence, these four types of complications were also evaluated and recorded.

Statistical Analysis

The data were collected and analysed based on the following factors: gender, age, occupation, season change, complications, location and size of injuries, and visual outcome. Statistical analyses were carried out using Graph Pad Prism 8 software. Chi-square test was used to compare the impact of various factors on ocular trauma cases and visual outcomes, and the results were presented as % cases or % injury type, and etc. One-way ANOVA was used to compare the impact of season change on the monthly percentage of ocular trauma. The percentage was calculated by the formula: % = (group case number/total case number 206) *100. $P < 0.05$ was considered significant.

Results

Ocular Trauma Pattern is Associated with Gender in the North Bund Area of Shanghai

Totally, 206 patients were reviewed at Shanghai General Hospital from January 2016 to December 2018. Of 206 patients, 96.12% of patients (n=198) were hospitalized for more than one day, and 77.67% of patients (n=160) received surgical treatment within the first 24 hours of trauma. We found that majority of ocular trauma patients (88.35%, n=182) is male, only a small portion of patients is female (11.65%, n=24) (Table 1, Figure 1A&B). Moreover, in the category of blue-collar worker, none of ocular trauma patients is female but all are males (Table 1). Ocular trauma type analysis revealed that male patients are the major source of penetrating injury (33.49%, n=69) and IOFBs (33.49%, n=69). In contrast, majority female patients had non-penetrating and IOFBs-free injuries (Table 2, Figure 1C&D). Collectively, these data strongly indicate that the ocular trauma pattern in the North Bund area of Shanghai is closely related to gender.

Table 1: Demographics of ocular trauma patients

Category	Case number (n)	Percentage (%)
Male (M)	182	88.35
Female (F)	24	11.65
Hospitalized > 1 day	198	96.12
Surgery received	160	77.67
Hospitalized for 1 day	8	3.88
Age (y/o)		
0-7	3 (1[a], 2[b])	1.46 (0.48[a], 0.97[b])
8-18	5 (4[a], 1[b])	2.43 (1.94[a], 0.48[b])
19-39	53 (52[a], 1[b])	25.72 (25.24[a], 0.48[b])
40-60	95 (91[a], 4[b])	46.12 (44.17[a], 1.94[b])
>60	50 (34[a], 16[b])	24.27 (16.50[a],7.77[b])
Occupation		
Child	3 (1[a], 2[b])	1.46 (0.48[a], 0.97[b])
Student	5 (2[ac], 2[ad], 1[bc])	2.43 (0.97[ac], 0.97[ad], 0.48b[c])
Blue-collar worker	121[a] (49[c], 64[d], 8[e])	58.74a (23.79[c], 31.07[d], 3.88[e])
Farmer	8[a] (7[c], 1[d])	3.88a (3.40[c], 0.48[d])
Retiree	58 [42[a] (7[c], 2[d], 33[e]), 16[b]]	28.16 [20.39[a] (3.40[c], 0.97[d],16.02[e]), 7.77[b]]
Clerk	11 [6[a] (4[c], 2[e]), 5[b]]	5.34 [2.91[a] (1.94[c], 0.97[e]), 2.43[b]]
a, male; b, female; c, penetrating injury; d, IOFBs; e, other injuries		

Table 2: Ocular trauma distribution by cause and trauma type

Damaging means		Cases	Percentage (%)
During work		111[a]	53.88
Road accident		34 (24[a], 10[b])	16.5 (11.65[a], 4.85[b])
Explosive accident		13 (9[a], 4[b])	6.31 (4.37[a], 1.94[b])
Quarrel and fight		40 (30[a], 10[b])	19.42 (14.56[a], 4.85[b])
During a game or sport		8[a]	3.88
Type of trauma			
Open globe injuries			
	Penetrating (IOFBs -free, caused by sharp object))	70 (69[a], 1[b])	33.98 (33.49[a], 0.48[b])
	IOFBs (Caused by sharp object)	69[a]	33.49
	Perforating (Caused by explosive accidents, such as firework)	13 (9[a], 4[b])	6.31 (4.37[a], 1.94[b])
	Rupture	6 (3[a], 3[b])	2.91 (1.46[a], 1.46[b])
Closed globe injuries	Contusion (Caused by blunt object)	46 (32[a], 14[b])	22.33 (15.53[a], 6.80[b])
a: Male; b: Female			

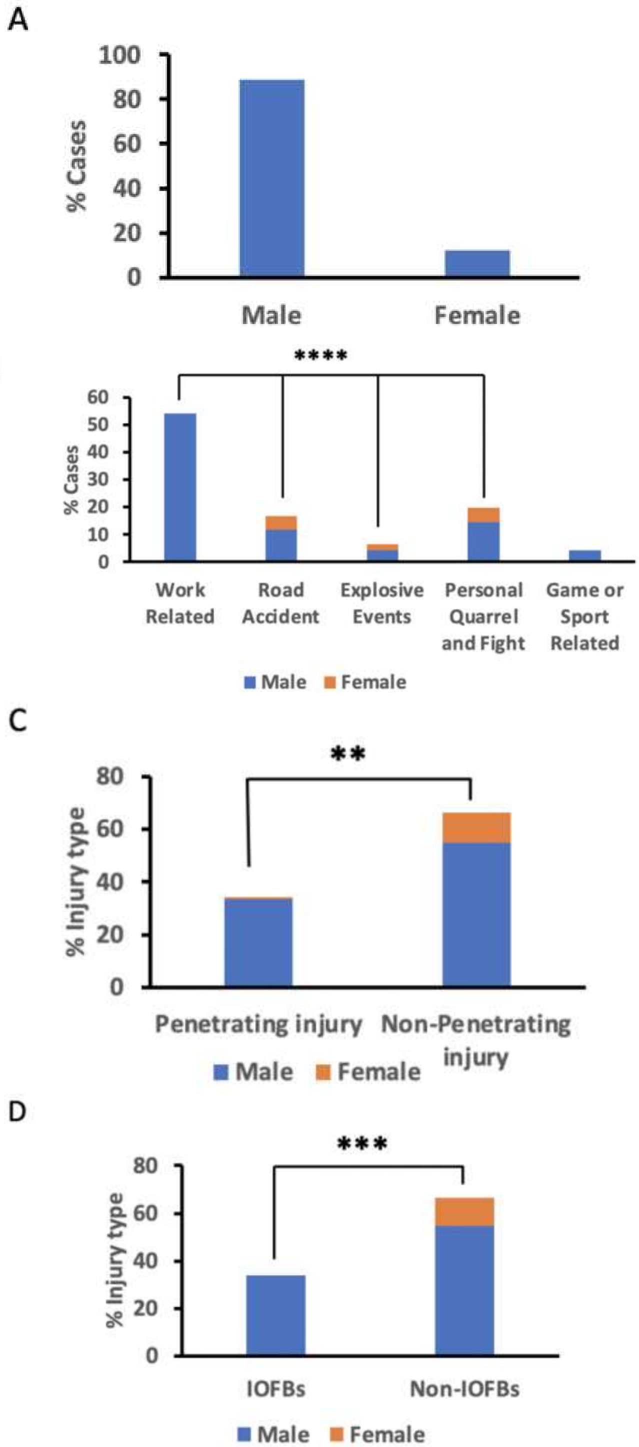

Figure 1: Ocular trauma pattern is associated with gender in in the North Bund area of Shanghai. A. Male is the major source of ocular trauma; B. The percentage of ocular trauma varies among different activities; C. Penetrating injury is mainly found in male patients but not in female patients; D. IOFBs is only found in male patients.

**, P < 0.01; ***, P < 0.001; ****, P < 0.0001, Chi-square test.

Age and Occupation are Two Major Risk Factors Associated with Penetrating and IOFBs Injuries

Since the patients' profiles exhibit an obvious age distributions in various occupations, we then investigated if age and occupation affect the risk of ocular trauma. After patients were divided into four age groups, we found that the percentage of ocular trauma reaches a peak at 46.12% in 40~60 years old (y/o) age group (n=95) (Table 1, Figure 2A). Although no statistical difference was seen between 19-39 y/o group and 40~60 y/o group, both groups showed significantly higher ocular trauma percentage than other groups (Figure 2A). In the meanwhile, we found that 58.74% of patients (n=121) were blue-collar workers except for farmers who rarely expose their eyes to the risk environment in this study. In contrast, much less eye injuries are found in students, teachers, and retirees, and etc., whose occupation is not related to manual labor job (Table 1, Figure 2B). Furthermore, ocular trauma type analysis showed that penetrating and IOFBs injuries are two major type of ocular traumas, which account for 33.98% (n=70) and 33.49% (n=69) of ocular trauma cases, respectively (Table 2). We found that majority of the penetrating/IOFBs injury cases fall into the category of blue-collar workers (23.79%, n=49 for penetrating injury; 31.07%, n=64 for IOFBs) (Table 1), and most of the cases (53.88%, n=111) occurred during work (Table 2). Taken together, these data suggest that age and occupation are two major risk factors associated with penetrating and IOFBs injuries.

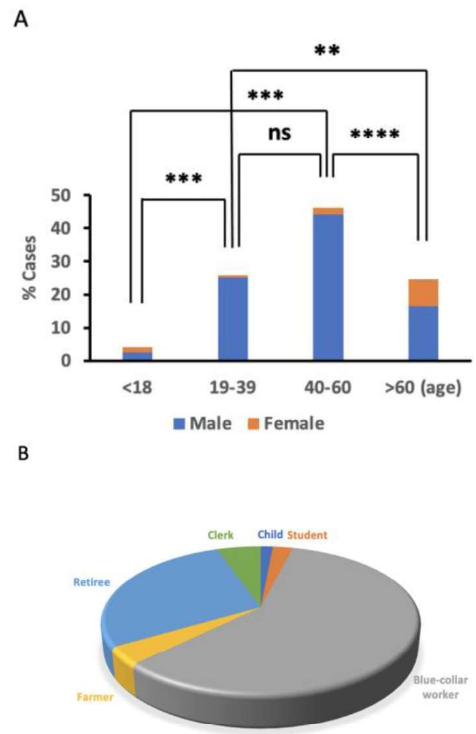

Figure 2: Ocular trauma pattern is associated with age and occupation. A. The percentage of ocular trauma reaches a peak at 40-60 y/o age group; B. More than 50% of ocular trauma cases are found in blue-collar workers. ns, not significant; **, P <0.01; ***, P < 0.001; ****, P < 0.0001, Chi-square test.

Season Change Alters the Risk of Ocular Trauma

To determine whether ocular trauma cases have seasonal variation, we reviewed the patient cohort by month in each season. We observed that ocular trauma percentage reached a peak in summer (32%, n=66). The average monthly percentage of ocular trauma in summer was 10.67%, which is significantly higher than that in other three seasons (Table 3, Figure 3). This observation suggests that season change adds another layer of risk factors in ocular trauma, and precautions have to be taken seriously in summer.

Table 3: Ocular trauma distribution by month and season

Season	Month	Case number (n)	%&	%#
Winter	January	15	7.28	18.4
	February	15	7.28	
Spring	March	16	7.77	24.3
	April	20	9.71	
	May	14	6.81	
Summer	June	18	8.74	32
	July	26	12.62	
	August	22	10.68	
Fall	September	28	13.59	25.2
	October	14	6.81	
	November	10	4.85	
Winter	December	8	3.88	

&, Average monthly percentage; #, percentage by season. Data were calculated from three years.

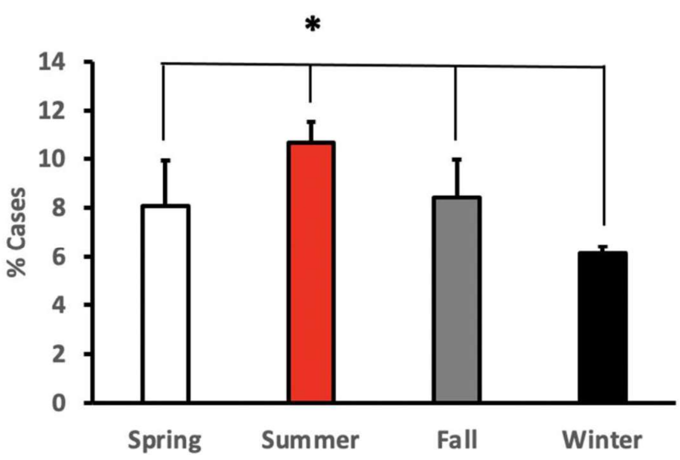

Figure 3: The percentage of ocular trauma reaches peak in summer. Data represent average monthly percentage of ocular trauma in each season (also see Table 3). *, $P < 0.05$, one-way ANOVA assay.

RD and VH are Two Common Types of Complications

Complications of RD, VH, lens dislocation and endophthalmitis are four common types of complications for ocular trauma closely associated with final visual acuity, which are also observed in our patient cohort (n=50, Table 4) [6]. Among the four types of complications, we found that RD and VH are two major types of complications, which accounts for 10.19% (n=21) and 8.74% (n=18) of total cases, respectively, whereas both lens dislocation (3.88%, n=8) and traumatic endophthalmitis (1.46%, n=3) only occurred in a small portion of patients (Table 4). To obtain better visual outcomes, extraction of dislocated lens was performed for patients with lens dislocation, and PPV was performed for patients with RD, VH, and traumatic endophthalmitis either during the first hospitalization or at the follow-up visit within three months for a second time surgery. None of the patients received enucleation as the primary procedure. Our study showed that these proper treatments are beneficial for patients with complications.

Table 4: Ocular trauma complications, location and size of injuries

	Case number (n)	Percentage (%)
Complications		
Lens dislocation	8	3.88
RD	21	10.19
VH	18	8.74
Endophthalmitis	3	1.46
Locations		
Zone I	80 (5^{I})	38.83 (2.43^{I})
Zone II	46 (3^{I})	22.33 (1.46^{I})
Zone III	37 ($31^{I\#}$)	17.96 (15.05^{I})
Wound size		
Group 1 ≤ 5mm	76 (0^{I})	36.89 (0^{I})
5< Group 2 <10 mm	47 (7I, 32^{II})	22.82 (3.40^{I}, 15.53^{II})
Group 3 ≥ 10 mm	40 (29I#, 13^{III})	19.42 ($14.08^{I\#}$, 6.31^{III})

I, NLP; #, 18 of the patients who have zone III trauma also have wound size larger than 10mm. II, patients have minor corneal scar that doesn't cause obvious vision damage; III, patients have severe corneal scar that causes low vision.

Location and Size of Injuries Determine Visual Outcome

To determine how injuries may affect the visual outcome, we analyzed the impact of the location and size of injuries on NLP (or VA IV), which is a sign of blindness. We found that most of the injuries are located in the zone I (38.83%, n=80), followed by 22.33% (n=47) of the patients in zone II and 17.96% (n=37) of the patients in zone III, which is also reflected in wound size with similar percentage, although some patients had overlapping in injury zones and wound sizes (Table 4). Patients with zones I and II injuries have relative benign visual outcomes and low NLP percentage (2.43%, n=5 for zone 1 injury; and 1.46%, n=3 for zone II injury, respectively), which is also the case for patients with wound size smaller than 10 mm (0%, n=0 in group 1 patients; and 3.4%, n=7 in group 2 patients, respectively) (Table 4, Figure 4A). However, patients with zone III injury or wound size larger than 10 mm exhibited much higher NLP percentage with poor prognosis (15.05%, n=31 for zone III injury; and 14.08%, n=29 for group 3 patients, respectively) (Table 4, Figure 4B), indicating that location and wound size significantly affect the visual outcomes.

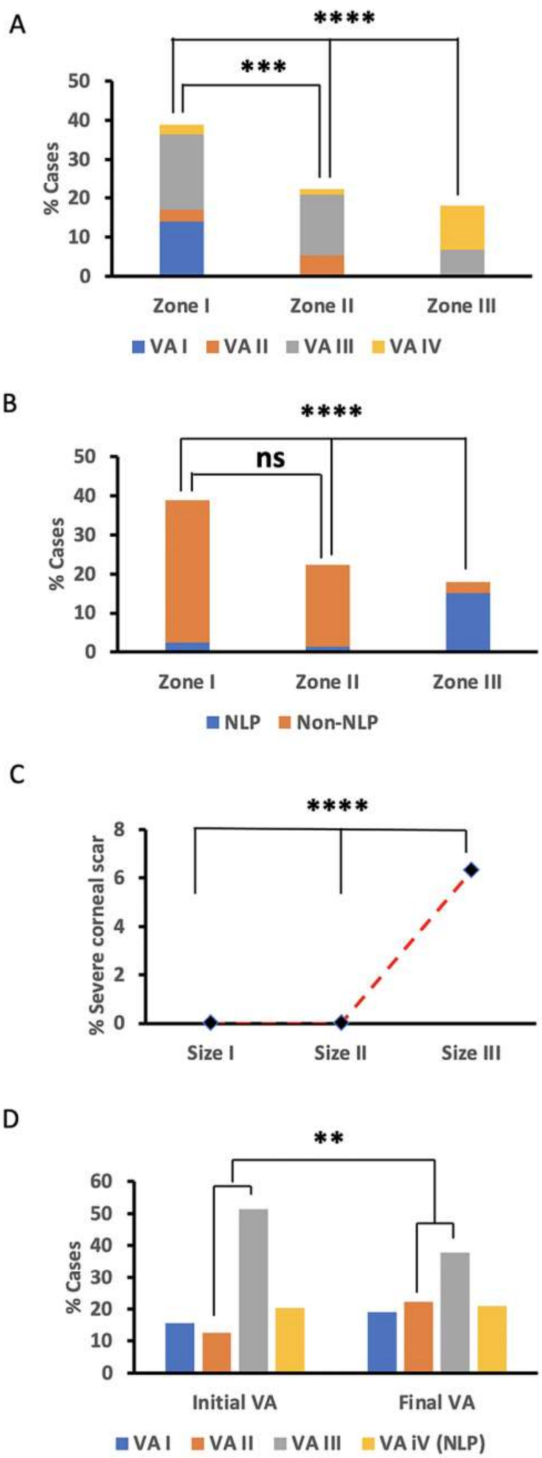

Figure 4: Location and size of injuries are prognostic factors for visual outcome. A. Percentage of cases with different VA in each injury zone; B. NLP is mainly found in patients with zone III injury; C. Severe corneal scar is only found in patients with wound size III injury; D. Patients with initial VA II score showed significantly improved final VA score than patients with initial VA III score. ns, not significant; **, $P < 0.01$; ***, $P < 0.001$; ****, $P < 0.0001$, Chi-square test.

To further verify our observations, we next analyzed patients initial and final VA score, which is typically used to measure vision improvement in ocular trauma patients, with level I (VA I) as the best, and level IV (VA IV, or NLP) as the worst. We found that 4.85% of patients (n=10) with level III VA (VA III) score and 14.08% of patients (n=29) with VA IV score had ≥10mm wound injury size. However, in patients with VA I and VA II score, ≥10mm wound injury size (group 3 wound size) is rarely seen (Table 5). In addition, corneal scar was seen in patients with group 2 (15.53%, n=32) and group 3 (6.3%, n=13) wound size, who had either VA III or level IV VA score (Table 4 and 5). Of note, severe corneal scar was only seen in patients with group 3 wound size (Table 4 and 5, Figure 4C). The other 32 patients had less severe corneal scar and showed better final VA score, since they all had group 2 wound size (Table 4 and 5). In addition, one patient who had zone II injury with 7mm wound size converted to NLP at the end of third month, which was caused endophthalmitis due to infection (Table 5). For most other conditions, however, the visual outcomes were promising after treatment. All the IOFBs were successfully removed through surgeries according to the different segments involved. Most importantly, patients with initial VA I and VA II scores had a better final VA scores compared to patients with initial VA III and VA IV scores. In particular, patients with initial VA II scores significantly improved their final VA scores compared to patients with initial VA III score, whereas patients with initial VA III score had worse final VA scores (Table 5, Figure 4D).

Table 5: Patient visual outcome by VA score

VA score	Initial VA		Final VA	
	n	%	n	%
Level ≥ I 0.3	32 (0[1])	15.53 (01)	39	18.93
0.05 ≤ Level II < 0.3	26 (1[1])	12.62 (0.48[1])	46	22.33
LP ≤ Level III <0.05	106 (10[12])	51.46 (4.85[1])	78	37.86
Level IV = NLP	42 (29[1], 3[2])	20.39 (14.08[1], 1.46[2])	42+1[3]	20.87

n: case number; %: Ocular case percentage; 1, wound size ≥ 10mm; 2, patients have severe corneal scar; 3, this patient who had zone II injury with 7mm wound size developed NLP caused by endophthalmitis.

Discussion

The incidence of ocular trauma has increased continuously in recent years in Shanghai owing to the quick increase of laborers, imposing heavy health and economic burdens on patients' families and communities, particularly in current pandemic era. To provide better strategies for ocular trauma prevention, it is necessary to identify ocular trauma pattern with risk factors [7]. However, the ocular trauma pattern with risk and prognostic factors still remains unclear in Shanghai area.

In this study, we identified a gender related ocular trauma pattern that consist of several risk factors, including age, occupation and season change by analysing a 206-patient cohort at Shanghai General Hospital. We found that males are major source of ocular trauma, which is likely caused by the more chances of exposure to dangerous situations during work or outdoor activities in males [8,9]. Age often determines an individual's responses when involving in physical activities. It has been shown that younger people tend to participate in risky activities with lack of supervision and coaching [10]. Indeed, our data showed that youths account for 25.72% of ocular trauma incidence. However, the riskiest age falls into 40-60 y/o group in our study with 46.12% of ocular trauma cases. The discrepancy may reflect the labor shortage in current labor market. Occupation is another major risk factor for ocular trauma, in particular for those people whose job requires intensive manual work in industrial fields, which could be further affected by living or working area, lifestyle and social culture [11-14]. It is worth noting that season change also alters the risk of ocular trauma [15]. Indeed, we found that the monthly percentage of ocular trauma is significantly increased in summer. It has been suggested that number of factors could contribute to increased ocular trauma cases during summer, such as increased outdoor activities, overtime work, and quarrel or fight after alcohol consumption, and etc. [16,17]. Thus, precautions have to be taken seriously in summer.

Penetrating and IOFBs injuries by sharp tools are major types of the ocular trauma in our study, which is consistent with previous findings [15,18-20]. We found these types of injuries are closely related to occupation, and mainly occurred in blue-collar workers. Moreover, the common ocular trauma occurring spots for blue-collar workers are workplace. In contrast, sports fields are the frequent ocular trauma occurring spots for white-collar professionals. Our finding strongly suggests that blue-collar workers are at higher risk of ocular trauma than people in other professions. Mandatory safety training and high level of protection are necessary for blue-collar workers.

Complications are closely associated with visual outcomes. It has been reported that RD, VH, lens dislocation and endophthalmitis are poor prognostic factors correlated with final visual acuity [6]. However, in this study, different surgeries were performed according to different situations of the patients. Meanwhile, antibiotics were applied appropriately to all the patients with open-globe injuries, especially to the patients with IOFBs. These personalized treatments provided best chances for our patients to achieve better final VA. Nevertheless, given the results of our study, traumatic endophthalmitis should also be considered as a poor prognostic factor, as one patient with less severe ocular trauma in our study cohort became blind due to bacterial toxic effect on the retina. For the patients who underwent extraction of dislocated lens, secondary intraocular lens implantation is strongly recommended for better VA achievement when the intraocular environment reaches stabilization after three months.

Location and wound size of injuries determining the visual outcome is one of the significant lessons that we learned from this study. Patients with wound size smaller than 10mm have better final VA compared to those with larger than 10mm openings in the globe. The visual outcome of patients with zone II injuries is significantly better than patients with zones III injuries. In addition, larger wound size also increases the chance of severe corneal scar that causes low vision. Thus, in addition to complications, our study underscored the prognostic role of location and size of eye injuries in predicting visual outcome. In particular, zone III and group 3 wound size for eye injuries are considered as significant poor prognostic factors for visual outcome.

While our study suggests that it is necessary to carry out mandatory safety training and mandatory application of personal protective equipment for people at high risk, it is also important to make as much precision medicine efforts as possible to improve visual outcome for patients. Therefore, the identification of ocular trauma pattern with risk and prognostic factors could open a new avenue for better ocular trauma prevention and treatment. Further studies are needed for making better strategies in both ocular trauma prevention and treatment.

Acknowledgements

Ethics Approval and Consent to Participate

This study was approved by the Research Council and the Research Ethics Committee of Shanghai General Hospital. All the patients consented to participate in this study.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are available in the repository of Department of Ophthalmology, Shanghai general Hospital. The datasets and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' Contribution

J.Z., F.Z. and F.C conceived the project. J.Z., F.Z. and F.C. wrote the manuscript, J.Z., F.Z., F.W., S.C. and F.C. analyzed the data. J.Z., S.C., Y.S., X.Y., F.W., and F.C. performed ocular trauma reevaluation.

Financial Support

This work was supported by National Natural Science Foundation of China (Grant No. 81700842, 81970812) and Excellent Medical Young Talent Projects of Shanghai General Hospital (Grant No. 06N1702019), National Key R&D Program of China [2016YFC0904800, 2019YFC0840607] and National Science and Technology Major Project of China [2017ZX09304010]. We thank all the members in Shanghai Key Laboratory of Ocular Fundus Diseases for their expertise and technical assistance.

Conflicts of Interest

None of the authors.

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