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Characteristics and predictive factors for visual outcomes of open globe injuries in Xizang Autonomous Region, China

Ouzhu Wangmu[1], *Sina Zhuoga*[1], *Zhou Yongkang*[1], *Ciren Qiongda*[1], *Cen Yujie*[2]

引用:欧珠旺姆,斯娜卓嘎,周永康,等. 中国西藏自治区开放性眼外伤的特征及视力预后预测因素. 国际眼科杂志, 2026, 26(12):2059-2065.

Foundation items: Young Scientists Fund (C) of the National Natural Science Foundation of China (No. 82301268); the Group-based Medical Aid Program for Xizang of Xizang Autonomous Region Natural Science Foundation [No.XZZR202402045(W)].

[1]Department of Ophthalmology, People's Hospital of Xizang Autonomous Region, Lhasa 850000, Xizang Autonomous Region, China; [2]Department of Ophthalmology, Peking University Third Hospital, Beijing 100191, China

Correspondence to: Cen Yujie. Department of Ophthalmology, Peking University Third Hospital, Beijing 100191, China. yujiecen@163.com

Received: 2026-05-23 Accepted: 2026-08-26

中国西藏自治区开放性眼外伤的特征及视力预后预测因素

欧珠旺姆[1],斯娜卓嘎[1],周永康[1],次仁琼达[1],岑羽捷[2]

基金项目:国家自然科学基金青年科学基金项目(C类)(No.82301268);西藏自治区自然科学基金组团式医学援藏项目[No.XZZR202402045(W)]

作者单位:[1](850000)中国西藏自治区拉萨市,西藏自治区人民医院眼科; [2](100191)中国北京市,北京大学第三医院眼科

作者简介:欧珠旺姆,毕业于西藏大学,本科,住院医师,研究方向:眼外伤。

通讯作者:岑羽捷,毕业于北京大学,博士,副主任医师,副教授,研究方向:眼外伤,眼部感染性疾病. yujiecen@163.com

摘要

目的:探讨中国西藏自治区开放性眼外伤(OGI)的流行病学特征,筛选患者视力预后的预测指标,以期提升西藏自治区OGI的预防与诊疗水平。

方法:本项回顾性研究收集2022年12月1日至2024年11月30日于西藏自治区人民医院就诊的OGI患者,所有患者均至少接受Ⅰ期眼球修补术。收集患者人口学资料(年龄、性别、居住地等)及外伤详细信息(致伤原因、就诊时间、损伤类型、伤口分区、伤口长度等);从病历中提取首诊视力,术后1 d,3 mo及末次随访视力。计算每例患者眼外伤评分(OTS)。采用卡方检验与二元Logistic回归分析评估影响患者最终视力预后的预测因素。

结果:共纳入76例76眼,其中男59例,女17例;平均年龄30.66±2.55岁,发病至首诊时间间隔中位数为23 h。农区、牧区及城镇患者占比分别为59%、24%、17%。卡方检验统计结果显示:年龄≥41岁、就诊延迟、伤口长度≥5 mm、伤口累及Ⅲ区、首诊视力差、OTS分级低是患者最终功能性视力丧失(最佳矫正视力BCVA<20/200)的预测因素。回归分析显示,OTS分级差异同样具有统计学意义。

结论:西藏自治区OGI具备独特流行病学特征。年龄、就诊时间、伤口长度、伤口累及Ⅲ区、首诊视力及OTS分级对患者最终视力预后具有预测价值。OTS评分可在西藏地区OGI临床诊疗中进一步推广应用。

关键词:开放性眼外伤;西藏自治区;眼外伤评分;藏族

Abstract

• AIM: To investigate the epidemiological characteristics of open globe injuries (OGIs) in Xizang Autonomous Region, China, and to identify predictive factors for patients' final visual acuities, so as to improve the prevention and management of OGIs in Xizang Autonomous Region.

• METHODS: This retrospective study included patients with OGIs from 1st December 2022 to 30th November 2024 in the People's Hospital of Xizang Autonomous Region. All patients underwent primary repair surgeries at least. Patients' demographic information (age, gender, residential area, *etc.*) and detailed injury information (cause of injury, presenting time, type of injury, zone of wound, wound length, *etc.*) were collected. The visual acuities (VA) of presenting, 1-day post-operative, 3-month follow-up and the latest follow-up were extracted from medical records. Ocular trauma score (OTS) was evaluated for each patient. Chi-square tests and binomial logistic regression analysis evaluated the predictive factors for final visual outcomes.

• RESULTS: Seventy-six patients (76 eyes, 59 males and 17 females) were included, with the mean age of 30.66±2.55 y, and the median presenting time was 23 h. The percentages of patients coming from agricultural, pastoral and urban areas were 59%, 24% and 17%, respectively. Chi-square tests showed that age ≥41 y, delayed presentation, wound length ≥5 mm, wound location involved zone III, low initial VA, and low OTS grading were the predictive factors for loss of final functional vision (best corrected visual acuity, BCVA<20/200). The OTS category was also statistically significant in the

regression analysis.
• CONCLUSION: OGIs in Xizang Autonomous Region have unique epidemiologic characteristics. Age, presentation time, wound length, zone III involvement, initial VA and OTS category are of predictive values for final visual outcome. OTS could be further promoted in the management of OGIs in Xizang Autonomous Region.
• KEYWORDS: open globe injury; Xizang Autonomous Region; ocular trauma score; Tibetan ethnicity
DOI:10.3980/j.issn.1672-5123.2026.12.01

Citation: Ouzhu WM, Sina ZG, Zhou YK, et al. Characteristics and predictive factors for visual outcomes of open globe injuries in Xizang Autonomous Region, China. Guoji Yanke Zazhi (Int Eye Sci), 2026,26(12):2059-2065.

INTRODUCTION

Openglobe injury (OGI) is a type of ocular trauma that injures the full-thickness of the eye wall[1], resulting in communication between the internal and external parts of the eye, causing severe damage to the eyeball structure and visual function[2-3]. The incidence of OGI is about 3.5-4.5 cases per 100 000 population[3-4]. The Birmingham Eye Trauma Terminology (BETT)[5-6] categorizes OGI into rupture and laceration, with laceration being further classified into penetrating, intraocular foreign body (IOFB) and perforating. The zones of OGI wounds are classified according to the Ocular Trauma Classification Group[7], where Zone I wounds involve only the cornea, Zone II wounds extend from limbus to anterior 5 mm of sclera, and Zone III wounds extend beyond 5 mm from limbus to posterior pole of the eyeball.

The Xizang Autonomous Region (XAR) is located in southwestern China, at the core of the Qinghai-Xizang Plateau, with a total area of about 1.2 million square kilometers. The average altitude is over 4000 meters above sea level with low air pressure and oxygen concentration, and the geography is of high complexity. There are seven prefectural-level cities in the XAR. Cities and towns are located far apart, with relatively inconvenient transportation. The distribution of medical resources in XAR is uneven, and the overall medical level is lower than that of inland China. The living areas of XAR can be categorized into urban areas, agricultural areas and pastoral areas, daily lifestyles of people living in different areas vary greatly. OGIs in XAR have their unique epidemiological characteristics but have not been systematically summarized, nor have BETT injury types or wound zones of OGIs in XAR been described.

XAR is a multi-ethnic region[8], and the willingness of patients to receive post-injury treatment is affected by a variety of factors, including family economic status, local medical resources, difficulty of transportation and religious beliefs. Patients may give up further ocular treatment for various reasons, and local ophthalmologists have difficulties in persuasion. The Ocular Trauma Score (OTS) is a widely accepted and applied tool for predicting the prognosis of OGIs[9-10], which was first introduced in 2002[11], but has not been widely used in XAR.

The People's Hospital of Xizang Autonomous Region (PHXAR) is located in Lhasa, the provincial capital of XAR, and is a tertiary hospital, receiving patients from all seven prefecture-level cities of XAR. This is a single-center retrospective study aimed at gaining insight into the epidemiological characteristics of OGIs in XAR, to investigate indicators that have predictive value for patients' final visual acuity (VA), and to have a theoretical backbone for improving the prevention and treatment of OGIs in XAR.

PARTICIPANTS AND METHODS

Ethical Approval This retrospective study was conducted at the PHXAR, Lhasa, China. The study was approved by the Institutional Review Board of PHXAR (No.ME-TBHP-24-KJ-123) and adhered to the tenets of the Declaration of Helsinki. Informed consent was waived owing to the retrospective design of this study.

The medical records of 102 consecutive patients presenting to the Ophthalmology Department of PHXAR with OGIs from 1st December 2022 to 30th November 2024 were identified in the institution's database. After removal of 19 duplicate records and 7 records with follow-up <3 mo, a total of 76 patients' medical records were reviewed and analyzed. All patients underwent regulated primary repair surgeries (including proper wound closure, treatment of prolapsed tissue, and elimination of foreign bodies from the anterior chamber) and intravitreal injection (vancomycin, 1 mg/0.1 mL) within 12 h of presentation. Whether the patient underwent further intraocular surgery varied greatly depending on their economic situation and religious beliefs.

We reviewed the demographic characteristics of all patients, including patient age, gender, and the area where the patient was injured. Each patient's OGI detailed information was collected, including cause of injury, presenting time, type of injury, zone and length of the wound tract, and the presence of hypopyon, endophthalmitis, retinal detachment, and afferent pupillary defect (RAPD) positivity. The type of injury was defined according to the Birmingham Eye Trauma Terminology (BETT)[5-6]. The zone of injury was categorized in accordance with the Ocular Trauma Classification Group[7]. The best corrected visual acuity (BCVA) of each patient was extracted from the medical records, including the initial presentation, 1-day post-operative, 3-month follow-up, and the latest available assessment (final VA). The BCVA data of child patients may be partially or completely absent due to inability to cooperate with the examination. Snellen VA was converted to LogMAR VA according to the following rules: no light perception (NLP) 3.0 LogMAR, light perception (LP) 2.7 LogMAR, hand motions (HM) 2.3 LogMAR, fingers count (FC) 1.9 LogMAR. Final BCVA of 20/200 or better was classified as functional success (can read letters). Patients were divided into two groups based on their final BCVA: functional success group (BCVA ≥ 20/200) and

non-functional success group (BCVA <20/200). Time from injury to presentation at the hospital >24 h was considered "delayed".

Ocular trauma score (OTS)[11-12] was evaluated for each patient according to the medical record of the initial visit. The OTS raw scores were calculated first according to six variables: the initial vision, rupture, endophthalmitis, perforating injury, retinal detachment, and RAPD, and then converted into five OTS categories, which may indicate the likelihood of the final VA.

Statistics Analysis Statistical analyses were conducted using SPSS 23.0 (SPSS Inc., Chicago, Illinois, USA). A one-way ANOVA test was used to compare the BCVAs at different time points. McNemar's Chi-square tests were used to compare functional success group and non-functional success group. Binomial logistic regression was performed to assess the impact on final functional success BCVA with age, presenting time, wound length, zone III involvement, and OTS categories as covariates. A statistically significant difference was considered at $P \leqslant 0.05$ for all tests.

RESULTS

Epidemiology A total of 76 patients' medical records were reviewed and analyzed. Among these OGI patients, 78% were male and 22% were female, with a significant excess of male patients over female patients. The age range of patients was 1 to 84 y, with a median of 34 y and a mean age of 30.66±2.55 y. A total of 26 (34%) of these patients were children younger than 12 y, and 29 (38%) were younger than 18 y. Patients of Tibetan ethnicity numbered 69 (91%), those of Han ethnicity numbered 6 (8%), and those of Hui ethnicity numbered 1 (1%).

Patients came from allseven prefectures of XAR: 15 (20%) from Lhasa, 29 (38%) from Shigatse, 15 (20%) from Nagqu, 13 (17%) from Lhoka, 2 (3%) from Qamdo, 1 (1%) from Nyingchi, and 1 (1%) from Ngari. More than half of the patients were from agricultural areas (59%), followed by those from pastoral areas (24%), and the fewest were from urban areas (17%). More detailed data were presented in Table 1.

Causes of Injuries The causes of OGIs in XAR have their own distinctiveness. In general, construction-related injuries (24%) ranked as the most common cause of injuries, followed by sharp object injuries (16%) and falls (13%). Blast injuries due to differential air pressure were a unique cause of injury in the plateau region, accounting for 7% of injuries and were seen in urban, agricultural and pastoral areas. All 3 cases of animal-related trauma were yak horn apex injuries. No car accident injuries were reported. Assault or fighting injuries were at the bottom of the list at only 3% (Table 1).

There were significant differences in the causes of injuries in urban, agricultural, and pastoral areas (Figure 1). The causes of injuries were more homogeneous in urban areas than in agricultural and pastoral areas. The most common cause of injury in both urban and agricultural areas was construction injuries, accounting for 38% and 29%, respectively, while there were no such injuries in pastoral areas. In pastoral areas, striking by sharp object (33%) was the most frequent cause of injury. Animal- and plant-related injuries occurred only in agricultural and pastoral areas.

Table 1 Demographic characteristics of patients and patterns of OGIs

Patients' characteristics	Value
Age (y)	
Mean±SD	30.66±2.55
Median (range)	34 (1-84)
Sex (*n*, %)	
Male	59 (78)
Female	17 (22)
Injured area (*n*, %)	
Urban area	13 (17)
Agricultural area	45 (59)
Pastoral area	18 (24)
Cause of injury (*n*, %)	
Constructing	18 (24)
Striking by sharp object	12 (16)
Fall	10 (13)
Playing/sporting	9 (12)
Farming	8 (11)
Striking by blunt object	6 (8)
Blast due to pressure difference	5 (7)
Animals	3 (4)
Plants	3 (4)
Assault	2 (3)

OGI: Open globe injury; SD: Standard deviation.

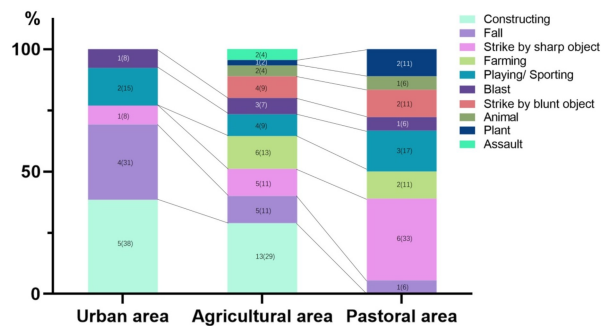


Figure 1 The causes of injuries in urban, agricultural and pastoral areas.

Pattern of Open Globe Injuries The percentage of patients with OGIs to the right or left eye was about equal, with the left eye (39, 51%) slightly more than the right eye (37, 49%). Time from injury to presentation at the hospital varied widely, ranging from 1 to 336 h, with a median of 23 h; 33% (25) were considered "delayed". Injury categories were classified according to BETT; rupture and penetration accounted for the majority of patients, 45% each, and intraocular foreign body (IOFB) accounted for 11%. No perforating injuries were reported in this study. The injury tract was located in zone I alone in more than half of the

patients (54%), and zone III was involved in 18% of patients. The length of the patients' injury tracts ranged from 1 to 23 mm, with a median of 6 mm and a mean of 7.2±0.5 mm (Table 2).

Initial VA at the time of the patient's presentation was most commonly HM (29%, 22), patients with NLP accounted for 9% (7), and 22% (17) of patients had a BCVA higher than 1/200. Thirteen pediatric patients were unable to cooperate with vision examinations at the initial visit, and the remaining 63 patients had a mean BCVA of 2.01 LogMAR, median 2.30 LogMAR, range from 0.2 to 3.0 LogMAR.

Based on the initial visit information extracted from the patients' medical records, 63 patients with complete data were evaluated for OTS, with a mean raw OTS score of 58.79±2.35, a median of 60, and a range of 26-100. The largest number of patients (40%) had an OTS category of 2, while 22% had a category of 1 (with the worst predicted prognosis), and 2% had a category of 5 (with the best predicted prognosis).

Visual Outcomes After regulated primary repair surgeries, the patients' BCVA results at 1 d postoperatively, and 3 months follow-up were 1.84±0.11 and 1.64±0.12, respectively. The mean value of the BCVA of the final visit was 1.46±0.12. We could observe a gradual trend of increasing VA, with a statistically significant improvement in final BCVA compared to initial BCVA ($P<0.01$; Figure 2)

Predictive Factors for the Final Visual Acuities Final VA data were available for 70 patients (6 pediatric patients remained uncooperative for VA testing), and based on the patients' final BCVA, 36 patients with visual acuity ≥20/200 were included in the functional success group, and 34 patients with VA<20/200 were included in the non-functional success group. Multiple factors were compared between these two groups with Chi-square tests (the Youden index was calculated from the ROC curve, age 41 y and wound length of 5 mm were chosen as the cutoffs). The results were shown in Table 3, with statistically significant differences ($P<0.05$) between these two groups for age, delayed presentation, length of the injury tract, whether zone III was involved, initial VA, and OTS category.

After the Chi-square analysis, we preliminarily identified 6 factors that significantly affected the final visual function of patients, among which the OTS category had a strong correlation with the presenting VA, and the effect of the OTS category was more significant (with a lower P value). Therefore, we conducted a binomial logistic regression analysis using 5 variables: age, presenting time, wound length, zone III involvement, and OTS category (Table 4). OTS category had a significant effect on final functional success VA. A sensitivity analysis excluding 6 pediatric patients with missing OTS grading showed regression results consistent with the original.

Table 2 Patterns of the OGIs

OGIs' characteristics	Value
Side (n, %)	
OD	37 (49)
OS	39 (51)
Presenting time (h)	
Mean±SD	43±7
Median (Range)	23 (1-336)
Injury type (BETT), (n, %)	
Rupture	34 (45)
Penetration	34 (45)
IOFB	8 (10)
Zone of wound tract (n, %)	
I	41 (54)
II	13 (17)
I+II	8 (11)
III	5 (7)
II+III	8 (11)
I+II+III	1 (1)
Length of wound tract (mm)	
Mean±SD	7.2±0.5
Median (Range)	6.0 (1.0-23.0)
Presenting VA (n, %)	
>1/200	17 (22)
Finger count	4 (5)
Hand motion	22 (29)
Light perception	13 (17)
No light perception	7 (9)
Unknown	13 (17)
Mean±SD	2.01±0.11
Median (range)	2.30 (0.2-3.0)
OTS raw score	
Mean±SD	58.79±2.35
Median (range)	60 (26-100)
OTS category (n, %)	
1	14 (22)
2	25 (40)
3	16 (25)
4	7 (11)
5	1 (2)
Follow-up duration (mo)	
Median (range)	3 (3-24)

OGI: Open globe injury; BETT: Birmingham Eye Trauma Terminology; IOFB: Intraocular foreign body; OTS: Ocular trauma score; SD: Standard deviation; VA: Vasual acuity.

DISCUSSION

OGI is one of the leading causes of ocular morbidity and monocular blindness worldwide, destroying the structure and function of the eyeball while causing psychological trauma and imposing a heavy financial burden to individuals and families[13-15]. XAR is a vast and sparsely populated region, which, together with its unique cultural and geographic environment, makes it extremely difficult for ophthalmologists to follow-up with patients with OGIs[16]. Due to a variety of complex reasons such as religious beliefs, financial

Table 3 Predictive factors for functional success of final VA

n(%)

Factors	Functional success of BCVA		*P*
	Yes	No	
Sex			0.313
Male	26 (48)	28 (52)	
Female	10 (63)	6 (37)	
Age			0.032
<41 y	26 (62)	16 (38)	
≥41 y	10 (36)	18 (64)	
Delayed presentation			0.039
Yes	8 (32)	17 (68)	
No	26 (58)	19 (42)	
Area			0.750
City area	6 (50)	6 (50)	
Farming area	23 (55)	19 (45)	
Grazing area	7 (44)	9 (56)	
Wound type			0.097
Rupture	13 (38)	21 (62)	
Penetration	18 (64)	10 (36)	
IOFB	5 (63)	3 (37)	
Wound length			<0.001
<5 mm	20 (80)	5 (20)	
≥5 mm	16 (36)	29 (64)	
Zone III involved			0.002
Yes	2 (14)	12 (86)	
No	34 (61)	22 (39)	
Hypopyon			0.936
Yes	3 (43)	4 (57)	
No	33 (52)	30 (48)	
Presenting VA			0.002
>1/200	17 (100)	0 (0)	
Finger count	3 (75)	1 (25)	
Hand motion	10 (45)	12 (55)	
Light perception	3 (23)	10 (77)	
No light perception	0 (0)	7 (100)	
Unknow	3 (43)	4 (57)	
OTS category			<0.001
1	1 (7)	13 (93)	
2	12 (48)	13 (52)	
3	12 (75)	4 (25)	
4	7 (100)	0 (0)	
5	1 (100)	0 (0)	
Secondary surgery			0.900
Yes	6 (33)	12 (67)	
No	26 (50)	26 (50)	
Follow-up duration			0.895
3 mo	28 (48)	30 (52)	
>3 mo	4 (33)	8 (67)	

VA: Visual acuity; OTS: Ocular trauma score; IOFB: Intraocular foreign body; BCVA: Best corrected visual acuity.

conditions, nomadic migration, patients may drop out of the course of medical treatment. A 2013 study reported that ocular trauma accounts for 4.1% of the causes of low-vision in

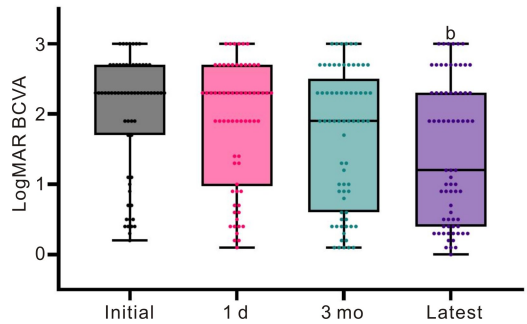


Figure 2 Patients' BCVA at each time point BCVA: Best corrected visual acuity. [b]*P*<0.01 *vs* initial.

Lhasa[17]. Until now, there has been no study on the epidemiology of OGIs in XAR that systematically applies international standards such as the BETT. The PHXAR is a tertiary hospital that receives patients from all over XAR and can partially represent the epidemiological profile of OGIs in the XAR.

From our analysis, there are very clear differences in the causes of OGIs among patients in urban, agricultural, and pastoral areas of XAR. XAR is still a region undergoing rapid construction and development, meanwhile, construction-related trauma takes first place in urban and agricultural areas (38.5% and 28.9%, respectively), which is consistent with the fact that the top reason for OGIs in many regions is work-related trauma[18-20]. In pastoral areas, on the other hand, there were no construction-related traumas, while the proportion of plant- and animal-related traumas increased. The incidence of OGI was highest in agricultural areas (59%), followed by pastoral areas (24%), and finally urban areas (17%), suggesting the necessity of increased public education and protection for residents of agricultural and pastoral areas. The average barometric pressure in XAR (about 500 torr) is about 50% lower than that at sea level, and blast injuries caused by large pressure differences occurred in all three regions. Meanwhile, ruptures (45%) were also relatively more frequent in XAR, equal to penetrations (45%), while in most other regions the incidence of penetrations (48.0%-56.4%) is be significantly higher than that of ruptures (17.3%-35.6%)[18-22].

There was a wide range in the time from injury to arrival at the hospital, from 1 h to 2 wk, with a median of 23 h and a mean of 43±7 h. The overall presenting time to hospitalization was late compared to reports elsewhere[23-27], which is related to the long distances between towns and cities in XAR as well as the relatively low motivation of Tibetan residents to seek medical care. The presenting BCVAs in XAR were lower than those of inland cities of China, with presenting BCVA of HM or worse in 66.7% of patients in XAR versus 52.9% in Zhengzhou[25].

We ensured that each OGI patient who visited PHXAR received standard primary repair surgery within 12 h from presentation, but whether the patient accepted secondary surgery was affected by multiple factors. In this study, only 18 (24%) of all patients underwent secondary surgeries,

Table 4 Binomial logistic regression analysis of predictive factors for final functional success VA

Independent variables	*B*	*S.E.*	Wald	*df*	Sig.	Exp(*B*)
Age	−0.010	0.018	0.303	1	0.582	0.990
Presenting time	0.022	0.012	3.014	1	0.083	1.022
Wound length	0.016	0.100	0.026	1	0.873	1.016
Zone III involved	1.008	1.240	0.661	1	0.416	2.740
OTS category	0.100	0.030	10.895	1	0.001	1.105

Overall percentage 77.8%, Hosmer and Lemeshow Test: Sig 0.865. VA: Visual acuity; OTS: Ocular trauma score.

including 8 (11%) who underwent traumatic cataract-related surgery and 12 (16%) who underwent vitrectomy. To better explain the visual prognosis to the patient and to enhance the patient's willingness for further treatment, it is important to identify key predictive factors for the patient's final visual outcome at an early stage after injury.

By analyzing the data in this study, we found that age ≥41 y (P = 0.032), delayed presentation (P = 0.039), wound length ≥5 mm (P<0.001), wound location involving zone III (P=0.002), low initial visual acuity (P=0.002), and low OTS grading (P<0.001) significantly indicated loss of final functional vision (BCVA<20/200). Of these, the lowest P values were found for wound length and OTS category. While in the binomial logistic regression analysis, only the OTS category was of significant predictive value among the variables, which may be because OTS comprehensively integrates multiple injury severity indicators and thus attenuates the statistical significance of single anatomical factors.

OTS is a predictive tool for final VA in OGI cases, which was first described by Kuhn *et al*[11] in 2002. The lower the OTS score and the lower the grading, the worse the visual prognosis: OTS category 1 has a 74% likelihood of ending up with NLP and a 1% likelihood to be higher than 20/40; OTS category 5 has a 0% likelihood of having NLP and a 94% likelihood of being above 20/40. OTS has shown a strong predictive value in multiple studies in different regions, including Nepal, Korea, Australia, and inland cities of China[9-10,28-29]. It is worth noting that the OTS remained highly predictive in this study even though many patients did not persist to the end of treatment. The study reported by Perez *et al*[30] in 2023 showed that in recent years OTS tended to underestimate the final prognosis for patients with very severe OGIs (*i.e.*, OTS category 1), which was attributed to the spread of secondary vitrectomy surgeries. In XAR, as there are currently fewer (16%) patients undergoing secondary vitrectomy, there is hope that the overall final vision of patients will improve further in the future as vitrectomy surgery becomes more widespread in XAR. The above results suggest that OTS can be used in XAR to help patients establish correct expectations for their final vision and improve their treatment willingness.

There are a few limitations in this study. Firstly, the number of patients enrolled was low. This is because before December 2022 XAR was in the midst of the COVID-19 epidemic, and the data from that period of time do not have good representativeness. Secondly, fewer patients came from Nyingchi, Qamdo, and Ngari, because Nyingchi and Qamdo are closer to Chengdu, an inland city with much better medical service, and patients prefer to go to the inland for medical treatment rather than to Lhasa, while Ngari is the prefecture-level city farthest from Lhasa by distance and has the smallest population. A multi-center study would be of more value and representativeness and could be conducted in the future.

In conclusion, in this study we found that OGIs in XAR have unique epidemiological characteristics due to its particular cultural and geographic environment. Age, presentation time, wound length, zone III involvement, initial VA and OTS category were of predictive value to final visual outcome. OTS is a valuable tool for the management of OGIs in XAR and could be further promoted in the clinical front line of XAR.

Conflicts of Interest: Ouzhu WM, None; Sina ZG, None; Zhou YK, None; Ciren QD, None; Cen YJ, None.

Authors' Contributions: Cen YJ was responsible for designing the study. Ouzhu WM, Sina ZG and Zhou YK were responsible for completing all the surgeries. Ouzhu WM and Cen YJ were responsible for extracting and analyzing data and interpreting results. Ouzhu WM and Cen YJ were responsible for drafting the manuscript. Sina ZG, Zhou YK and Ciren QD were responsible for reviewing and contributing to the final manuscript.

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